STRATEGIC CRISIS MANAGEMENT IN THE EUROPEAN UNION

SAPEA

Science Advice for Policy by European Academies

Evidence Review Report No. 11

The consortium identified all relevant interests of the experts requested to contribute to this Evidence Review Report, assessed whether an interest constituted a conflict of interests, and took — where relevant — measures to exclude that an interest could compromise or be reasonably perceived as compromising the impartiality or objectivity of the report. Further information about SAPEA's quality guidelines and working processes is available at www.sapea.info.

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Science Advice for Policy by European Academies

Strategic crisis management in the European Union

Informs the Scientific Opinion
of the European Commission Group of Chief Scientific Advisors

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About SAPEA

SAPEA brings together outstanding expertise from natural, applied, and social sciences and humanities, from over a hundred academies, young academies and learned societies in more than 40 countries across Europe.

SAPEA is part of the European Commission's Scientific Advice Mechanism. Together with the Group of Chief Scientific Advisors, we provide independent scientific advice to European Commissioners to support their decision-making.

We also work to strengthen connections between Europe's academies and Academy Networks, and to stimulate debate in Europe about the role of evidence in policymaking.

Europe's academies draw on the best scientific expertise to provide independent, balanced and authoritative scientific advice. This approach makes SAPEA a critical source of evidence for policymakers and the wider public.

Our Academy Networks collectively represent over a hundred academies, young academies and learned societies across Europe. SAPEA works to strengthen these academies and provides a means for close collaboration in a unique and interdisciplinary way.

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Foreword

In our increasingly interconnected, globalised and rapidly changing world, the type and nature of the crises we face are also evolving rapidly. There is therefore a pressing need for our theories, principles and practices linked to crisis management to keep up with these changes, in order to better prevent, prepare, respond and recover. The COVID-19 pandemic has revealed the important role that the European Union can play as a crisis manager, as well as the many challenges this role represents.

Against this backdrop, the College of Commissioners asked the Scientific Advice Mechanism of the European Commission to provide evidence-based advice that can inform the improvement of the EU's strategic crisis management.

This is the eleventh Evidence Review Report to be published by the SAPEA consortium. This Report informs a corresponding Scientific Opinion by the independent Group of Chief Scientific Advisors to the European Commission, and both the Report and the Scientific Opinion will inform policymakers.

To address the highly complex nature of the topic and all its interlinkages, SAPEA assembled an outstanding working group of European experts from a wide range of disciplines, backgrounds and countries. This makes this report unique in the field of strategic crisis management. The project was coordinated by ALLEA, the European Federation of Academies of Sciences and Humanities, acting as the lead network on behalf of SAPEA. Academia Europaea acted as collaborating network.

We warmly thank all contributing experts for their time and contributions, in addition to everyone else involved in assembling this report. We would also like to express our sincere gratitude to the science academies across Europe, thanks to whom SAPEA can bring together the best available science.

A special thanks goes to the project chair, Professor Tina Comes, who has shown boundless dedication, energy and enthusiasm in this role.

Professor Antonio Loprieno
Chair of the SAPEA board

Preface

The combined shocks of the COVID-19 pandemic, the war in Ukraine, and the climate crisis have affected the lives and livelihoods of millions of people around the globe. Because of the transboundary nature of these crises, the EU has emerged as an important player in the field of strategic crisis management. Distinct from operational crisis management, the realm of emergency services or control room operations, strategic crisis management is concerned with the facilitation and orchestration of crisis management and covers the decisions and policies that are needed to better prepare for, respond to and recover from crises. In this Evidence Review Report, as a response to a request for advice from the Commissioner for Research and Innovation and the Commissioner for Civil Protection and Humanitarian Aid, we set out to provide the evidence on how the EU can improve its strategic crisis management.

This Evidence Review Report started out in 2021 as the final report in a series synthesising the lessons from the COVID-19 crisis. But the ongoing climate crisis, and especially the war in Ukraine, brought about new questions. As this report is being finalised, at the beginning of June 2022, it is yet uncertain how the looming risks of food insecurity, inflation and economic instability, energy shortages, or even the risk of a nuclear escalation will evolve. In this Report, we have aimed to address the questions that arose, and added texts on food security and refugee crises, while maintaining the integrity of the review process and addressing the questions that were put forward in the original request, formulated in a scoping paper.[1]

But we realise that the world is likely to have changed by the time this report is published. Therefore, the Evidence Review Report focuses on the generic principles and frameworks for strategic crisis management that are relevant to the role of the EU. Since the type and nature of crises that the EU will be confronted with is changing, we especially focused on transboundary, compound, and protracted crises — which conventionally receive less attention. This turn towards complex and longer-term crises also required us to embed strategic crisis management in the context of risk and resilience.

Crises are complex and have implications for virtually all areas of our societies: from governance to infrastructure, from economics to health, from environment to ethics. One of the unique features of this review report is that it brings together a broad range of disciplines. This review is grounded on evidence from the social and behavioural

1 https://ec.europa.eu/info/sites/default/files/research_and_innovation/groups/sam/scoping-paper_crisis-management-in-the-eu_june_2021.pdf

sciences, engineering, resilience, (public) health, law, and environmental sciences. This interdisciplinary approach is crucial to develop effective policy options.

I would like to thank the members of the working group. As we were writing about how to manage crises, we were collectively managing the repercussions of the COVID-19 crisis and the war in Ukraine. Working group members were subject to lockdowns, had to juggle care responsibilities, made ad-hoc shifts to online education, and were welcoming family or refugees that had to flee Ukraine. Yet because of a shared sense of urgency, and despite the tight timeline of the report, the members of the group made an impressive contribution by dedicating their precious time to this effort. Even though, throughout the process, they never had a chance to meet in person, I was impressed by the constructive atmosphere, mutual respect despite diverging views, and their willingness to learn from each other.

Tina

Professor Tina Comes
Chair of the Working Group

Executive summary

Crises like climate change, the recent pandemic and the war in Ukraine have a profound effect on all of us. Crises are growing in number, severity and complexity, and at an accelerating pace. The connectedness of European societies increases their vulnerability, and today's crises have multiple cascading and rippling effects that can extend to all parts of society, the economy and environment.

The need for effective strategic crisis management is evident and, given the increasingly transboundary nature of crises, the EU has emerged as an important player.

Crisis management can be highly sectoral and not always geared to effective performance over the long term, especially when crises become protracted. The consequences of failed or ineffective crisis management can be severe, with rising inequalities and negative impacts such as political fragmentation, societal polarisation and economic disruption.

Recent crises have illustrated starkly the need for preparation, improved capacity and resources. This Evidence Review Report is designed to address issues described in the scoping paper,[1] which sets out the formal request for advice from the European College of Commissioners to the Group of Chief Scientific Advisors to the European Commission. This report synthesises the evidence in response to the main question from the scoping paper:

> Based on a broad and multidisciplinary understanding, how can the EU improve its strategic crisis management?

This report focuses on the strategic level, involving those decision-makers and policymakers who are responsible and accountable for the outcome of a crisis. During the response phase in particular, strategic issues are often neglected because of the urgent need to act and react. For a response to be effective, it is essential to develop rapid decision-making capabilities and appropriate resources.

Although crises are all different in terms of their type, duration and governance arrangements, there are underlying principles that are common to their management. This report identifies fundamental generic principles and frameworks that relate to the roles played by the EU in strategic crisis management. It provides concrete examples of past and ongoing crises, reflecting on trends and developments in the field. Importantly, it embeds strategic crisis management within the context of risk and resilience.

1 https://ec.europa.eu/info/sites/default/files/research_and_innovation/groups/sam/scoping-paper_crisis-management-in-the-eu_june_2021.pdf

Summary of chapters

The main chapters of this report are as follows:

- **1, p.20**, provides the introduction to this report, setting out both purpose and framing. It emphasises that the report is based on a synthesis of multidisciplinary evidence from academia and practice, rooted in the areas of crisis, risk and resilience. It sets out a taxonomy of crises, based on scale (magnitude and frequency), hazard (type of crisis), time (onset and duration) and governance level (local, national or transboundary).
- **2, p.38**, sets out the concepts that are characteristic of strategic crisis management and provides an overarching framework to embed them within the context of risk and resilience. The chapter provides concise definitions for each of the main concepts, showing where and how they are linked. The framework integrates the crisis and risk management cycle into a consolidated overview that demonstrates how crisis and risk management capacities, practices and mechanisms can be organised. Finally, this chapter emphasises the importance of building response diversity and resilience across different sectors.
- **3, p.65**, focuses on EU crisis governance and management. The chapter sets out the EU's current competencies, capabilities and mechanisms for addressing crises of various types, both within and outside the EU. In recent years, the EU has continued to invest its crisis management capacities in different sectors, and the report identifies recent EU initiatives in areas like health, finance, climate change and data governance. Over the years, bridges have been built to connect capacities, and there is an emphasis on enhanced information management, risk detection and communication of early warnings. Given the rise of systemic, interconnected and transboundary crises, it makes sense for the EU to continue to invest in information-based tools and capacities. The rise of transboundary crises may increase public expectations that the EU will invest in building and strengthening transboundary crisis management capacities.
- **4, p.87**, considers risk management for the EU, examining the evidence for the improved integration of risk management within crisis management practice. This approach is based on the rationale that effective, systemic and anticipatory risk management is key to crisis preparedness and resilience. Instead of traditional approaches to risk classification, the chapter puts forward a new taxonomy of risks, clustering them into four main groups:
    1. system breakdown
    2. globally pervasive risks
    3. socially induced risks
    4. amplifier risks

The chapter then looks at risk perception, closely linked to risk communication. Based on the evidence, the chapter provides an assessment of EU risk governance, acknowledging the long tradition of EU risk assessment, reduction and management. At the same time, it suggests that existing procedures and associated tools may be insufficient for handling systemic, complex risks. A systems approach to risk governance is required.

- **5, p.111**, addresses ways to improve science advice during crises. It covers three main areas:
  - the function of science advice, especially during a crisis
  - the needs of policymakers
  - ways of improving science advice

  Three core functions of science advice are identified, each with its strengths and shortcomings, but collectively complementing one another. Five basic needs of policymakers are then described: enlightenment, orientation, strategic planning, integration and knowledge co-creation. The chapter highlights how science advice may be used in a crisis situation, identifying what the challenges are and how these might be addressed. It emphasises that preparation is key, with a number of ways forward for strengthening the policy-science nexus for crisis management. The emphasis should be bringing together different sources of expertise and knowledge into a network, creating shared spaces for discourse between EU and regional bodies and actors.

- Crises have a profound impact on societies, and **6, p.129**, covers equality, trust and participation during crises in Europe. The chapter underlines that equality, trust and participation are closely interlinked. Inequalities are wide-ranging (for example, income, age, gender, ethnicity and more), and crises disproportionately impact people with low income and wealth. Policies and actions need to be adapted to the diverse realities encountered on the ground. Public trust is key in crisis response and beyond; building trust is a long-term investment that pays off during times of crisis, yet can be lost quickly if the public view crisis response as leading to increased inequality. One way to increase trust is by improving public participation and engagement. While there are many potential challenges to social media or information and communication technologies that are discussed in other chapters, here, we highlight that using these technologies for improving participation, such as via citizen-based forums, can be a potent means of strengthening crisis management. The model of analytic–deliberative participation is proposed as one of the most promising ways of developing an integrative approach, based on engagement with experts, stakeholders and the general public.
- **7, p.172**, covers information, data and intelligence for crisis management. It suggests that a potential role for the EU would be to support local and regional

capacities in using scenarios for prevention and preparedness, employing strategic foresight across different regions and administrative levels. The chapter considers approaches to decision support that are especially useful during the crisis preparedness phase, such as safety and security risk assessments, expert judgement and statistical early-warning signals. Emphasis is given to collaborative resilience — that is, the ability of a community to prepare for, respond to and recover from a crisis. The chapter underlines that sensemaking and situational awareness can provide an accurate overview of a crisis situation. It suggests that existing EU platforms should be able to integrate feedback loops and should also focus on information quality — timeliness, accuracy, relevance, completeness, and consistency. The chapter outlines the broad range of training tools available, pointing out a lack of comparable standards, curricula and evaluation criteria. On data harmonisation, it proposes that EU data strategies be extended to meet the special quality requirements for data-driven, cross-border crisis management, facilitating access while also safeguarding data privacy. The chapter acknowledges the initiatives currently being prepared at European level, including the establishment of a Joint Cyber Unit by 2023.

- **8, p.207**, translates the report's findings into concrete case studies, following the methodology suggested in the scoping paper:
  - **Wildfire management** is of increasing global concern, and the EU has developed strategies to respond to these new threats. Evidence suggests that greater efforts should be made for risk reduction and recovery, and that the EU Civil Protection Mechanism should become a more integrated system, interoperable with other existing mechanisms.
  - **Deliberate biothreats** pose a significant and growing threat to global security. The EU in becoming better prepared to respond to cross-border health emergencies, as well dealing with chemical, biological, radiological and nuclear (CBRN) incidents and attacks. The case study highlights the importance of alignment with international information, regulations and guidelines from, for example, the WHO, member states, organisations at different levels, and EU actors. Raising awareness and increasing legislative oversight on dual-use research is crucial.
  - Enhanced and increasingly ubiquitous information and communication technologies (ICT) offer unprecedented capabilities but also create new risks, with smart environments introducing new cyber vulnerabilities. **Cyberthreats** have become a real concern and ransomware a prime threat. Cyberwarfare has also become a serious concern. Fast and effective data exchange is paramount, with trustworthy ICT a cornerstone of successful crisis preparedness and response. Stepping up cyber-defence requires a multi-dimensional effort, and the EU has built up cooperation among several services. A renewed and multidisciplinary approach, with a broader, more proactive view and an increased emphasis

on preventive measures and an effective response, can contribute to better-protected networked systems.

- The case of **displaced populations** is ongoing and of particular concern. This case study reviews past refugee crises to identify important lessons. The EU has activated a temporary protection directive to deal with the war in Ukraine, and this instrument provides a great basis for dealing with a sudden influx of displaced populations, even if long-term social integration remains a challenge. Principles of solidarity among member states are important so as to avoid overwhelming some states, yet this is difficult to achieve. In the longer run, no robust mechanism is in place to avoid a state of 'permanent temporariness' for displaced populations. Evidence suggests that well-developed contingency planning, with the application of the precautionary principle, is key. Good information systems need to be in place that allow authorities to plan for adequate capacities and resources, although data ownership, privacy and data protection raise serious concerns. Here, the EU — which has been spearheading data protection and privacy initiatives — could have a strong role to play.

While each crisis comes with its own sectoral specificities, many of these crises overlap. Each case also illustrates the proportions that each sectoral crisis can take, which inevitably calls for a broader and more integrated approach to risk and crisis management. The EU needs to have mechanisms in place to coordinate and manage these and other ongoing risks and crises at the same time. These case studies call for:

- increasing coordination and alignment with other levels of governance, which is especially relevant for transboundary crises
- increasing capacity in prevention and preparedness
- improving information and data

These conclusions are in line with the conclusions reached in previous chapters of the report.

- In the concluding **9, p.240**, the report warns that Europe is likely to face crises of increasing frequency, magnitude and duration. This also implies that crises and risks are increasingly co-occurring, as crises are becoming more protracted and transboundary in nature with serious cascading effects on society, the economy and the environment, that likely hit the most vulnerable people hardest. Although the EU was never intended or designed as a crisis manager, it has been growing into this role in recent decades. The EU has developed a range of instruments and mechanisms that have been continuously adapted over successive crises. Yet the increasingly transboundary nature of crises may raise expectations and provide opportunities for the EU to fulfil the role of facilitating coordination between member states, providing a flexible and cross-sectoral response, in concert with strong local capacities that can safeguard the functioning of society and the economy. A further role for the EU in strategic crisis management could be in training and setting standards that guide risk management, decision-making and information-sharing. This explicitly targets not only the typical training of civil protection services, but those decision-makers and policymakers that need to rapidly make strategic decisions when responding to crises. New forms of ICT may increase risk of misinformation or cybersecurity, but also offer ways by which to engage citizens and empower them in preparation for and management of crises. Protracted (long-term) crises can blur the lines between risk and crisis management. They require an integrated vision and the effective coordination of activities and organisations across all phases of the risk and crisis management cycle. Crisis management techniques and decision support tools are most useful when tailored to the complexity and context of a given situation, providing flexibility and supporting (rapid) adaptation. At the same time, there is a need and unique opportunity given the progress in technology development to develop data preparedness protocols, harmonised data standards and clear information management guidelines.

Evidence-based policy options

This report puts forward a range of policy options, drawn from the evidence. They cover three main areas.

In the area of governance and institutions:

- Consideration could be given to establishing a European risk and crisis governance board or body. This could help to monitor and analyse risks and crises, develop common approaches for transboundary impacts, offer training and capacity building, and oversee the science-policy interface. It could provide guidance to more flexible, decentralised units that are closer to the locations or sectors in which crisis management is needed.
- Cross-disciplinary risk management taskforces, situated within existing European institutions, could assess, monitor and regulate the physical, financial, and governance links between different risk domains.
- An EU-wide information and communication taskforce could respond and engage the public as soon as a potential crisis arises and counter the impact of mis- or disinformation.
- The science-policy nexus for crisis and risk management could be strengthened. This could include a reform of the EU science advisory system for crisis and risk management.

In the area of resilience, preparedness and capacity-building:

- The development of new cross-sectoral risk assessment protocols and standards could take into account hitherto unconsidered impacts of crises, such as their duration, indirect and long-term effects, the distribution of impacts, welfare and wellbeing.
- Learning and training are vital for crisis preparedness, and there is an opportunity to improve decision-support capabilities of all decision-makers. European standards could be developed that evaluate the impact of crisis management training.
- To strengthen public participation, training could be provided to crisis management authorities and emergency responders on how to coordinate and manage their interaction with volunteers. Standards could be set on data sharing and guidance to (digital) volunteers to help them understand the context in which they are operating. The EU can also spearhead privacy efforts by developing and setting standards to ensure compliance with GDPR and address the question of data ownership.
- Monitoring and engagement with social media can be used to understand public sentiment, trust, and risk perception. There is an opportunity to establish formal or informal consultation mechanisms as a means of fostering participation in the preparedness and recovery phases of transboundary crises — promoting trust, equality and empowerment.

In the area of intelligence, technology and data:

- An EU-wide dynamic risk radar methodology and monitoring protocol could provide early indicators of crisis and improve overall preparedness for transboundary systemic risks.
- Strategic foresight and improved intelligence could be connected to concrete scenario and contingency planning for enhanced decision-support.
- Harmonised standards for data preparedness and data sharing could be developed.

1. Introduction: The need to rethink crisis management in Europe

1.1. Summary

This chapter provides the introduction to this Evidence Review Report, and sets out the frame and purpose.

The report's aim is to inform the Group of Chief Scientific Advisors to the European Commission by providing evidence to answer the questions put forward in the scoping paper:[2]

> Based on a broad and multidisciplinary understanding, how can the EU improve its strategic crisis management?

The Scoping Paper formulates the formal joint request for advice from the Commissioner for Research and Innovation and the Commissioner for Civil Protection and Humanitarian Aid to the Group of Chief Scientific Advisors (see Annex 2 for information about the background on this report). The focus on European strategic crisis management implies that the Evidence Review targets the policymakers and decision-makers who are responsible for facilitating and coordinating crisis management across the member states, rather than providing operational guidelines.

This report warns that crises are becoming increasingly frequent, complex, protracted and compound in nature. As such, they can cascade into other sectors, regions, and nations, making them transboundary. For policymakers, overlapping 'polycrises' will be characteristic of the future. This trend also implies that the conventional lines between crises, risk and resilience is becoming blurred. Therefore, this report is based on multidisciplinary evidence from academia and practice rooted in the areas of crisis, risk and resilience.

Although there are many different types of crises, there are underlying principles that are common to managing them. This chapter sets out a taxonomy of crises, based on scale (magnitude and frequency), hazard (type of crisis), time (onset and duration) and governance level (local, national or transboundary). The report identifies generic principles based on the crisis taxonomy, while reflecting on the most pressing trends and

2 https://ec.europa.eu/info/sites/default/files/research_and_innovation/groups/sam/scoping-paper_crisis-management-in-the-eu_june_2021.pdf

developments in strategic crisis management as far as possible, given that this report was finalised in June 2022.

1.2. Ambitions and aims

The war in Ukraine and the resulting human suffering has shaken our societies to the core. The possible threat of nuclear warfare, the sanctions with their widespread economic consequences, the implications for energy autonomy and food safety, millions of refugees fleeing the war, and looming inflation highlight once more the need for effective crisis management.

And the Ukraine war is not the only crisis that confronts policymakers. The COVID-19 pandemic was still raging when this report was written, and monkeypox is a reminder that the threat of other pandemics remains present. The latest report of the Intergovernmental Panel on Climate Change (2022), on the impacts, adaptation, and vulnerability to climate change, paints a dire picture of future climate crises. The cascading effects associated with these three parallel crises range from political fragmentation and societal polarisation, driven by misinformation and cyberwar, economic disruptions and geopolitical shifts. They underline the need to urgently replace ageing infrastructure systems, accelerate the transition to a sustainable economy, reduce dependence and increase autonomy.

As a result, this report is written with a sense of urgency, as we witness the enormous suffering associated with the unfolding conflict and war; the arrival of refugees from Ukraine; the challenges of coordinating COVID-19 response strategies and lockdowns across different countries, even though the benefits and the costs were known (Goniewicz et al, 2020); the deep effects of the COVID-19 pandemic that ripple through health, economic, social, educational, and environmental systems; and the looming threats of increasing climate and environmental crises.

Any crisis has several levels. At the operational level, emergency responders and volunteers set up emergency shelters, dispatch ambulances, organise call centres, and transport goods to where they are needed. However, the focus of this report is on the strategic level. Strategic crisis management is designed to facilitate and orchestrate crisis management across all phases of the crisis management cycle, including preparedness, response, and recovery. As such, it concerns the decision-makers and policymakers who are ultimately responsible and accountable for strategic direction, and the outcomes of a crisis. Therefore, this report does not present checklists, guidelines or a 'cookbook' on how to better organise the operational crisis response. Rather, it focuses on the broader strategic and policy issues in the context of crises, risk and resilience.

Introduction: The need to rethink crisis management in Europe

Because there is such a vast range of crises and member states, it is impossible to list each possible crisis and its consequences, or to discuss and compare how the response may unfold in each member state. At the time of finalising this report (early June 2022), the war in Ukraine is still ongoing, yet the full implications of the war, such as inflation and economic recession, energy shortages, and the massive risk of food insecurity, go beyond the scope of the present report and are not yet covered by (scientific) evidence. We have chosen to ensure the integrity of the evidence review process and retain the initial mandate of the scoping paper, while providing additions and adjustment to reflect the most urgent developments wherever possible.

Although the types of crises are different, and we cannot predict what the most pressing questions will be once this report is published, there are underlying principles that are common to managing crises. These principles pertain to:

- crisis governance, coordination, and management
- resilience, risk management and preparedness
- science-policy advice
- equality, trust, and participation data, foresight and intelligence

Therefore, in this report, we analyse how to prepare for and respond to different types of risks and crises. We focus on the European level and how the EU helps facilitate and orchestrate crisis management, given the heterogeneity of crisis response mechanisms and respect for the subsidiarity principle. While we identify generic fundamental principles, we also provide concrete examples and applications of both past and ongoing crises wherever possible, and reflect on the most pressing trends and developments in strategic crisis management.

Importantly, crisis management must contend with increasingly **complex and compound crises**. While traditional crisis management has been largely concerned with local or sectoral crises, decision-makers and governments must increasingly ready themselves for threats that emerge in faraway domains and manifest themselves in unsuspected ways. Hitherto smaller events or crises can cascade into other sectors, regions, and national countries. In other words, crises are becoming **transboundary** in nature (Boin, 2019). Moreover, they are harder to manage as they evolve within complex and deeply interconnected systems (Perrow, 1984; Renn & Lucas, 2021). A series of cascading effects occurring at different timescales has the potential to lead systems towards amplifying feedback loops that eventually result in large-scale disasters (Helbing, 2009). As the ongoing war in Ukraine demonstrates, crises that happen outside of the European Union can also have severe implications for and within the EU, calling for humanitarian interventions and external assistance, as well as managing the cascading effects within and for the EU.

While we are confronted with increasingly complex crises, modern societies are heavily dependent on the continuous smooth functioning of complex socioeconomic, technical, and environmental systems (Aarestrup, Bonten, & Koopmans, 2021; Comes & Van de Walle, 2014; Helbing, Ammoser, & Kühnert, 2006; Helbing & Kühnert, 2003). Yet crisis management arrangements still tend to be sectoral, giving rise to a **fragmented governance** system (Den Uyl & Russel, 2018; Morsut & Kruke, 2018) that is prone to the so-called Robinson Crusoe syndrome ('we are alone on an island'). There is a vast body of literature that describes the shortcomings of brittle or unclear coordination structures (Boin & McConnell, 2007; Comes, Van de Walle, & Van Wassenhove, 2020a; Comfort, 2004), the difficulty of making decisions under tremendous uncertainty in very volatile conditions and under time pressure (Klein, Calderwood, & Clinton-Cirocco, 2010; Mendonça, Jefferson, & Harrald, 2007; Turoff, Chumer, Van de Walle, & Yao, 2004; Van de Walle, Brugghemans, & Comes, 2016), and the challenges of communicating risk (Renn, 2008).

The COVID-19 pandemic has laid bare the many barriers and shortcomings that prohibit a timely, effective and legitimate response to a transboundary crisis. The response has revealed a lack of preparedness, especially in the most vulnerable communities. Moreover, it has illustrated the difficulties of working across borders and coordinating response efforts to jointly manage a protracted crisis that now is well into its third year. Crisis management arrangements do not seem to be geared towards long-term performance, even though the boundary between crises and complex policy problems begins to blur over time. Now, with the war in Ukraine, we are potentially confronted with another long-term protracted crisis with dire consequences, even though these consequences are hard to foresee.

As the pandemic inevitably collides with other crises, leading to an increasing risk of compound crises (Kruczkiewicz et al, 2021), new challenges continue to emerge. For instance, how can refugees who are fleeing a war be protected from (spreading) a pandemic? How can European healthcare systems be prepared to deal with the potential double-shock of a combined epidemic and a climate disaster such as a flood — as witnessed in Belgium, the Netherlands and Germany in July 2021? Meanwhile, the 2020 *State & Trends* report by the Global Center for Adaptation[3] (2020, p.2) states that "the pandemic is eroding recent progress in building climate resilience, leaving countries and communities more vulnerable to future shocks". The response to one crisis can also amplify the impact of future crises and lead to polycrises, in which decision-makers are confronted with multiple, mutually reinforcing challenges (Zeitlin et al, 2019).

Because of the increasing protracted, compound and polycrises, the traditional lines of division between risk management and crisis management blur. Rather, recognising,

3 https://gca.org/wp-content/uploads/2021/01/GCA-State-and-Trends-Report-2020-Online.pdf

preventing and managing the risks that one crisis may bring for another sector or region over time becomes of paramount importance for strategic crisis management. Therefore, this report goes beyond the traditional crisis management literature and discusses the interplay of crises, risk management and resilience. Our overarching framework on how to tie together crisis, risk and resilience is presented in 2, p.38.

At a societal level, the consequences of failed or ineffective crisis management can be severe. Crises invariably amplify existing inequalities, leading to disaster injustice (Parthasarathy, 2018; Patel et al, 2020). If leaders do not explicitly address social inequalities, then trust in public institutions and political leaders arguably erode (Everett et al, 2021) and societal fragmentation may further increase (Zeemering, 2021; see also 6 of the present report). Lack of trust, fragmentation and polarisation in turn decrease social resilience and therefore leave us less prepared for future crises and disasters (see 6.4, p.146).

There has been hope that new information and communication technologies (ICT) can help us improve crisis and disaster management, by providing better information in real-time to those who need it (Comes, Meesters, & Torjesen, 2019; Crowley & Chan, 2010; Mahajan et al, 2022). Accordingly, a range of information and data analytics tools have been developed to support European policymakers in dealing with crises, ranging from the Global Disaster Alert and Coordination System to the new Risk Data hub launched in 2022 by the European Commission's Disaster Risk Management Knowledge Centre. Yet the proverbial 'infodemic', the increasing threats of cyberwarfare and the use of technology as a weapon to destabilise countries have also highlighted the downsides of information technology. ICT has accelerated the spread of lies and rumours, which now spread quicker than facts (Vosoughi, Roy, & Aral, 2018), thereby eroding trust and hampering an efficient response.

The war in Ukraine and the COVID-19 crisis have starkly illustrated the need for better preparation, improved capacity, and resources to respond at an EU level. In response to the Ukraine war, the challenge has been to mobilise humanitarian support, organise joint sanctions and the supply of weapons, and wean Europe off its dependence on Russian oil and gas. In response to COVID-19, Europe faced critical shortages of resources, capacities and supplies, from hospital beds and critical supplies to procurement, logistics and planning capacity; from the capacity to rapidly mobilise financial resources to the flexibility to reorganise life as we know it. In this report, we review research findings to provide an overview of the evidence on the status quo and suggest potential policy options to improve strategic crisis management in Europe.

This report focuses on evidence that demonstrates the effectiveness (or lack of) and the impact of different concrete policies or actions in the different areas outlined by the scoping paper. We present an integrated perspective that consolidates and combines knowledge and evidence across a broad range of domains and disciplines.

This chapter has outlined the scope of this Evidence Review Report, its purpose within the European Commission's Scientific Advice Mechanism, and its focus on strategic crisis management of the EU. It has also emphasised the urgency of the questions that we seek to address.

This report offers a scientific perspective on the state of the art with regards to strategic crisis management, to inform the Group of Chief Science Advisors in their formulation of a Scientific Opinion for policymakers. Yet at the time of writing this report — between October 2021 and May 2022 — the policy focus and thereby also the requests to the Working Group shifted from an ERR that provided deeper lessons to the COVID-19 response to the currently still ongoing war in Ukraine and the many cascading effects that are yet expected. As outlined above, we decided to ensure the integrity of the review process and answer the questions that were set out in the scoping paper with the best available evidence to date. Furthermore, we provided additions on specific challenges such as refugees and food security wherever possible. In order to provide a robust review of the available evidence, we brought together a broad range of experts from different backgrounds, drawing from multiple sources of evidence.

Reflecting the complexity of the field and the breadth of questions provided in the scoping papers, we included a total of more than 800 references in this report. But fields such as crisis management, risk or resilience have led to vast bodies of literature that go beyond our mandate. Therefore, our report represents a rapid synthesis of the most urgent questions that were posed, rather than a full and systematic literature review of crisis management. This required us to make choices and select specific areas that we deemed best suited to address the requests brought forward. In addition, this report also highlights ambiguities, uncertainties, and knowledge gaps that we identified to inform future actions.

Our first reference point for this review report was the academic peer-reviewed literature, as published in journal articles and book chapters. But, as we are also invited to reflect on the current practices of crisis management, and as our goal is to inform policymaking, we reviewed past, current and upcoming EU policies and guidelines, with support from the Cardiff European Documentation Centre and most recent updates provided by the Secretariat of the Scientific Advice Mechanism in the European Commission. Furthermore, we reflect on best practices and recommendations from various international organisations such as the UN (International Strategy for Disaster Reduction), the World Bank, the OECD and the IPCC. Especially for the definition of core concepts (2) and the reflection on risk management and crisis governance (1 and 4), this approach has been instrumental. This pragmatic stance on what constitutes evidence also allowed us to include evidence about emerging crises or trends that are not yet published in peer-reviewed sources.

1.3. Future trends and threats: Challenges for strategic crisis management in the EU

Humanity has been confronted with risk, emergencies, and crises big and small throughout history. But there are several environmental, social, technological trends and developments that have changed fundamentally the type and nature of the risks and crises that we will confront in the future. The World Economic Forum (2022) Global Risks Report anticipates that the likely high-impact risks over the next decade include climate action failure and extreme weather events, the erosion of social cohesion, infectious diseases and livelihood crises, as well as geo-economic confrontations and debt crises. Interestingly, scientists rank both the likelihood and the impact of these crises significantly higher than the WEF respondents, painting an even more dire picture of the situation (Future Earth, 2021).

The following images present evidence of the impacts of disasters. First, Figure 1 provides an overview of the registered natural disasters globally between 1980 and 2019. Important spikes are noticeable in the most recent decades, with a growing trend in meteorological and hydrological events.

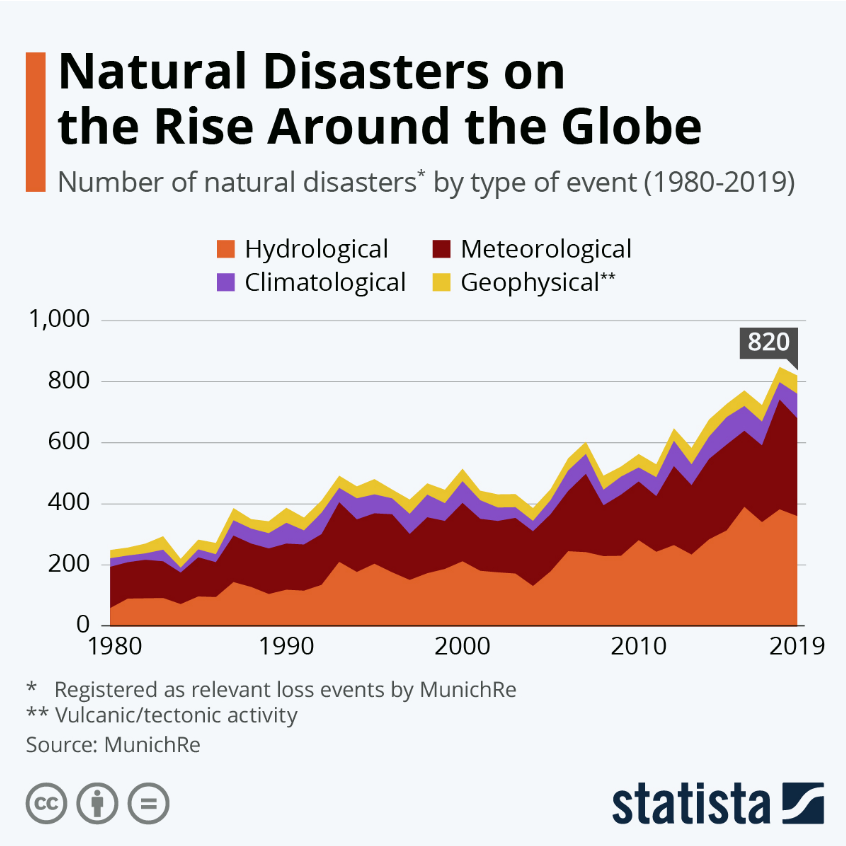

Figure 1. Natural disasters on the rise around the globe
Source: https://www.statista.com/chart/22686/number-of-natural-disasters-globally/

Looking ahead, the G20 Risk Atlas for Europe (Spano et al, 2021) provides an overview of assessed economic impact for the EU under different climate scenarios. For instance, the duration of urban heatwaves is expected to increase by 1247% (i.e., more than 12-fold) by 2050, and significant GDP losses which range from 1.5% of the EU's GDP by 2050 and up to a 4.7% GDP loss under a high emission scenario.

The Joint Research Centre's PESETA IV report (Feyen et al, 2020) further specifies the expected economic losses in different macro-regions and for different types of climate-related events (Figure 2).

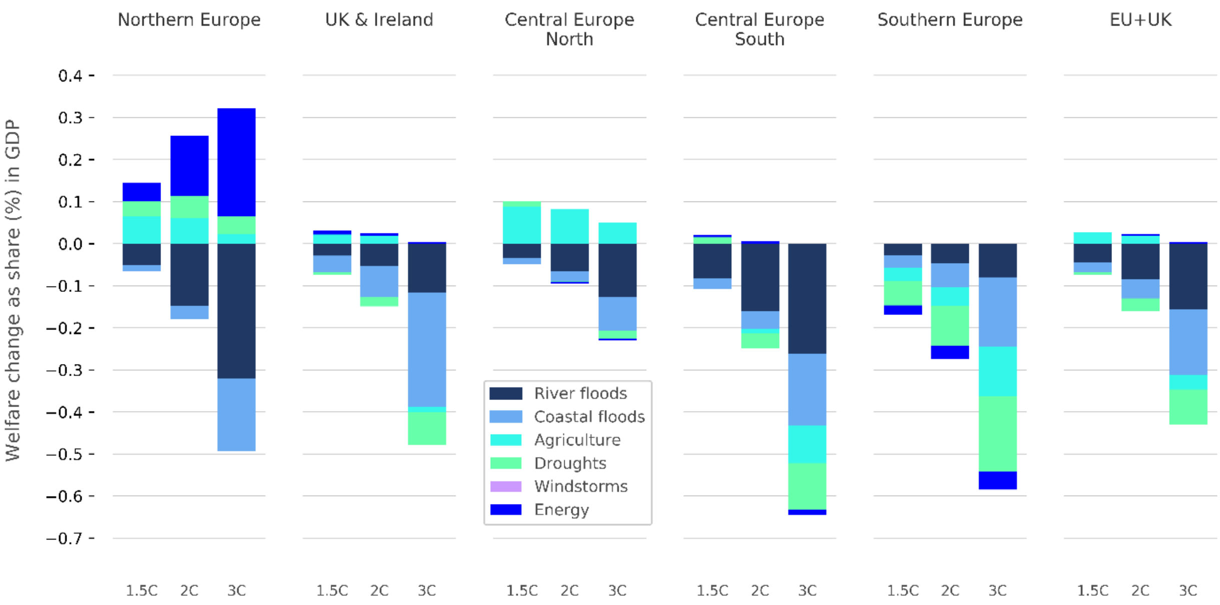

Figure 2. Welfare loss from considered climate impacts for the EU and the UK
Source: PESETA IV Report, https://op.europa.eu/en/publication-detail/-/publication/c707e646-99b7-11ea-aac4-01aa75ed71a1/language-en

As stated previously, the overall increase in crises and risks that European policymakers will be confronted with goes beyond the climate sector. Overlapping polycrises will be characteristic for the future of crisis management, and there will be a stress on crisis management capacity. For instance, as shown in Figure 3 (which covers the period up to 2020 and so does not include the impact of the Ukraine war), Europe will be confronted with a growing number of refugees and displaced people.

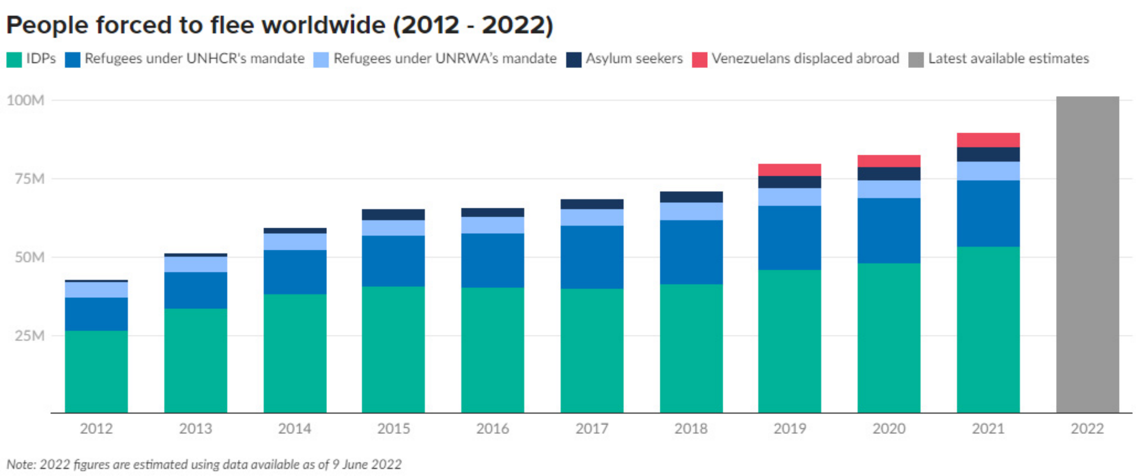

Figure 3. People forced to flee worldwide, 2012–2022
Source: UNHCR, https://www.unhcr.org/flagship-reports/globaltrends/

In this report, we focus on three overarching trends that pose significant challenges and require a fundamental change in the way the EU prepare for and manage risks and crises:

- **Increasing frequency and severity of hazardous events.** The climate is changing, and we are beginning to see the consequences in terms of more extreme events. The IPCC (2021) report confirms that every region on the planet is seeing increasing changes, with far-reaching implications for flooding, changing rainfall patterns, coastal water and heatwaves. The latest IPCC (2022) report stresses that cumulative stressors and extreme events are projected to increase in magnitude and frequency, and will accelerate the loss of livelihoods, flooding, drought risk and food insecurity. At the same time, the changing climate also threatens our biodiversity, affecting especially marine ecosystems — and the people who rely on them. Given the pace and magnitude of these changes, we are also in uncharted territory in terms of the scope and severity of the disasters that will confront us.
- **Increasing vulnerability.** A variety of drivers increase our vulnerability, ranging from increasing urbanisation and ever more dense cities — especially in low-lying areas — to increasing pressure and physical stress on ageing infrastructure systems, and the dependence on globalised supply chains. To manage and address these challenges, decision-makers and infrastructure providers alike have turned to a plethora of 'smart' systems. They now influence virtually every aspect of modern living — from smart energy systems to smart health systems, intelligent houses, mobility and intelligent traffic control. Paradoxically, the increasing ubiquity of ICT can exacerbate the problems that it promises to address, by adding new vulnerabilities. At the same time, paradigms of efficiency, lean management and reliance on global markets have led to a reduction in system redundancies, buffer capacities and response diversity (see 2.5, p.52).
- **Increasing complexity.** Overall, the increased vulnerability of systems, and the increased frequency and severity of crises and disasters, is related to their increased complexity and often global interconnectedness. In tightly coupled systems that are highly complex, local disruptions can cause unprecedented cascading or rippling effects, making it increasingly hard to contain crises geographically and sectorally (Perrow, 1984). Most systems are now networks, or even networks of networks, which promotes cascading effects (Helbing, 2013). Combined with delayed responses to perturbations (i.e. deviation from the normal state) and amplifying feedback effects, it implies that the nature of systemic problems is so 'wicked' (Rittel & Webber, 1973) that there are limitations to our ability to predict and control the crises that arise. These systemic considerations are not accommodated by existing risk management and planning methods.

  Whereas in the past we were able to contain crises to a specific critical infrastructure or region, nowadays more systems across a larger area are likely to be affected. Furthermore, the systemic crises of the future are likely to have long-term effects on society, public health, the economy and the environment. For instance, there is ample research to show that the COVID-19 pandemic is affecting progress on all UN Sustainable Development Goals (e.g. Ahmed et al, 2020). The pandemic also amplifies existing inequalities, both within EU member states as well as across member states, and globally.

1.4. Taxonomies of crises and focus of the report

As outlined above, the focus of this report is on strategic crisis management, and the role of the EU in facilitating and coordinating it. To further distinguish the different types of crises and help focus the report, given the plethora of crises that the EU and its member states may or might be confronted with, crisis typologies can be of help. Crisis scholars and practitioners have a long tradition of developing typologies of crises to understand the underlying mechanisms and provide advice on how to prepare and respond adequately.

Here, we discuss four such typologies, based on scale, hazard, time and governance level. These definitions provide the basis on which to scope the types of crises where the EU, as an overarching organisation, can bring the most added value with respect to its member states — and this is the focus of this report.

Magnitude and frequency of a crisis

Crises can be of different magnitudes and frequencies, ranging from frequently recurring smaller emergencies (Tennakoon, Serrao-Neumann, & Hanna, 2021; Vargas-Florez, Lauras, & Comes, 2021) to rare large-scale disasters or catastrophes (Holguín-Veras, Jaller, Van Wassenhove, Pérez, & Wachtendorf, 2012).

Hazard

Traditional reviews on crisis management (Kuipers & Welsh, 2017) tend to distinguish between different types of hazards/threats, such as extreme weather, terrorism, pandemics, cybersecurity and so on. Sometimes, a simpler and more direct distinction is made between humanmade and natural hazards. This hazard-based perspective has, over time, made room for the idea that the precise nature of the hazard matters less than the vulnerabilities it can exploit and the impact it generates. Academics and practitioners tend to advocate for a so-called all-hazards approach, meaning that governments should address risk and crisis management problems with approaches that allow for dealing with the wide range of hazards and threats in an integrated manner (Dynes, 1983). 4, p.87, proposes an alternative classification of risks.

A typical example of such a classification is shown below, adapted from IRGC (2005):

- **Physical agents**
  - ionising radiation
  - non-ionising radiation
  - noise (industrial, leisure, etc.)
  - kinetic energy (explosion, collapse, etc.)
  - temperature (fire, overheating, overcooling)
- **Chemical agents**
  - toxic substances (threshold)
  - genotoxic/carcinogenic substances
  - environmental pollutants
  - compound mixtures
- **Biological agents**
  - fungi and algae
  - bacteria
  - viruses
  - genetically modified organisms
  - other pathogens
- **Natural forces**
  - wind
  - earthquakes
  - volcanic activities
  - drought
  - flood
  - tsunamis
  - (wild)fire
  - avalanche
- **Social-communicative hazards**
  - terrorism and sabotage
  - humiliation, mobbing, stigmatisation
  - experimentation with humans (such as innovative medical applications)
  - mass hysteria
  - psychosomatic syndromes
- **Complex and hybrid hazards (combinations)**
  - food (chemical and biological)
  - consumer products (chemical, physical, etc.)
  - technologies (physical, chemical, etc.)
  - large constructions (buildings, dams, highways, bridges, etc.)
  - critical infrastructures (physical, economic, social-organisational, communicative)
  - natural hazards triggering technological accidents ('natech')

In this report, we follow an approach — wherever possible — that covers both manmade and natural hazards, and threats of diverse types at onset.[4] Where needed, we provide clear distinctions and considerations for the different types of crises that emerge.

4 Also see https://www.ifrc.org/what-disaster

Time

Another element that is conventionally considered to characterise crises and disasters is time. Crises and disasters are characterised according to their onset (slow versus sudden) and their duration. This allows us to distinguish three types:

- **The sudden onset crisis.** This is a crisis that that manifests itself from one moment to the other, like an earthquake or explosion. When a crisis of this type is studied, it is usually discovered that there was an incubation period (Turner, 1978), during which the crisis was latent or ignored. Therefore, to decision-makers, this type of crisis typically comes as a surprise. The most prominent examples of sudden onset crises are earthquakes; while we know which regions are prone to earthquakes, it remains extremely hard to predict when and where an earthquake will occur and on which magnitude (Asim et al, 2018). As such, earthquakes often surprise decision-makers, emergency services and affected communities alike — with potentially devastating consequences — especially if emergency services are understaffed or not readily deployed, as shown in the L'Aquila Earthquake in Italy (Alexander, 2010; see also Box 7, p.124).
- **The creeping crisis.** This is a crisis that flows from a threat that has been slowly building up over time, accumulating damage potential, in full view of the authorities. The risk of escalation is not understood, not appreciated, or simply ignored (Boin, Ekengren, & Rhinard, 2020). Examples include climate change, anti-microbial resistance and organised crime (Boin, Ekengren & Rhinard, 2021).
- **The protracted crisis.** This is a crisis that lasts a long time. In the humanitarian domain, protracted crises are defined as situations in which sections of the population face threats over an extended period, with institutions failing to provide adequate support (Russo, Hemrich, Alinovi, & Melvin, 2008). At some point, it may not be clear whether the crisis should still be addressed in terms of crisis but perhaps rather as a wicked policy problem (Rittel & Webber, 1973). While there are many examples of humanitarian emergencies outside of the EU, examples within the EU include COVID-19 (Mojifur et al, 2021; Ruktanonchai et al, 2020) and the financial plight of countries struck hard by the 2008 global financial crisis (Brada et al, 2021).

Governance level

With respect to governance and geographical scale, we distinguish the following types of crises (Tasic & Comes, forthcoming):

- **Local crises** play out within the boundaries at a low administrative level, such as a village, city, or region. A local crisis can be geographically located and does not 'move' beyond the administrative boundaries.

- **Crises within the state** unfold within the borders of the nation state. They conventionally prompt a response from local or national emergency services or civil protection units. Examples range from extreme weather events to cyberattacks against individual organisations. If a crisis exceeds the coping capacity of a member state, it may ask help from other member states, which can be coordinated through EU mechanisms. In reality, this rarely happens, but recent cases such as immigration crises, financial crises, and COVID-19 have shown that a member state can suddenly become overwhelmed by events and need the collective support of other member states.
- **Transboundary crises** affect multiple sectors in multiple states. These crises are not static and go across geographical and sectoral boundaries. We may distinguish:
  - EU-wide or global large-scale events such as epidemics and pandemics, financial crises, migration crises or large-scale extreme weather events (heatwaves)
  - transboundary events that occur in border regions, such as radioactive clouds, riverine pollution, or flooding.

  Both types of events require coordination across countries and between services. While transboundary crises that affect few member states are not likely to overwhelm the response capacity of the EU as a whole and therefore do not threaten to exhaust the EU's capacities and resources, large-scale (EU-wide or global) crises may strain the capacity to respond and thereby hamper solidarity between countries.

  Additionally:

  - External crises occurring outside the EU, but demanding the EU's involvement. External crises may directly or indirectly affect EU citizens, or may cause cascading effects for the EU. Prominent examples range from the current war in Ukraine, to the Boxing Day 2004 tsunami in Aceh where thousands of tourists from the EU were directly affected. Some crises outside the EU bring about the migration of the fleeing population, such as the ongoing Syrian refugee crises and the war in Ukraine. These crises may also have implications for the disruptions on globalised supply chains and a general shortage of critical resources and supplies (e.g. Thailand floods, 2011; Suez Canal blockage, 2021; Russia-Ukraine war, 2022). In these cases, the EU can, for instance, operate via its External Action Service to protect EU citizens, or provide humanitarian assistance via the European Civil Protection and Humanitarian Aid Operations, while it can internally prepare for and respond to the repercussions of the crisis.

Importantly, whereas a hazard (such as a flood or an earthquake) often has a clear origin, it is increasingly difficult to confine the impact of a crisis to a specific region or sector. This is often referred to as a cascading effect (Zuccaro et al, 2018) or as trans-sectoral effects (Renn et al, 2020). A crisis may originate in the environmental sector but its impacts might extend into the health, financial and political sectors, depending on the interactive links between the original target of the crisis and the interconnected domains.

This report is aimed at the EU level. We are especially interested in crises in which the EU has a critical role to play in the preparedness, management and coordination of the crisis. These are:

- crises that exceed the coping capacity of a single member state
- crises that directly or indirectly affect more than one member state via cascading and rippling effects (e.g. migration, supply chain disruptions, or disruptions in the mobility of the workforce)
- crises that occur outside the EU but demand involvement from EU member states

1.5. What is evidence in the context of crises?

It is widely recognised that, to be rational, decision-making must be well-informed (Poot et al, 2018). This usually means that it must take account of the evidence of past events and the experience of managing them. As a fully-fledged concept, evidence-based practice originated in medicine (Trinder and Reynolds, 2008). Clinical decisions need to be made in awareness of previous histories of whether procedures worked, what caused particular pathologies and syndromes, and so on. Medicine needed to learn from both its triumphs and its mistakes. Other fields of human endeavour soon adopted the same approach and began systematically marshalling evidence, synthesising and analysing it, and feeding the results into the decision-making process.

Evidence-based practice is not simple. The first question to answer is what constitutes evidence (Rycroft-Malone et al, 2004). By definition, it is factual information that can contribute to the solution of a problem. The information must be obtained by objective methods and not introduce any form of deliberate bias into the picture of the problem that it creates. For the better part of a century the compilers of evidence have used the 'DIKW pyramid', invented (it is said) by the poet T.S. Eliot. Data and facts constitute the lowest layer. When these are combined, they produce information, a form of low-level, or preliminary, interpretation. Ability to interpret information gives knowledge, in which conclusions are made about the significance of the information. At the top of the pyramid, wisdom constitutes the ability to act — rationally and with justification, of course — on the basis of knowledge (Frické, 2019).

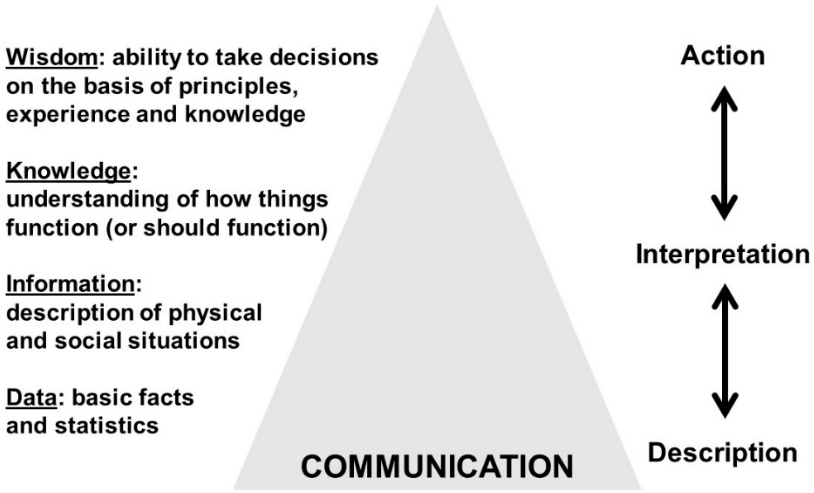

Figure 4. The DIKW Pyramid

Beyond the DIKW pyramid, things start to become complex. Clearly, evidence is the base of the pyramid, and with modern methods such as data mining and supercomputing it has broadened considerably since the pyramid was first conceived in the 1930s. What significance should we attribute to evidence? Evidence of what? Even the most neutral facts require interpretation in order to endow them with meaning. Perhaps the interpretation is subjective or questionable in some way. Not all evidence can be verified and most of it has the character of a sample of reality, not a survey of an entire population of immutable facts. Is the sample a legitimate representation of the wider reality and is the evidence therefore sufficient to form a basis for supporting rational decision-making? This also largely depends on the sample itself.

Much political decision-making has a strong ideological basis. In this sense, evidence may be welcomed where it supports the ideology and it may be roundly ignored where it does not. Selective use of evidence is widespread in the process of finding a justification for decisions that are not based on a clear assessment of what is actually happening but instead on a desire to impose a particular ideology or agenda. Hence, evidence may be collected and analysed, but the analysis may not be directed towards making an objective determination on the basis of all the evidence, by comparing and weighing up the relative significance of each factor.

Among those who seek to improve disaster risk reduction, 'evidence-based practice' has become a rallying call and something of a mantra (Alexander, 2021). Despite the reservations expressed above, it is still an extremely important part of good decision-making in the face of the risk of disasters. Moreover, as research on emergencies, crises and disasters has grown enormously in recent years, there is more and more opportunity to make use of evidence as it is collected and also to base expert judgement upon it. 'Good practice' and 'best practice' require that experience be gathered, collated and interpreted as inspiration for new developments, probably in a different part of the world to that from which the evidence is derived (Aitsi-Selmi et al, 2016).

In dealing with evidence for disaster risk reduction, two particular caveats need to be borne in mind. The first is that most disaster data constitute an exceedingly uneven time series. Impacts tend to show extreme 'spikes' over time, often combining massively destroyed infrastructure with a surge in need for assistance (Holguín-Veras et al, 2013). This extreme shift in needs, demand, capacity, and human response to the crises, interferes with many conventional and linear planning processes such as moving averages. Many extreme geophysical phenomena, and some anthropogenic ones, have the potential to unleash exceptionally large events, perhaps without sufficient forewarning. The second caveat partly follows from this. Past data and historical time series may not be a reliable guide to what the future holds in store. Vulnerability to extreme events is conditioned by the evolution of human society as well as by the nature of each threat or hazard (Hewitt, 1983). This is highly complex and currently rather unstable. Nevertheless, we know that meteorological extremes are likely to become larger and more frequent. In a world composed of unequal and fragmented human societies, emergent risks such as disease pandemics may cause impacts that are profound and difficult to predict. Modern society is highly dependent on networks and, when these fail, the cascading consequences may be profound (Pescaroli & Alexander, 2016).

All of this adds up to a challenge to collect evidence with care and discrimination, analyse it objectively, and advocate for it to be used rationally and honestly. In this process, it is important not to read too much into evidence. Occam's razor (by William of Occam, 1987/1347) quite rightly states that the explanation of a phenomenon should be the simplest one that is upheld by the evidence. We may treat this as a plea not to 'overload' evidence with imagined significance, but to give it its right place in the process of interpreting reality in order to make rational decisions about disaster risk. The use of evidence needs to be transparent, fair and impartial.

In the European Union, as elsewhere in the world, there is a pressing need to improve the use of evidence as a support for policymaking and strategic decisions. As Albris et al (2020) noted, there is an abundance of research, experience and therefore evidence. The challenge is to make good use of these things. To begin with, it would help to clarify what constitutes 'evidence' in the context of disaster response, preparedness, emergency intervention and recovery. Perhaps standards for the collection, verification and marshalling of evidence could be proposed. Secondly, there is a need to share evidence and, within the constraints of national sovereignty, ensure that decisions are made that effectively tackle international hazards and threats (Migliorini et al, 2019). Thirdly, there is a need to ensure that the decision-making process takes full account of evidence and that the latter is subject to fair, transparent and authoritative evaluation before it is used.

Applied science is ready to serve the process of ensuring public safety (Carabine, 2015). It needs to be utilised.

Approach to this Evidence Review Report

Even though we cast our net as wide as possible, for some questions brought up in the scoping paper, only limited evidence is available. This especially concerns the question of the impact of regional research at the EU level. Nevertheless, we aim to provide pointers to the existing evidence and present suggestions for the additional research required to answer the questions adequately.

This report acts on the premise that there is an urgent and chronic need "to apply the existing fruits of research and development" in crises and disasters (Alexander, 2013, p.847). It is the ambition of this evidence review to synthesise the state-of-the-art in crisis and disaster management and make accessible the insights and crucial findings from disaster and crisis research. Indeed, there is no shortage of analyses and recommendations. Since the 1980s, the professional risk and crisis community has studied the crucial role of social and organisational networks in disasters (Dynes, 1983), and the importance of risk and crisis communication, information flows, decision-making and the development of adaptive coordination structures (Quarantelli, 1988; Turoff et al, 2004).

While there is a widespread consensus about the need to improve strategic crisis management, there are of course many questions about how to achieve this. Importantly, there is an ongoing debate around the need for centralisation versus decentralisation that we will highlight throughout the report. In this report, we aim to focus on general principles of risk management, crisis governance and management, intelligence, equality, trust, participation and policy advice, while providing examples to illustrate our findings. Our report concludes with case studies that demonstrate the implications of our results in specific areas, and turn the evidence from the preceding chapters of the report into concrete and actionable findings. We followed the guidance from the scoping paper and explored three major areas: climate change-related crises; cybersecurity crises and digital risks; and health crises.

2. Concepts and frameworks for crisis management

2.1. Summary and key messages

The scoping paper asks for clear definitions of key terms and their integration into a comprehensive framework. Chapter 2 therefore sets out the concepts that are characteristic of strategic crisis management, and provides an overarching framework that embeds strategic crisis management (focusing on the decision-makers and policymakers who provide strategic leadership) in the context of risk and resilience.

To develop the definitions of core concepts, a review team analysed definitions of terms within major policy documents and academic literature. The definitions covered in the Report are: vulnerability; risk; emergency; crisis; disaster; response; resilience; adaptation; absorption; recovery. Chapter 2 provides a brief definition and, where needed, explains the roots of the concept, along with underlying paradigms. It also gives an overview of the dependencies between the different concepts, including overlaps and conflicts

With crises that are complex, compound and protracted, the boundaries between the phases can blur, the challenge being to coordinate activities within and across the different phases of the crisis and risk management cycles. Therefore, the Report's overarching framework integrates the Crisis and risk Management Cycle to an integrative overview that shows how crisis and risk management capacities, practices and mechanisms can be organised. The report's consolidated framework highlights the interplay between risk, crisis and resilience. Finally, this chapter emphasises the importance of building response diversity and resilience across different sectors.

The key messages for Chapter 2 can be summarised as follows:

- There is a plethora of available scientific knowledge on risk and crisis management that can be further integrated into European policy and practice.
- European crisis management has to adjust to the increasing importance of transboundary and compound crises. Such crises cannot be contained within specific sectors, geographical regions, or set periods of time. Cascading and rippling effects can affect all parts of society, the economy and environment. More frequent global crises could strain principles of solidarity.
- The prevalence of compound risks and polycrises blur the lines between risk and crisis management.

- The changing nature of crises requires the EU to re-think conventional — often sectoral — approaches to risk and crisis management. There is a need to capture the dynamics and interdependencies between risks and crises, at different levels and scales.
- Developing flexible responses to various types of disruptions, many of which can never be exactly determined in advance, means that society can increase its response diversity. Society needs to recognise, value and enable the opportunities a diversity of response options provides.
- In the presence of cascading effects, crises cannot be controlled within a single sector. Management requires coordination between different sectors and governance levels. To achieve resilience, key principles such as flexibility, redundancy, adaptiveness, diversity, multi-scalarity and self-organisation need to be implemented.

Under the pressure of increasing uncertainty, volatility and complexity of modern societies, policy and science have developed key concepts and methods by which to study and support the management of the many crises and emergencies, large and small. We here proceed with a review of the concepts that characterise the crisis event (emergency — crisis — disaster, Chapter 2.2). Herein, we distinguish the phase prior to the event, which focuses on identifying, managing and monitoring risks and reducing vulnerabilities (Chapter 2.3.), from the crisis management which evolves around the capacity to prepare, respond and cope. We relate crisis management to other relevant concepts: resilience — adaptation — absorption — recovery.

Yet a closer look into the use of all these terms reveals that their exact meaning is far from clear. In practice, different EU sectoral strategies and policy instruments may use different concepts and terms. This is especially true in the areas of vulnerability and risk (Cardona, 2004; Heckmann, Comes, & Nickel, 2015), and resilience (Elmqvist et al, 2019; Meerow, Newell, & Stults, 2016; Saja, Goonetilleke, Teo, & Ziyath, 2019; Woods, 2015).

To provide an overview of the definitions of core concepts mentioned above, a review team was set up by professional staff members of Cardiff University's Library Services/ Specialist Unit for Evidence Review (SURE) under the guidance of the Working Group Chair to analyse the use of the concepts and terms in key policy documents and the academic literature. The methodology and review process are detailed in Annex 6. In chapters 2.2 and 2.3, we provide a brief definition that is guiding the use of the term throughout this ERR. In addition, where needed, we outline the roots of the concept, along with underlying paradigms and provide an overview of the dependencies between the different concepts, including overlaps and conflicts. From there, we develop an overarching framework that captures the interplay of risk and crisis management in Chapter 2.5, and highlight the need for response diversity and resilience.

2.2. Strategic crisis management

The various capacities, practices, and mechanisms to respond to crises can be organised according to the crisis management cycle (Figure 5, p.41, right hand side in orange). This cycle tells us what the activities in question focus on. A conventional distinction is made between prevention and mitigation, preparedness, response and recovery (Altay & Green, 2006; French & Geldermann, 2005, Mitroff et al, 1987). Each phase in the crisis management cycle has specific characteristics, in terms of urgency of the decisions, the type and nature of uncertainty, the number of actors involved, and the capacity and resources that can be mobilised, for instance. Conventionally, crisis management focuses on the response phase and is reactive in nature, especially in fast-burning crises, whereas preparedness focuses on the knowledge and capacities to anticipate, respond to, and recover from the impacts of crises via planning, organisation and training (Djalali et al, 2014).

In this report, we focus on strategic crisis management of the EU. The strategic management of crises focuses primarily on strategic issues in preparedness, rapid decision-making capability and resources in the response. It also focuses on the extent to which crisis management considerations are integrated into the strategic vision and management of an organisation, and conversely, the integration of strategic issues in the response to and recovery from a crisis (Taneja et al, 2014).

This is different from operational crisis management decisions, typically done by emergency services such as firefighters or police. Operational crisis management is concerned with everyday dispatching, scheduling, or maintaining situational oversight. In contrast, strategic crisis management focuses on the decision-makers and policymakers who are responsible and accountable for the outcome of the crisis (Ansell & Boin, 2019). As such, strategic crisis management of the EU aims to facilitate and orchestrate crisis management across member states, sectors and regions. The OECD further stresses the need for strong strategic leadership, as well as a common set of principles and values that ensures that capacities and resources can be mobilised efficiently in crises (Baubion, 2013). As the EU and its member states will be increasingly confronted with complex and transboundary crises, we see here a key role for the EU.

Importantly, as we are confronted with complex, compound and protracted crises, the boundaries become blurred between the different phases of crisis management, and between risk management and crisis management. At the time of writing, as the war in Ukraine is entering its fourth month and a heatwave in India has led to an export ban on wheat, we see an increasing risk of food insecurity, energy shortages, inflation and economic recessions. Even though these risks are linked to one or several acute crises, it is important to assess, evaluate, prevent, control and monitor them.

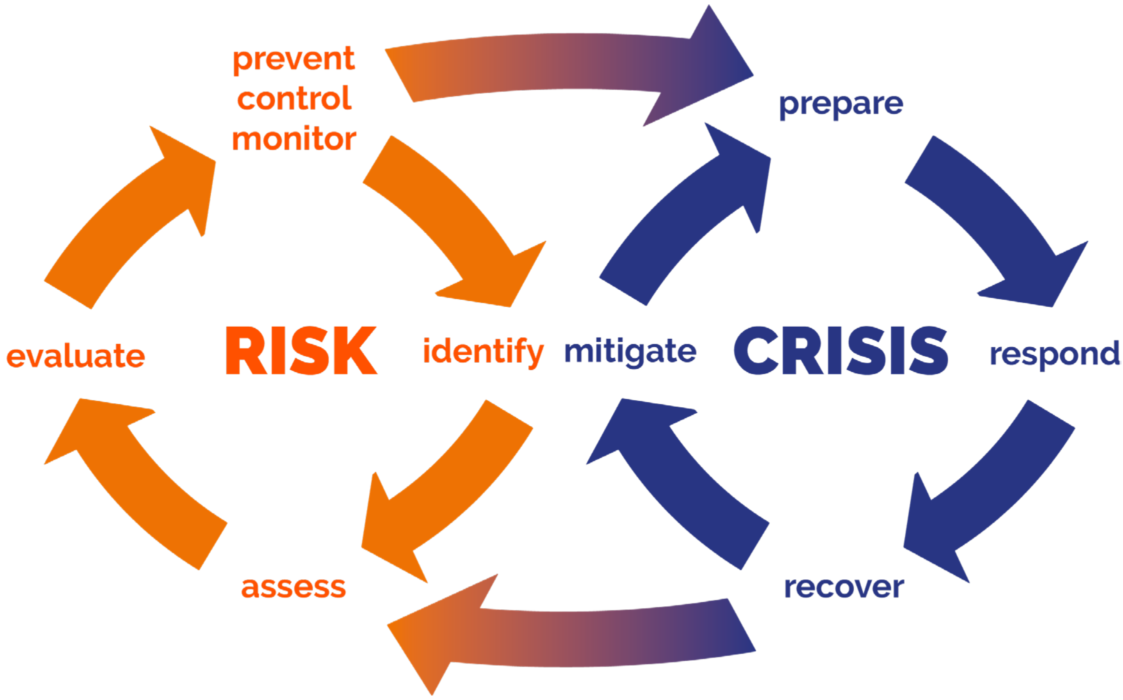

Figure 5. Integrated risk & crisis management cycles
Author: Tina Comes

Figure 5 shows our overarching framework for strategic crisis management that highlights the interplay of risk and crisis management: in risk management (left hand side, in blue), the aims are to identify, assess, evaluate and then monitor, control or (ideally) prevent a risk from occurring. We argue that this control and monitoring should be matched by preparedness in the crisis management cycle. For instance, as we see the risks of food insecurity or shortages of oil and gas growing, what can be done to prepare (crisis management cycle, right hand side, orange)? This approach is designed to ensure a faster and more efficient response. As crises are becoming protracted and their longer-term implications are becoming visible, new risks may arise during the response and recovery phases. For instance, the response and recovery from COVID-19 has led to an increase in mental health risk,[5] which in turn needs to be evaluated, controlled, and monitored.

A key challenge across all phases therefore remains overseeing and coordinating activities that are organised in the various phases of the risk and crisis management cycles, for the different and interdependent crises and risks with which the EU is confronted. Yet conventionally, crisis and risk management, as well as the activities pertaining to different types of crises, are often delegated to different organisations. Because of the interdependencies outlined in Figure 5, this report is not structured into the different phases of the crisis management cycle. Instead, in the subsequent chapters, we highlight the implications across and within the different phases of the

5 https://www.europarl.europa.eu/RegData/etudes/STUD/2022/697217/EPRS_STU(2022)697217_EN.pdf

crisis management cycle and we will also argue for a further integration of risk and crisis management in Europe.

2.3. Before the onset: From vulnerability and risk to emergency, crisis, disaster

While 'emergency', 'crisis' and 'disaster' may often be used interchangeably in everyday language, or even in academic articles, they have distinct meanings and differentiate between scope, scale and nature.

To understand crises, it is also important to understand how they arise. Conventionally, vulnerabilities create risks that — when unaddressed — can develop into crises, often initiated by a triggering event or series of events (see Figure 6, p.43).

In the following, we first provide the core definitions along with some prototypical examples of such events, and then discuss the major differences and similarities between them from the point of view of policymakers and decision-makers.

Importantly, within some member states, all or some of these concepts might legally enable the use of particular emergency powers, enabling emergency management organisations or giving access to particular financial instruments. Particularly in the context of federal member states, the relationship in crisis between state and federal competences are often tied to such threshold concepts as 'disaster', 'major crisis', 'state of emergency' or 'calamity'. The use of such concepts will often be dependent on definitions within particular domains of regulation (e.g. nuclear, pollution or cyber), and thus not something defined across regulations even within the same jurisdiction (Lauta, 2015; Guttry et al, 2012; Lyster, 2015). While this is important to bear in mind, it does not make it less relevant to create a coherent use of such concepts in an EU context. Furthermore, even where definitions seem similar, the actual application might vary substantially (Orru et al, 2021).

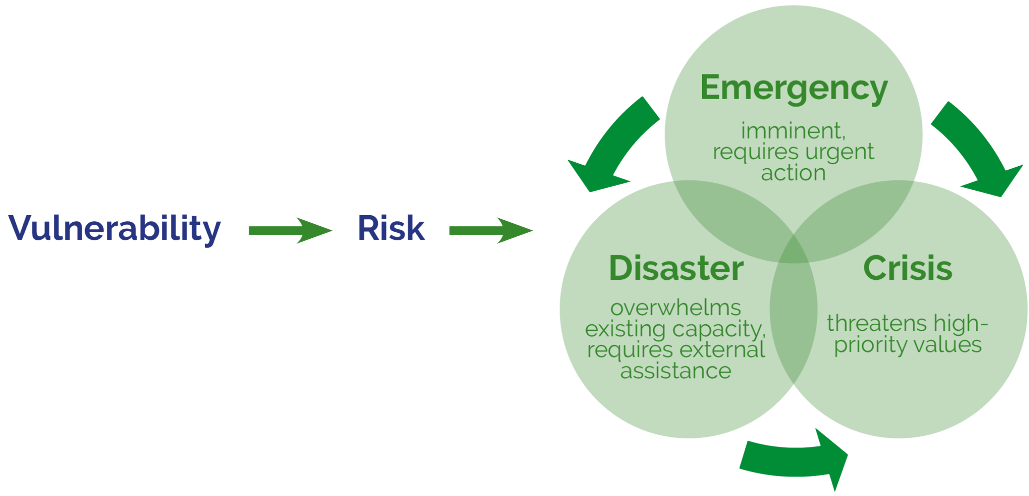

Figure 6. From vulnerability and risk to emergency, crisis and disaster
Author: Tina Comes

Risk: a central concept

A central concept in this section is the notion of 'risk', which then leads to crises, emergencies or disasters. Since the term 'risk' has been used in different sectors, there is a multitude of definitions and applications. Because of its central role, we give here an overview of the different strands of the risk literature before then providing a concise definition.

As decision-makers have been confronted with risk in many different contexts and sectors, there is a plethora of approaches to measuring and managing risk, for instance also put forward by the Society for Risk Analysis:[6]

- In **finance**, 'risk' is conventionally defined as the fluctuation around the expected value of return, or — more broadly — as the deviations from set objectives.
- In the **technical sciences**, 'risk' is conventionally operationalised as the function between probability of occurrence, multiplied by the value of damage or loss to a society or community (Aven 2003). The first component, related to the hazard, has led to multiple taxonomies that characterise the risk by the triggering event (e.g. flood risk) or source (e.g. external or internal).
- In the **natural hazard** literature, 'risk' is normally understood as at the product of hazard intensity, exposed targets (individuals, buildings, etc.) and the resulting damage (Aitsi-Selmi,et al, 2015).

6 https://www.sra.org/wp-content/uploads/2020/04/SRA-Glossary-FINAL.pdf

- In the field of **food safety and chemical exposure**, 'risk' denotes the combination of hazard release, exposure, dose-response and resulting damages (Wu & Rodricks, 2020).

Uncertainties are a main element of risk. Conventionally, probabilities are used to characterise the likelihood of occurrence, but there are various authors who define different levels of uncertainty (Walker et al, 2003). The spectrum ranges from full knowledge (determinism) to total ignorance (indeterminacy), as shown in Figure 7. These uncertainties can relate to a limited understanding of the situation (e.g. because information is missing or conflicting during an emerging crisis) or to our limited knowledge about the future.

Depending on the level of uncertainty, different methods or techniques can be used to assess risks. Events that are so extreme that there is little to no prior experience with predicting or managing such a crisis correspond to situations of Knightian or deep uncertainty. Deep uncertainty is defined as the condition in which decision-makers or experts do not know or cannot agree upon the appropriate models to describe interactions among a system's variables, the probability distributions to represent uncertainty about key parameters in the models, and/or how to value the desirability of alternative outcomes (Walker et al, 2013). In these cases, scientists have argued for scenario-based approaches to characterise the risk (Heckmann et al, 2015). Of course, there are elaborate probabilistic models for the reaction of our physical systems and environment, especially the complex response of our societies over time, but the many cascading and rippling effects are hard to assess — and even harder to assign a probability (French & Niculae, 2005).

Figure 7. Levels of uncertainty.
Source: adapted from Walker et al, 2003

Acceptable levels of risk may be different for science and society. This is mainly because individuals as well as social groups share different perceptions of risk, and use different rationales for judging the acceptability of a risk — for example, based on the ratio between perceived benefits and perceived risks, but also on the perceived fairness of risk-benefit distributions among the population or the perceived likelihood that oneself or a loved one will be affected (Hansson, 2008). Risk perceptions are major factors in policy debates, which contribute to conflicts and polarisations between social groups, as recently witnessed in the debate about vaccination against COVID-19.

Risk assessment, management methods and protocols have proven to be very effective in many risk domains, such as occupational health, technical accidents or sanitation. They have been less effective in emerging nonlinear global risks such as those posed by the global financial system, climate change or the growing inequality between the rich and the poor. The most recent outbreak of COVID-19 is an example of such global risks that threaten the critical functions of society's wellbeing. In order to take these types of risks into account, the Organisation for Economic Cooperation and Development (2003) introduced the category of 'systemic risk'. A widely-used definition of systemic risk in the context of finance has been provided by Kaufman and Scott (2003, p.372):

> Systemic risk refers to the risk or probability of breakdowns in an entire system, as opposed to breakdowns in individual parts or components, and is evidenced by co-movements (correlation) among most or all parts.

Systemic risks exhibit five properties (Renn et al, 2020; Homer et al, 2021):

- extremely complex and dynamic networks of multiple, synergistic causes and feedback loops
- highly nonlinear cause-effect relationships, with multiple equilibria, unpredictable tipping points, and hysteresis phenomena
- causal processes that cross boundaries of administrative and political units, social sectors and scientific disciplines, and that operate on multiple timescales across natural, social and technological systems
- a propensity to generate multiple 'black swan' configurations

and for all these reasons,

- deep uncertainty regarding both the likelihood and ultimate consequences

Systemic risks are transboundary or cross-sectoral. They may originate in ecological systems, humanmade systems, or biological systems. But their ripple effects spread out towards other systems, also of different kinds, where they have an impact to a greater or lesser extent (Aven & Renn, 2010). The cascading effects of systemic risks can cut across national as well as sectoral boundaries, possibly increasing in intensity and impact. Systemic risks can transcend boundaries of jurisdiction, nationality or sectoral responsibility and therefore often call for multi-level governance (Hooghe & Marks, 2003) and international cooperation. The COVID-19 pandemic demonstrates these transboundary effects of systemic risks particularly well (Collin et al, 2020).

Definitions and concepts

Vulnerability

- **Definition.** Vulnerability describes the susceptibility of a system or asset to damage, and as such is one of the determinants of risk.

- **Explanation.** Generally, vulnerability describes conditions that make the system or element prone to loss, adversity or hazard, including a lack of capacity to protect from harm. Unsurprisingly, under the umbrella of vulnerability, there is a combination of physical and technological, social, economic, and environmental factors and processes. As such, vulnerability is also intrinsically linked to resilience (Cutter et al, 2008; Gallopín, 2006).

Risk

- **Definition.** Risk denotes the possibility of undesired effects associated with an event or an activity (Renn 2008, p.3; Kates et al, 1985, p.21).
- **Explanation.** See above.

Emergency

- **Definition.** An emergency is an imminent, serious situation requiring immediate action. It tends to occur with some sort of regularity, which has allowed professionals to prepare a response to particular sorts of emergencies.
- **Explanation.** In emergencies, the focus is on the urgent need to rapidly intervene. Time pressure is high on decision-making and operations (French & Geldermann, 2005; Turoff et al, 2004), and emergencies will often involve deployment of emergency services such as medical emergency care, the police, firefighters or medical emergency care. Emergencies can become crises or disasters if unmanaged or left unattended. Importantly, the initial phase of a crisis or disaster is also frequently characterised by urgency, especially for sudden-onset events. Therefore in such cases, crises and disasters share the characteristic of time pressure and urgency (Quarantelli, 1988).

Crisis

- **Definition.** A crisis occurs when people perceive a severe threat to the fundamental values or functioning of a society or system, requiring an immediate response that must be delivered under conditions of (deep) uncertainty (Boin, Ekengren, & Rhinard, 2016; Rosenthal, Charles, & Hart, 1989).
- **Explanation.** Crises essentially bring together a fundamental threat to our societies with time pressure and tremendous (deep) uncertainty, which hampers our possibilities to predict — even with the most advanced models (French & Niculae, 2005). Importantly, the combination of time pressure, high stakes and uncertainty are also known to induce cognitive biases in decision-making (Comes, 2016).

  The literature distinguishes declared or discovered crises from underlying or hidden (latent) ones. There can be cascading crises, where initially localised events ripple through intertwined systems and create systemic disorder. Often, crises require urgent reactions. Crisis management aims to prevent a dangerous situation from turning into a disaster.

Disaster

- **Definition.** A disaster is a severe disruption of normal functioning of a system, leading to widespread losses and impacts that overwhelm the response capacity of a system or society.[7]
- **Explanation.** A disaster requires urgent response and typically requires external assistance, as the local capacities to respond are overwhelmed. A disaster is an emergency of great magnitude. As it requires external assistance, it could be a typical case for intervention at EU level.

2.4. After the onset: crisis response and resilience

While planning and preparedness were discussed in the preceding section, in this section we unpack the response side of crisis management, where a vulnerability exposes to a hazardous event or series of events (the 'shock' in Figure 8), and thereby a disruption of the system is initiated. The literature on resilience of social-technical systems suggests that in this response phase, three distinct phases can be distinguished (indicated at the bottom of Figure 8) (Shen et al, 2020; Poulin & Kane, 2021):

- **Resistance and robustness.** How severe are the disruptions given the severity of the event? How important are the losses?
- **Re-stabilisation.** How rapidly can we restore key functions of the system? Do we have sufficient capacity to cope and respond? How can we organise crisis management most effectively?
- **Reconfiguration.** What have we learned? How can we prevent future hazards from triggering harmful events? How can we embark on a more sustainable path?

Notably, the conventional response and resilience conceptualisations (as presented in Figure 8) have been developed for a single shock event that hits a specific sector or region, and from which the system then recovers. Protracted crises, such as the current COVID-19 pandemic, are characterised by a series of shocks and stresses that co-occur and interact. For instance, evidence suggests that the intersection of climate-related extreme events and the pandemic will amplify and be amplified by the economic crisis and existing inequalities within and across countries (Phillips et al, 2020). Because the situation is so dynamic, volatile, and complex, it requires a different approach to

7 https://www.un-spider.org/risks-and-disasters

management and decision-making. In the following chapters, we will specifically review transboundary and protracted crises (see section 1.4, p.30, for definitions).

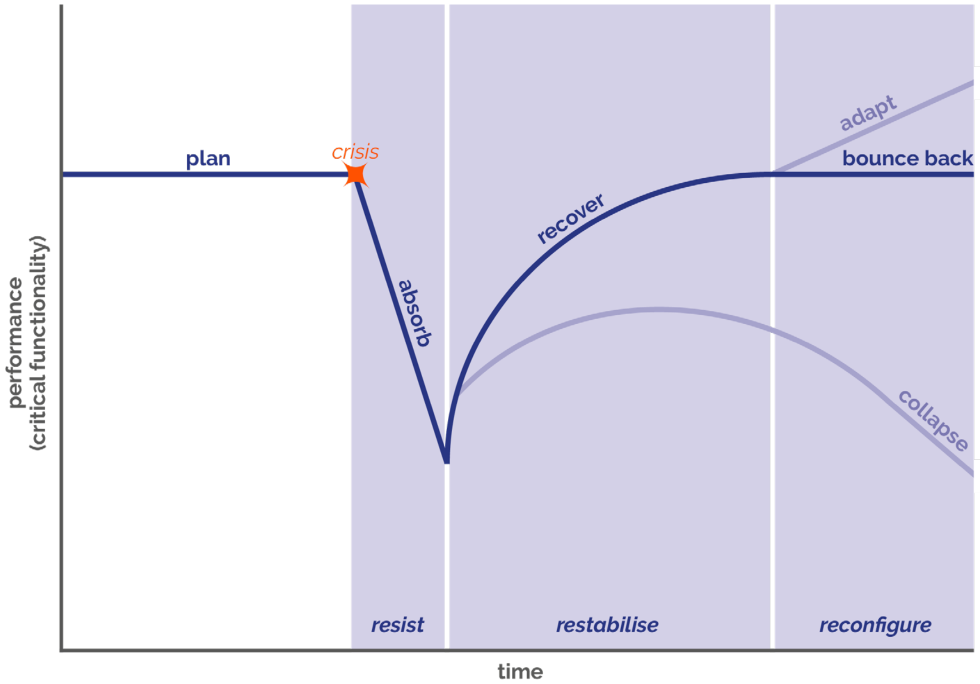

Figure 8. Relation of resilience, absorption, adaptation, and recovery
Adapted from Townend et al, 2021; reproduced from Linkov et al, 2014

Resilience

Resilience is a core concept in contemporary discussions about crisis management. It is also a concept that is used in very different ways. Here, we first provide some background on the most common uses of the term 'resilience'. After that, we provide concise definitions of the related concepts and terms.

The concept of resilience has been used in many disciplines to describe the ability to respond adequately and recover rapidly when the system is under stress (for an overview see Comfort, Boin & Demchak, 2010). The triple roots of resilience are in (social-) ecological systems (Folke, 2006; Holling, 1973), psychology and cognition (Fletcher & Sarkar, 2013), and engineered systems and infrastructures (Coaffee, 2008; Comes, Warnier, Feil, & Van de Walle, 2020b; Hollnagel, Woods, & Leveson, 2006; Woods, 2015). The phases of resist, restabilise and reconfigure (see Figure 8) correspond to the phases of the crisis management cycle from immediate response to recovery (see Figure 5, p.41). In (social-)ecological systems, resilience has been widely applied in ecological research to denote the resistance of natural ecosystems to cope with stressors (Holling, 1973). In engineering, resilience is focused on the ability and capacity of systems to resist shocks, to recover rapidly from threatening events, and to adjust to a new equilibrium (Comes et al, 2020b; Woods, 2015). This idea of resistance and recovery can also be applied to social systems (Adger, 2009; Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008). The main emphasis here is on organisational learning and institutional preparedness to cope with stress and disaster. The US Department of Homeland Security uses this definition:

> Resilience is the ability of systems, infrastructures, government, business, and citizenry to resist, absorb, and recover from or adapt to an adverse occurrence that may cause harm, destruction, or loss [that is] of national significance.
>
> *(cited after Longstaff et al, 2010, p.19)*

Hutter (2013) added to this analysis the ability of systems to respond flexibly and effectively when a system is under high stress from unexpected crisis. Drawing from an interdisciplinary body of theoretical and policy-oriented literature, Longstaff et al (2010) regard resilience as a function of resource robustness and adaptive capacity.

Notable divergences

- **Scope.** Resilience can be understood as an ability or capacity that is inherent in a system (Cutter et al, 2008; Pursiainen & Gattinesi, 2014) versus a process in which resilience is continuously built (Comes et al, 2019). Questions pertain to whose resilience it is and whose should be considered (Copeland et al, 2020; Meerow & Newell, 2019). For instance, the example of Hurricane Katrina shows that the reconstruction efforts have led to gentrification, even more than a decade after the hurricane hit (Van Holm & Wyczalkowski, 2019). While New Orleans may now be more resilient than ever before, the poor residents that were affected by Katrina may now be less resilient than ever.
- **Timeframe.** In the literature on crises and disasters, resilience is often understood as rapid recovery from a shock (Cimellaro, Reinhorn, & Bruneau, 2010; Comes et al, 2020b; Zobel & Khansa, 2014), while in social-ecological contexts, resilience is viewed as including adaptation, learning and re-organisation (Folke, 2006).
- **Normativity**, or the idea of resilience as an ideal to strive for. Resilience can be used as a descriptive term, primarily understood as the ability to rapidly recover. In policy contexts, it is also often used as a normative concept (something to strive to), such as the resilient city or state (Cutter et al, 2013). The governance framework suggested by the International Risk Governance Council (2017) depicts resilience as a normative goal for risk management systems to deal with highly uncertain events or processes (surprises). It is seen as a property of risk-absorbing systems to withstand stress (objective resilience) but also of the confidence of risk management actors to be able to master crisis situations (subjective resilience). Questions also pertain as to what is considered a key function of society, and by whom. For instance, the COVID-19 pandemic has brought important trade-offs to the forefront between immediate health-concerns related to the virus and economic prosperity, long-term wellbeing and education.

There are many attempts to measure resilience, yet with notable divergences between engineering (Bruneau, et al, 2003), social/community (Saja et al.,2019), urban (Meerow et al, 2016) and social-ecological (Salomon et al, 2019) resilience. In addition, current resilience measurement frameworks have been criticised for a lack of validation (using longitudinal data) and their inadequacy for following dynamic events (Jones, Constas, Matthews, & Verkaart, 2021).

There are important links between resilience and sustainability or sustainable growth, where crisis events are described as windows of opportunity to transformation (Elmqvist et al, 2019). This is especially relevant as urgent action is needed to address climate change, and as a rationale also underlies EU policy such as the European Green Deal or the COVID-19 Recovery and Resilience Facility. At the same time, there is also evidence that exposure to hazard does not lead to a change of policy (Nohrstedt, Mazzoleni, Parker, & Di Baldassarre, 2021; Tollefson, 2021), which urgently has to change if we would like to transition to a more sustainable future.

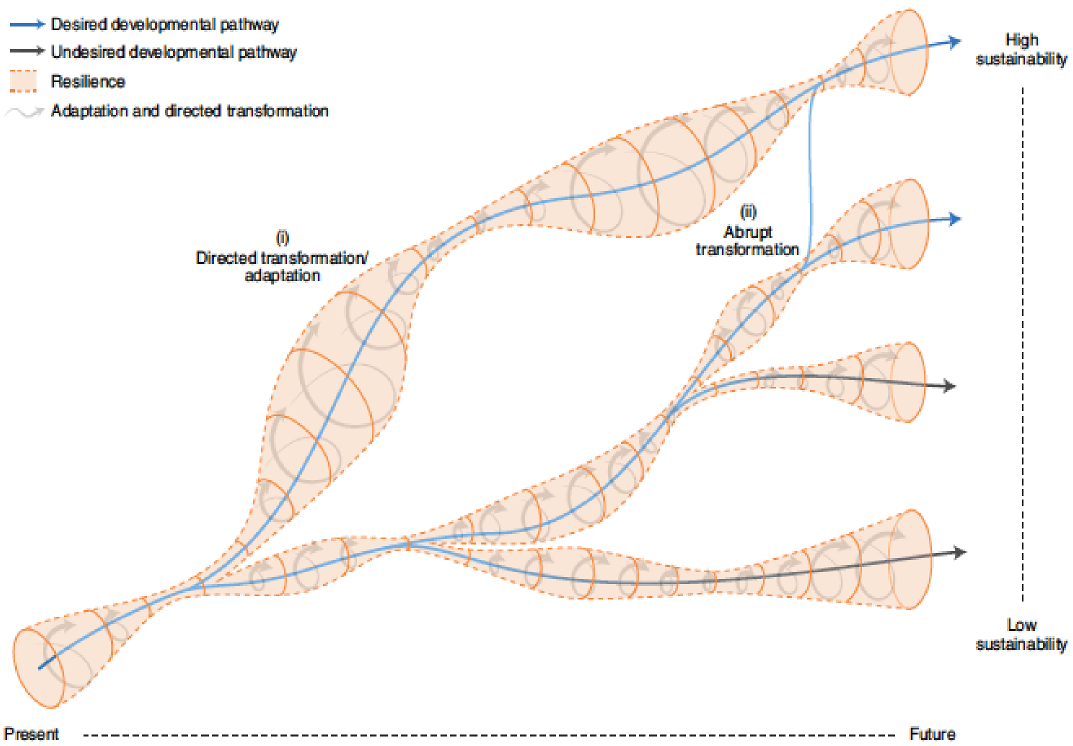

Figure 9. Relation between resilience, sustainability and transformation
Source: Elmqvist et al, 2019

Resilience needs to be understood within the constantly-changing dynamics of complex adaptive systems. Instead of having multiple stable states, complex adaptive systems may be described as having multiple possible development pathways or trajectories (blue lines in Figure 9; Elmqvist et al, 2019). Resilience is here understood as the capacity to adhere to, or simply strengthen, a specific pathway. In Figure 9, this is visualised as a tunnel surrounding a trajectory, where the width represents the tolerance of the system to external disturbances, experimentation, mistakes and errors, that is, the capacity to deal with uncertainties, to continue to develop while maintaining functions and to stay on the same trajectory. The width of the tunnel can be managed by applying resilience thinking and either widened to make sure a system stays on a desirable trajectory and allow for necessary transformations (adaptation and directed/facilitated transformation), or narrowed to facilitate a fundamental abrupt transformation to a more desirable trajectory. Directed transformation is here viewed as proactive and distinguished from adaptation viewed as being a more reactive response. Directed transformation is further distinguished from abrupt transformation by scale and abrupt transformation, representing a leap from one less sustainable trajectory to another that is more sustainable, made possible in cases when resilience is managed and reduced. The capacity to adapt and transform are key concepts of resilience thinking, but so far rarely treated together with sustainability, even though these concepts together can help us understand capacities needed to release lock-ins and create and embark on new desirable trajectories (Elmqvist et al, 2019).

Definitions and concepts

Resilience

- **Definition.** Resilience is the ability of a system to sustain or rapidly recover its key functions in response to abrupt shocks or chronic stresses through absorbing, responding to, recovering from, adapting to, or reorganising (see Figure 8).
- **Explanation.** Provided above.

Adaptation

- **Definition.** Adaptation is the process of adjustment to changing conditions including risks, crises and disasters.
- **Explanation.** In social systems, adaptation and adaptive behaviour seek to moderate harm or exploit beneficial opportunities. In environmental or engineered systems, human intervention may facilitate this adjustment. The European Commission's JRC (2017) defines adaptation in their resilience definition as 'adopting a degree of flexibility and making small changes to the system (adaptive capacity)' in contrast to the more transformative ideas in strands of the literature. This approach is central to the definition of resilience in social-ecological systems but is only rarely used in resilience engineering (and if so as the capacity to 'build back better'). Conventionally, adaptation is thought of as a long-term process, yet there are also many links to adaptive capacities (as in the capacities needed to adapt) and adaptation tipping points. Some authors have advocated recently for rapid adaptation for the resilience

of engineered systems as the ability in crisis situations to maintain function, based on ingenuity or extra effort (Wei, Chen, & Rose, 2020).

Absorption

- **Definition.** Absorption refers to the ability of a system to keep the same level of performance and service delivery (in terms of quantity, quality and equity) despite a disruptive event, using the same level of resources and capacities.
- **Explanation.** Absorptive capacity as the ability to withstand a shock and refers to the 'resistance and robustness' phase in resilience engineering (see Figure 8) (Klibi, Martel, & Guitouni, 2010; Markolf, Hoehne, Fraser, Chester, & Underwood, 2019).

Recovery

- **Definition.** The restoring or improving of livelihoods, economic, physical, social, cultural and environmental assets, systems and activities of a disaster-affected society or system.
- **Explanation.** The recovery process is both a phase of the crisis management cycle and included in the resilience process (Figure 8). In the context of resilience, a central measure is the speed of recovery.

  Maher et al, 2013 question the endpoint of the recovery, and highlight its inherent subjectivity. In economics and complex systems literature, it is often viewed as achieving a new steady state (Comes et al, 2020b; Wei et al, 2020). Yet in the context of policymakers and decision-making, conventionally fixed timeframes are used of approximately 6 months to several years, depending on the scale and magnitude of a disaster. Aldrich (2010) stresses the need to include social connections and community cohesion rather than the current focus on physical infrastructure and assets.

2.5. Integrated conceptual framework

After having provided the core concepts and definitions across all phases of the crisis management cycle, we present here a consolidated framework that highlights the interplay of risk, crisis and resilience. Figure 10 shows the integrated framework that we have been developing throughout this section.

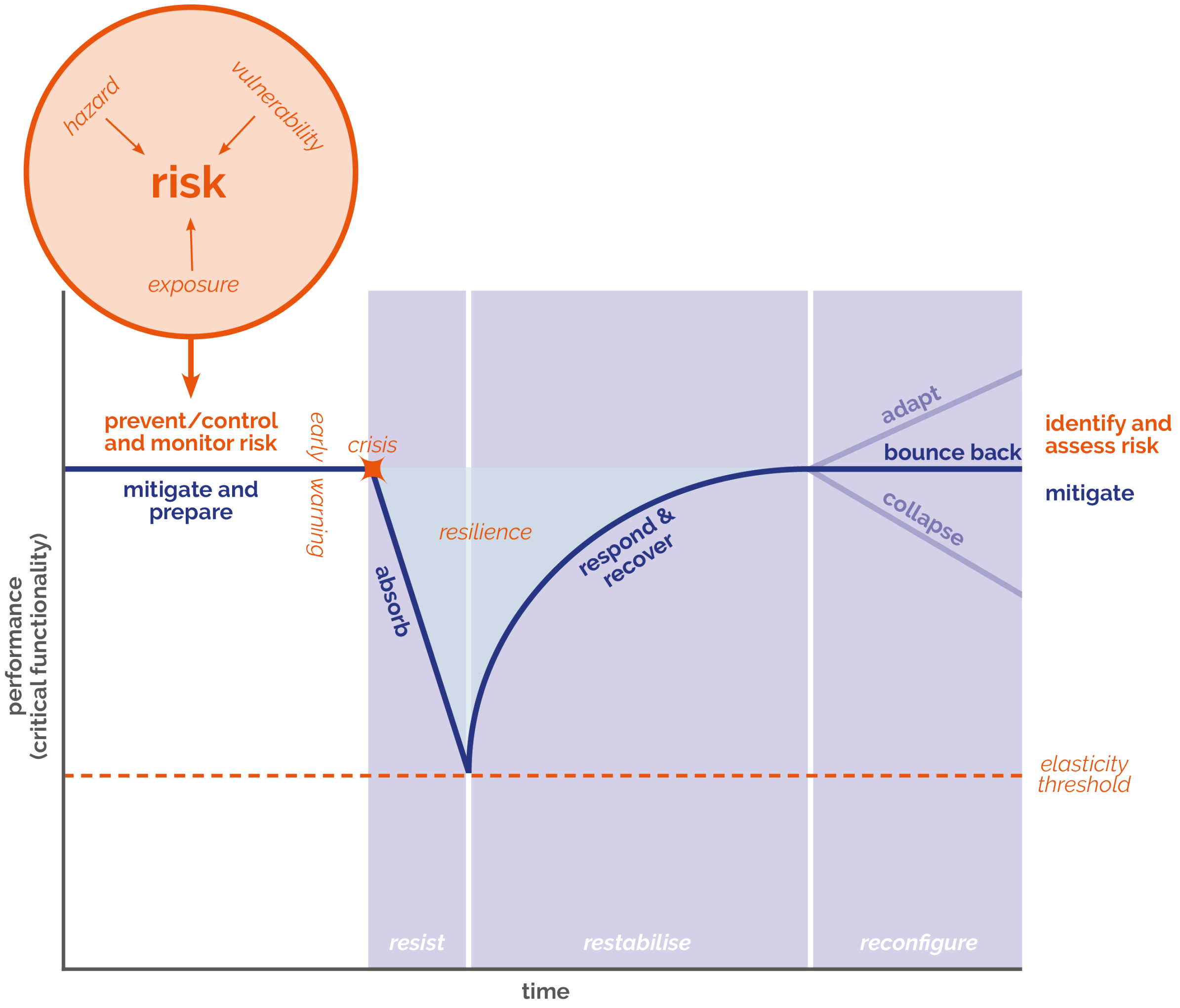

Figure 10. Integrated framework
Adapted from Townend et al, 2021; reproduced from Linkov et al, 2014

The dynamically evolving vulnerabilities in a society lead to increasing risk if they are left unattended. Here, the planning and preparedness phase of crisis management can focus on reducing vulnerabilities (e.g. by closing potential breaches in a dyke) and exposure (e.g. by avoiding settlements in low-lying areas) or reducing the probability of occurrence of a hazard.

When a shock event — an emergency, a crisis or a disaster — occurs, the crisis response phase starts. The initial shock will damage the lives and safety of people, and at the same time will lead to a drop in performance that is vital for crisis response, such as disrupted transportation networks, power blackouts, and impaired telecommunications. Depending on the scale and magnitude of the shock, and the buffer capacity and redundancies of a system, the shock can be absorbed completely or partially (e.g. a flood absorbed by a dyke or polders). In the subsequent phase, the system restabilises. The rapidity of recovery crucially depends on the capacity of the society, community, economy and environmental systems and institutions to adapt and reconfigure — which constitutes their resilience. Crises have been described as important moments of learning and transformation ('building back better') — and as such have been seen as an opportunity to adapt as large portions of the system have to be re-established. At the same time, there is also the risk of collapse and system failure, where the strain on the system is too high, and the initial damages cascade from initial damages throughout the socioeconomic-environmental systems (e.g. Haiti after the 2010 earthquake).

Two interrelated concepts that are useful to guide and improve crisis management are **response diversity** and **cross-sectorial resilience**. The need for response diversity reflects the socioecological and socioeconomic perspective on systems resilience. Central to this resilience lens is the notion of adaptation, by which the system adjusts and learns. We complement this evolutionary perspective with a resilience engineering perspective on cross-sectorial resilience which has its roots in the critical infrastructure resilience literature. This literature focuses more on planning and decision-making and stresses the need to create resilience by design.

The need for response diversity

Social-economic systems of different kinds have developed a variety of ways for providing essential services with differing coping capacities, such as diverse types of water storage and delivery infrastructure, modes of transportation, sources of various materials and products. Adaptive institutions provide a diverse repertoire of 'software solutions' for social organisation and thus maintain critical response diversity. Some of these strategies emerged after existing services had failed to respond to some new kind of shock; others were planned in advance.

The diverse ways in which the different kinds of actors (individuals, groups, species, etc) respond to a variety of shocks and the apparent redundancy, enables the function concerned to continue, thereby helping the system as a whole to continue functioning in much the same way, whatever shocks it might encounter. This is response diversity (Elmqvist et al, 2003), conferring resilience to disturbance and shocks.

Before the financial crisis unfolded in 2007–2008, individual banks pursued diversification as a strategy to cope with uncertainty (i.e. increasing their response diversity). However, since banks deployed similar risk management models, a homogeneity of responses was cultivated at the global scale (i.e. response diversity was eroded at a global scale), which had ramifications for the response of the sector as a whole (Haldane, 2009; Haldane & May, 2011). In general, increasing response diversity at one scale may occur at the expense of response diversity at another scale. It comes from a wish to dampen the negative impacts of local or short-run variability, which in the longer run and at larger scales may result in eroded resilience, in particular if many local systems copy each other and adopt a similar behaviour (Carpenter et al, 2015, Nyström et al, 2019).

Awareness of the vulnerability of global supply chains has been highlighted by the COVID-19 pandemic outbreak and in the example described in Box 1. Albeit different in their nature, they expose weaknesses such as global complexities and the 'just-in-time' approach. Although, in general, global supply chains so far seem quite resilient, these events have had impacts on people's livelihoods, food security and prices and other essentials due to transportation and logistical and knock-on effects (e.g. piling-up of shipping containers due to closed borders).

Box 1. The ship *Ever Given* and the Suez Canal blockage

On the morning of 23 March 2021, the giant container ship *Ever Given* was passing through the Suez Canal on its way to Rotterdam. At 7:40, near the village of Manshiyet Rugola, the ship was suddenly hit by strong winds and ran aground diagonally, blocking the entire canal. As the container ship was one of the largest in the world, with a length of nearly 400 metres (compared to a canal width of 205 metres and a gross tonnage of 220 000 tonnes, traffic was jammed in both directions for six days. Hundreds of vessels were at a standstill for these six days and billions of dollars' worth of trade were lost. Disruptions at bottlenecks like this can have major consequences for billions of people, enterprises and nations, in terms of food shortages, reductions in food quality, price spikes and volatility, lack of machinery and spare parts etc., due to knock-on effects on supply chains (Davis et al, 2021) with lost crops, famine, civil unrest and geopolitical conflicts as potential consequences.

Good preparation to avoid and respond to disruption is not just a matter of optimisation and engineering. It is also about examining the likelihood and potential impacts of a range of possible disruptions and then, based on knowledge and foresight about the system (cf. Chapter 7), planning and developing a diversity of different potential responses that can be mobilised if and when such disruptions occur. The current 'just-in-time' and 'efficiency' paradigms seem ill-suited in this regard as they are not designed to handle unexpected new situations, such as the *Ever Given* incident or the COVID-19 pandemic. Widening the Suez Canal would clearly increase the resilience of its traffic flow to incidents like the *Ever Given* but would be ineffective against other kinds of disruptions (political, armed conflicts, etc.) that interrupt traffic. Other kinds of responses might include increasing storage capacity at receiving ends of the traffic or diversifying how goods are transported (China's silk railroad, for example). Indeed, a wide range of potential options are currently available for responding to disruptions and escaping rigid structures, which in the long-term lead towards unsustainable and vulnerable pathways (Abson et al, 2017;, Westley et al, 2011). An overarching danger lies in failing to recognise, value and enable the opportunities this diversity of response options provides before they are lost (Walker & Salt, 2012).

Increasing awareness of all the uncertainties humanity faces has led to calls for building resilience, as evidenced by the increasing use of the term. In particular, it is about resilience to threats in general rather than to particular threats; and of the many kinds of attributes that confer such general resilience (Walker and Salt, 2012), the most crucial is having a diversity of responses to different kinds of threats or shocks. Though it has been recognised for a long time ("don't put all your eggs in one basket"), the rapid increase in frequency and severity of ecological, social and economic disruptions is emphasising its importance.

In conclusion, to address a variety of vulnerabilities to society and build resilience to all kinds of disruptions, which can never be exactly determined in advance, society needs to build its response diversity.

Box 2. Food systems, response diversity and EU policy initiatives

The 2022 war in Ukraine has impacted food security locally, nationally, and internationally. Humanitarian organisations have set up support to supply food to the currently estimated 11.6 million people who had to leave their homes.[8] Meanwhile, the supply shock of the war has led to skyrocketing prices, especially for cereal, oils and fats.[9] The potential shortage is further exacerbated by panic buying and irrational stockpiling of consumers, a well-known phenomenon from the COVID-19 and other crises (Billore & Anisimova, 2021). Internationally, and especially in Africa, the prospects are even more dire: both the Food and Agriculture Organisation's Cereal Price Index and the Vegetable Oil Price Index reached record highs in March 2022.[10] This global food inflation is a driver of socioeconomic fragility, especially in Africa where countries are highly dependent on food imports. These phenomena highlight once more the complexity of crises and their impact on different spatial-temporal scales. In this box, we review the current trends and developments of the global food systems, and the mechanisms and strategies the EU has in place to increase the sustainability and resilience of the food system.

The consolidation and homogenisation of actors in the global food system has led to a decrease in the diversity of practices, food cultures and ways to produce and consume food, resulting in a gradual loss of response diversity (Elmqvist et al, 2003) in different parts of the system (Kummu et al, 2020; Nyström et al, 2019). In global agriculture, crop portfolios have become more homogeneous in composition, shifting towards a globally standardised and increasingly animal-based food supply based on a few crop types such as maize and soybean, predominantly used for animal feed, and wheat and rice, predominantly used for human consumption (Nyström et al, 2019), and concentrated in a few regions in the world, of which Europe is one (Figure 11, p.58). International trade accounts for 24% of all agricultural land (Weinzettel et al, 2013), 23% of all freshwater resources used for food production, and more than 35% of global seafood production (FAO, 2018). This wide international trade network results in a spatial decoupling which allows industries to substitute supplies from different species or production ecosystems so that global consumers remain relatively unaffected by, and unaware of, changes occurring at individual source areas (see discussion in Nyström et al, 2019). Thus, at least initially, trade provides response diversity (Kinnunen et al, 2020) that enables buffering against disruptions by providing alternative food sources, backup distribution, or emergency supplies.

Over the past two decades, the number of regional trade agreements in force has more than tripled and Tu et al (2019) suggest that the resilience of the global food system

8 https://ec.europa.eu/echo/where/europe/ukraine_de

9 https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/commodity-price-dashboard_2022-03_en.pdf

10 https://www.fao.org/worldfoodsituation/foodpricesindex/en/

has declined over the past decades because of the trade-induced increased interconnectedness and reduced modularity. They argue that, owing to the structural characteristics of the food trade network, additional trade links may well further erode the resilience of the global food system. Indeed, despite efforts to maintain high and predictable yields, food production shocks have become more frequent over the past 50 years at a global scale, both on land and in the sea (Cottrell et al, 2019). The very same policies that increase national food security may therefore at the same time cause global food security crises (Nyström et al, 2019). Recently, such global-level disruptions were caused by, and experienced early on in, the COVID-19 pandemic (Laborde et al, 2020).

The EU is the world's biggest exporter and third largest importer of agri-food products and seafood (European Commission, 2021) and thus a major player in the global food system. The European Commission has recently outlined its intention to come up with a sustainable food system[11] framework initiative. More recent developments including the war in Ukraine has led the Commission to publish a communication on food security and resilience of food systems, which maintains the overall aim to transition food systems into sustainability, but introduces short term measures to ensure sufficient food production and prevent trade distortion in affected areas.

The Farm-to-Fork Strategy has announced the adoption of a horizontal framework law, so as to accelerate and facilitate the transition and ensure that foods placed on the EU market increasingly become sustainable. This EU-level intervention aims to establish new foundations for future food policies by introducing sustainability objectives and principles on the basis of an integrated food system approach.

However, the overall EU food system is characterised by different approaches at EU, national and sectoral levels with respect to different sustainability aspects. Where sustainability aspects are addressed at those different levels, they often lack a common approach and are not always comprehensive. This results in divergences, inconsistencies and even some gaps, jeopardising the achievement of the European Green Deal and Sustainable Development Goals. Consequently, there is a significant risk that a number of concrete and well-known problems will persist also given the current dynamically developing context.

A proposal for a Regulation is due in 2023. The intervening time provides an opportunity to prepare a realistic and holistic proposal, applicable in the global and divergent fast-paced setting, addressing the current imminent needs, but also ensuring achieving the longer-term vision of the Green Deal and Farm to Fork Strategy. The EU should consider that all policy development and implementation should be made in a global food system context and that measures taken in Europe should avoid leading to exporting negative environmental externalities to countries outside the EU.

11 The European Commission's Scientific Advice Mechanism defines a sustainable food system as a system that "provides and promotes safe, nutritious and healthy food of low environmental impact for all current and future EU citizens in a manner that itself also protects and restores the natural environment and its ecosystem services, is robust and resilient, economically dynamic, just and fair, and socially acceptable and inclusive. It does so without compromising the availability of nutritious and healthy food for people living outside the EU, nor impairing their natural environment" (SAPEA, 2020).

A future EU sustainable food system should represent a shift away from a dominant focus on the volume of food produced to the nutritional and environmental quality of food; this will require a holistic food system approach (SAPEA, 2020; EASAC, 2022).

However, the Ukrainian crisis also stresses the importance of being aware of global supply chains, as well as localisation of and diversity in food production systems. The trade-driven breakdown of local and national farm-to-table links, with an increasingly urban population, has resulted in substantial impacts on regional and national production diversities (e.g. Elmqvist et al, 2021). Of importance is to understand that there exists parallel processes of both diversification and homogenisation of agricultural production within countries (Aguiar et al, 2020). The recent discourse on localising food for dietary diversity and food system resilience is probably based on a yet-incomplete understanding of the dynamics of food and production systems. However, it is very clear that the trend of uniformity of diets towards a 'global diet' drives export-oriented agribusinesses towards simplification, monocultures, and homogenisation of agricultural landscapes and farming systems, with declining resilience in the food system as a result (EASAC, 2022).

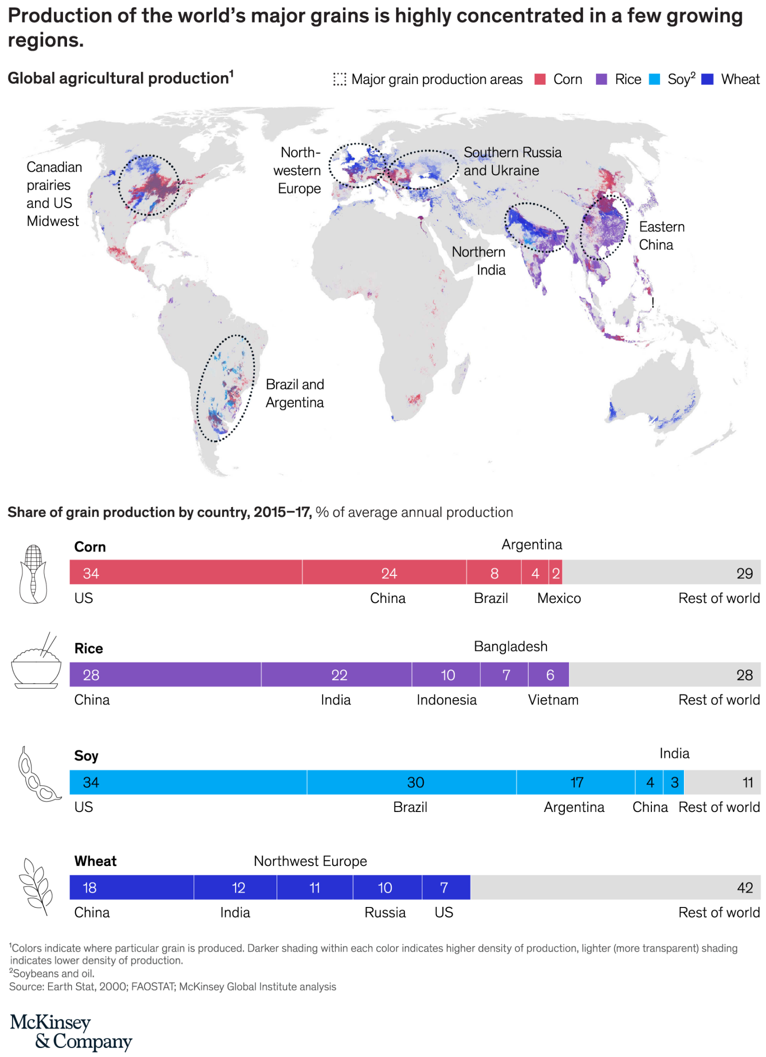

Figure 11. Global agricultural production of four major global grain staples
Source: McKinsey Global Institute 2020

The need to improve cross-sectorial resilience

The food system is only one of the critical infrastructure systems that are vital for the functioning of our societies. In Europe, the European Programme for Critical Infrastructure Protection and subsequent initiatives like the Critical Infrastructure Warning Information Network. as well as the European Reference Network for Critical Infrastructure Protection, establish the overall framework for the activities around the improvement and protection of critical infrastructure (see Box 3). However, since the focus is on protection and prevention, resilience, especially cross-sectorial resilience, is not (yet) embedded as a core design principle and standard, even though there is evidence that it is be economically beneficial to invest in critical infrastructure resilience (Hallegatte et al, 2019).

Generally, one can distinguish networked infrastructures (such as energy supply; transportation; or information and telecommunication) and services (such as governance, health care, or finance). Crucially, infrastructure services combine the physical assets or the technical system (such as a roads, trucks or energy networks and oil) with the social system that govern, manage, provide or use the technical infrastructure, e.g. via the capacity to provide the service (via drivers or operators). For instance, evacuations in Hurricane Katrina failed, even though there was sufficient transportation capacity. Yet as drivers had been denied the right to take their families onboard, there was a shortage of people that were able and willing to drive the buses (Nigg et al, 2006).

Box 3. Infrastructure resilience

EU communities are served by physical systems (e.g. the electric power network, the railway transportation network, the water distribution system, the gas distribution system, the telecommunications network, etc.), which constitute the backbone of activities and operations, and are interconnected and interdependent (for instance, the banking telecommunications information system depends on the electricity infrastructure). To achieve risk mitigation and community resilience, this system-of-systems organisation requires high interdisciplinarity, and the development and deployment of knowledge, skills and technologies for the security of the physical environment.

For the resilience of such transnational critical infrastructures, the EU must drive and monitor at national level the effective implementation of international policies and directives in the field of Disaster Risk Management. This, of course, corresponds to the directions taken with the Sendai Framework for Disaster Risk Reduction (2015–2030), the European Programme on Critical Infrastructure Protection, the EU Climate Adaptation Strategy, EU environmental policies (e.g. Seveso III Directive, Flood Directive), the EU Chemical, Biological, Radiological and Nuclear Action Plan, and Explosives Action Plan. This needs to be done in light of the Sustainable Development Goals, and in particular 'A low-carbon and greener Europe', which dedicates specific attention to the themes of risk prevention and loss reduction. These themes are also included in the *Promoting our European way of life strategy*, among the main investment objectives. In this context, investments aimed at increasing resilience of critical infrastructures (and urban systems) are needed, also to respond to the range of natural risks linked to climate change.

The main attributes to be considered in the issue of infrastructure resilience are:

- intrinsic vulnerability of systems due to deterioration
- multiplicity of natural and anthropogenic hazards
- imperfect or incomplete knowledge (i.e. uncertainty) of hazardous events and their impact
- robustness and repairability/maintainability

Furthermore, the main intrinsic complexities of network structures, infrastructures and systems must be recognised, deriving from:

- multiplicity and heterogeneity of elements (hard-humanware and cyber-humanware) and technologies
- dependencies and interdependencies
- spatial extension of the systems and the consequences of possible disasters, potentially intersectorial and transnational (e.g. domino and cascade effects)
- evolution over time and residual useful life
- limited availability of economic resources for security and resilience
- comparability of risks resulting from different hazards
- rapid technological evolution (e.g. energy transition)

Some specific needs and issues of particular importance emerge for the resilience of critical infrastructures in EU countries, namely: multi-hazard and multi-risk assessment, analysis of complex and interdependent systems, strategies for the mitigation of consequences and awareness and preparation for community risks. Analysis and evaluation tools must be researched, developed and deployed considering the opportunities coming from digitalisation, smart materials, smart cities, smart grids, smart systems, data science, big data, machine learning, situation awareness, remote metering, fault diagnosis, robotics and drones, and the Internet of Things. The definition of objective and shared metrics, based on economic, temporal and social factors, is fundamental in the design phase of both new actions and intervention on existing ones, to guide the choice between different possible solutions and to compare the resilience solutions of different systems that perform the same functions.

In general terms, the impact expected from a resilience-based development and operation of the critical infrastructures in the EU would be:

- Losses from natural, accidental and manmade disasters are reduced through better societal resilience and improved disaster risk management.
- Resilience and autonomy of physical and digital infrastructures are enhanced and vital societal functions are ensured with the help of modern technologies, as well as better cooperation between stakeholders.
- Security threats are more effectively addressed thanks to better cross-cutting knowledge across different areas of risk, resilience and security assessment and management. They need to take into account that such threats are purposeful and adaptive (war, cybersecurity, terrorism,...) and require tools from game theory, adversarial risk analysis, etc.

For this positive impact to be realised, a systemic approach needs to be adopted in the design phase, then managed and maintained in an operational state throughout the life cycle. The multiple dangers, current, emerging and future, of both natural and anthropogenic origin, which threaten the safety of communities due to the individual and systemic vulnerability of structures, infrastructures and networks at a national and supranational scale, must be considered. Methodologies must be developed that take into account the characteristics of complexity and interdependence of these systems, which make them systems of heterogeneous systems, with physical, cyber and human components that interact and that can lead to a cascade propagation of failures, damage and losses. In this context of complexity, with systems that age and degrade, accurate models must be developed to evaluate the effects of the phenomena that expose structures, infrastructures and networks to risk, as well as to describe their resilient response taking into account uncertainties. Stochastic, topological and logical system and process simulation models must be developed to predict the occurrence and consequences of events (including extreme ones) that damage the integrity of structures, infrastructures and networks and to holistically analyze the resilient response to the crisis considering all the technical, economic and social aspects involved. It is also necessary to develop patterns of human and social behavior that can have a mitigating or aggravating effect. Furthermore, the need for harmonious and sustainable economic development make it a strategic objective for the EU to maintain the efficiency and security of networks and critical infrastructures (energy, telecommunications, transport, supply chains). This requires the optimisation of economic efforts for ordinary/extraordinary intervention programmes and, crucially, tools for the rapid assessment of the state of security, especially after disasters (including criminal ones), but also for continuous monitoring of integrity during operation. It appears important to provide in a very short time scenarios of possible spatial distribution of the impact, direct and indirect (cascade effects) of unexpected events, developing advanced models for the quantification of hazard, exposure and vulnerability. Similarly, considering the size of the problem in Europe, systems for real-time risk reduction must be developed through the reduction of exposure (e.g. early warning systems), which in some cases may represent a sustainable alternative (or be complementary to) traditional solutions. These more traditional solutions are essentially based on the reduction of vulnerability, and are more onerous and longer to implement. Finally, metrics must be defined to quantify the risk and monitor the degree of security that allow management systems to make decisions in ordinary and emergency conditions.

To ensure the cross-sectorial resilience of critical infrastructures understood as social-technical systems against different types of shocks and stresses, there is a series of design principles that have been suggested in the literature:

- **Buffer capacity** and **redundancy** (Biggs et al, 2012; Brown et al, 2017; Shen et al, 2020) to ensure that any shortages or disruptions of supplies or infrastructural elements do not lead to immediate disruptions of the service. Buffer capacities include stockpiles of vital supplies ranging from food and fresh water and medical supplies to oil and gas. Redundancies refer to capacities that allow for systems to function even though a specific element or line has been disrupted — for instance, in terms of energy lines or road segments.

- **Diversity** has already been discussed in 'The need for response diversity', p.54, but for critical infrastructure it refers to spreading the risk by having a variety of options (Farrell et al, 2004). Examples are multiple sourcing from different suppliers in different geographical regions to avoid simultaneous impacts, or a diversified portfolio of sources for electricity.
- **Flexibility** as the ability to act upon better information versus creation of path-dependencies and lock-ins (Rosenhead, 1980; Baharmand et al, 2019). The concept has already been introduced in Chapter 1, but in the context of infrastructure often also relates to multi-functionality of amenities, (manufacturing) capacity or public spaces and adaptivity (see Chapter 1).
- **Robustness** as the ability to withstand a shock includes protective measures such as 'winterisation' or flood proofing of assets and infrastructures (McPhail et al, 2018). Especially for frequently re-occurring and predictable risks (such as seasonal flooding or wildfires), increasing robustness has been a successful strategy. However, in the case of extreme and outlier events, systems that are robust against smaller events yet have a reduced flexibility may suffer from catastrophic losses.
- **Multi-scalarity** and **self-organisation** are two fundamental principles of complex social-technical systems. Multi-scalarity is especially used in urban contexts (e.g. Palazzo, 2019) and refers to the interdependence of different spatial scales — local, regional, national, and international levels. Here, it is vital to take into account the interdependencies and to coordinate across spatial scale.
- **Self-organisation** refers to the ability of the social-technical system to adapt and respond with limited external intervention (Comes, 2016). Examples range from volunteering in flood-ridden areas of the Ahr river, citizen initiatives in the COVID-19 response, to the support for refugees from Ukraine. Importantly, self-organisation in crises will occur, yet is often ad-hoc, and disconnected from the professional and institutional response system (Nespeca et al, 2020). Therefore, appropriate mechanisms are needed to coordinate, connect, support and manage the interplay of both the volunteer and the institutional system.

While conventionally, critical infrastructure resilience focuses on single infrastructures such as food, energy or health, we observe increasingly that shocks ripple through interlaced infrastructure systems. These cascading effects call for intersectorial approaches to strengthen resilience. Importantly, the indirect damages create business interruptions and 'domino effects' that often exceed the direct impacts (Merz et al, 2013; see Box 3, p.59). For instance, the war in Ukraine already threatens our energy supplies and cybersecurity. At the same time, the price spikes for wheat and other commodities threaten food security for many, especially in the Global South (see also Box 2, p.56). The long-term economic impact of the sanctions and subsequent high inflation is still highly uncertain, even though Eurostat decreased its GDP growth projections in March 2022.[12]

While the events in Ukraine are still unfolding, there are important lessons to be learned from the COVID-19 pandemic. The initial public health crisis quickly cascaded through virtually all sectors with important economic and social consequences. Non-pharmaceutical interventions such as lockdowns, export and travel bans quickly led to a sharp decline in mobility, electricity usage and economic activity (Chen et al, 2020; Demürguc-Kunt et al, 2020). At the same time, border controls, trade and travel bans in combination with a lack of workforce (Nikolopoulos et al, 2020) and severe business disruptions created severe disruptions of globalised supply chains (Guan et al, 2020). In turn, this led to a rapid decline in productivity and GDP (Jena et al, 2021), while also creating shortages of the medical supplies that were desperately needed to combat the pandemic (Falgara Sigala et al, 2022).

Lockdowns and interventions to protect public health also led to an increasing volatility on the labour market (Su et al, 2021), giving rise to increased gender inequality (Reichelt et al, 2021), higher unemployment and a decline in purchasing power (Almeida et al, 2021). Only policies aimed at protecting those most hit by the crisis could partly reduce the roll, in the form of either discretionary measures (e.g. income subsidies), or automatic stabilisation (e.g. unemployment benefits or lower taxes paid as a result of job loss or decrease in market incomes) (Almeida et al, 2021).

Crucially, these examples demonstrate that isolated approaches trying to manage only one aspect of the complex system, such as health in the COVID-19 pandemic, always fall short, as they fail to address the many feedback loops. Furthermore, time delays in detecting the rise of infections delay response even more — even though several authors confirmed that early interventions were both more effective and better for the economy (Demürguc-Kunt et al, 2020). For COVID-19, data on positive virus tests and hospital or intensive care admissions were only available weeks after the actual infections and only represent a small portion of infections. This is not atypical for epidemics: in the West-African Ebola Outbreak in 2014, decision-makers indicated they knew "too little, too late" (Comes et al, 2015), resulting in delayed and ineffective response.

To manage these cascading effects, an important first step is mapping and analysing the critical dependencies between different sectors and socioeconomic-environmental systems (Comes & Van de Walle, 2012). For critical infrastructures, most common approaches focus on identifying interdependencies at a structural level (Rinaldi et al, 2001), or simulating and modelling how the impacts affect different infrastructure systems (Ouyang, 2014). For supply chains and economic analyses, conventionally,

12 https://www.ecb.europa.eu/pub/projections/html/ecb.projections202203_ecbstaff~44f998dfd7.en.html

macro-economic input-output (Kunz et al, 2013) or general equilibria models are used (Ma & Chen, 2022). Yet to expand from there, we also need to predict and integrate the continuous dynamics and adaptation at the micro-level in coupled socioeconomic and technical systems that consider shifts in human behaviour, the decision-making process, governance arrangements, economic adaptation, and environmental consequences.

In order to address the results of the detected interdependencies, risk management and crisis governance have to be adjusted to take into account the effects across sectors and disciplines. While deep domain knowledge is needed to manage intra-sectorial problems that pertain to health, energy, food, cyber etc., a coordinating instance is needed that informs the respective actors of the plans and challenges; and allows us to monitor, forecast, and mitigate any repercussions that result from measure taken in one sector for another.

3. The EU as crisis manager: an overview of competences and capacities

3.1. Summary and key messages

This chapter reviews existing evidence that can help answering some aspects of the following questions in the scoping paper:

> What new EU-level policy would have the most added value, for which types and sources of threats (e.g. climate-, health-, security-related; for which stages of crises (e.g. prevention, preparedness, response, recovery); for which time scales (e.g. short-, mid-, long-term)?
>
> What are the differences and commonalities between crisis management mechanisms in member states, and at lower levels of government, including science advice to policymaking in crises? How do they affect crisis management at the EU level?
>
> What [more] could the EU do — while respecting subsidiarity — to support crisis management at these levels for major cross-border and/or transboundary threats, including the support for cross-sectoral resilience?

The chapter reviews the competencies and capacities that the EU has in place to manage the variety of crises it is confronted with, and an appraisal of this evidence is offered at the end of the chapter.

The chapter first reviews evidence on the types of crises for which the EU has competency to act. It starts by recalling that the EU was not created to manage crises, and that the need for this particular role is a relatively recent development. The EU's competence as a crisis manager has grown gradually over the years, adjusting to new needs and types of crises, and it is mainly spread across different sectors (civil protection, terrorism and cybercrime, health, critical infrastructure, environment). National security always remains the sole responsibility of each member state. While it is close to impossible to review all member states' crisis governance systems, authors have observed commonalities and differences between definitions used, governance systems, administrative structures or approaches, that make it very challenging to formulate directives or mechanisms that would apply to all member states. However, member states have granted a role to the EU in that respect.

We then review the capacity that the EU has in place to support and coordinate member state activities in the realm of risk, disaster, and crisis management. The EU has developed significant capacities, but it is somewhat scattered. In general, these capacities are not designed to 'manage' a crisis, but rather to inform management about unfolding threats (including the anticipation of risks) and coordinate member state response efforts. The actual management of crisis and disaster remains largely a member state responsibility. We provide an overview of the most relevant EU capacities:

- **Capacities to assist the member states overwhelmed by disaster or crisis:** An overwhelmed state may request help from member states through the European Commission's Civil Protection Mechanism. This mechanism has evolved and been significantly strengthened since its inception in 2001, from a focus on information exchange to the reinforcement of risk assessments, planning, and humanitarian aid under the Directorate General for European Civil Protection and Humanitarian Aid Operations. The example of the fight against forest fires is presented in this section. However, this mechanism is not used very frequently, and when it is used it is not always very effective.
- **Capacities to manage transboundary crises.** In an increasingly interconnected world, EU member states as a whole have become vulnerable to shocks that may undermine their functioning. In response, the EU has strengthened these particular crisis management capacities, but mostly sectorally. The EU has also developed a large number of early warning and information management systems. The European Commission's systems and network monitoring instrument ARGUS has been established but remains under development. The Council Presidency's Integrated Political Crisis Response was established in the early 2000s to coordinate the political response of the member states, to achieve effective management of cross-border crises. This mechanism has been fully triggered at least three times since 2015. There are many sectoral transboundary management capacities, and two sector examples are presented here: cybersecurity and health security.
- **Capacities to assist with crises outside the EU.** The EU has traditionally assisted countries and regions outside the Union that suffered from natural disasters, and more recently from non-disaster crises. The Civil Protection Mechanism was made available to facilitate the response and has undertaken many such missions. These capacities are largely organised under the Council and the European External Action Service of the European Commission. A move towards a more integrated approach occurred from 2016 onwards with the EU Global Strategy followed by a Joint Communication recognising the need to move away from crisis containment to a more structural, long-term, non-linear approach to vulnerabilities, with an emphasis on anticipation, prevention and preparedness.

In recent years, the EU has continued to invest in enhancing its crisis management capacities in different sectors, showing the growing ambitions of the EU in the security and foreign crises area.

Based on available evidence presented, this chapter offers the following conclusions:

- Over the years, the EU has built an array of tools that can be used to collect, analyse and share critical information; warn member states about impending threats; and organise a joint crisis response.
- The responsibility for managing risks, crises and disasters remains with the member states. There is no drive to centralise power in EU institutions to manage crises (except in the realm of financial risk and crisis management). The EU has limited formal competencies. The EU can only assist if member states request assistance and/or agree to a joint initiative.
- The EU's capacities have been developed with different types of crises in mind: the overwhelmed member state (typically by natural disaster), the transboundary crisis, and the crisis outside EU borders. Each of these crisis types has led to policy developments initiated by different Commission Directorate-Generals. Over the years, bridges have been built to connect these capacities. The traditional Commission-Council divide has been bridged by deepening cooperation between the Emergency Response Coordination Centre (ERCC) and the Integrated Political Crisis Response (IPCR) mechanism, for instance.
- The emphasis in the development of risk and crisis management capacities tends to lie with the aims of enhanced information management, risk detection and the communication of early warnings. The EU has been quite successful in this regard. Given the rise of systemic, interconnected and transboundary crises, it makes sense that the EU continues to invest in information-based tools and capacities.
- The EU continues to develop its capacities: each crisis experience leads to new initiatives. There appears to be public support for a strengthened role of the EU in the risk and crisis management domain. The rise of transboundary crises may indeed fuel expectations.

3.2. For which types of crises does the EU have competence to act?

The EU was, of course, not created to act as a crisis manager (Boin et al, 2013). In its beginnings, the European Community was intended to prevent war by integrating industries and enhancing trade between the member states. The Community did have mechanisms to resolve conflicts, but there were no mechanisms that would allow it to help manage disasters or any other sort of crisis. The main competence to prepare for, respond to, and recover from crises has traditionally rested with the member states.[13]

13 An exception, at least theoretically, is the Euratom Treaty of 1957.

The EU as crisis manager

Since the 1980s, the EU has gradually developed a suite of capacities and mechanisms that aims to support member states in managing crises.[14] In this chapter, we briefly describe the crisis types for which the EU has competence to act. We describe the various crisis management capacities that the EU has developed over time and provide examples of specific instruments. We then discuss where gains are most needed and can be implemented most easily.

Since the EU was not created to manage crises, member states never had to take into account guidelines or regulations for crisis management arrangements. National security remains the sole responsibility of each member state, as set out under Article 4 of the Lisbon Treaty. It is therefore only logical that member states have developed very different crisis governance systems. This variance applies to cultures, norms, policies, and structures (Kuipers et al, 2015; Bossong and Hegemann, 2015). Comparative research into crisis management systems across Europe offers the following observations:[15]

- On an abstract level, most countries appear to work with a basic shared understanding of what constitutes a crisis. At the legal and policy level, however, European countries use rather different definitions.
- Most crisis governance systems are primarily civilian, which reflects the wider structural transformation of civil defence systems since the end of the Cold War. Yet the involvement of the military varies widely across member states.
- The administrative crisis management structures vary from decentralised, to rather decentralised, and centralised. Decentralisation appears most established in central and northern European countries (see for example, the Finnish example on p.229), whereas many 'new' and candidate countries in South-Eastern Europe and the Baltic region have a higher propensity to adopt centralised models. These crisis management structures also vary depending on the general administrative structure of each country.
- The majority of countries display a combination of multi-hazards and specific threat approaches.

These findings suggest the challenge that EU initiatives face with regard to formulating directives or mechanisms that would apply to all member states. Member states work with different definitions, different structures, and different key actors. It is hard to imagine a single best or 'one-size-fits-all' model for civil security that would be acceptable for all member states.

14 These capacities were not always dressed in the language of 'crisis', a term that was traditionally reserved to describe emerging military conflicts.

15 The findings are drawn from the FP7 ANVIL project (Analysis of Civil Security Security Systems in Europe). See https://cordis.europa.eu/project/id/284678.

Nevertheless, the member states have granted a role to the EU with regard to the development of risk and crisis management capacities.[16] All member states agree that risk assessments are an important tool and could constitute a basis for further EU cooperation. The EU has been granted a role in reviewing national risk assessments and suggesting improvements. More recently, the EU has adopted resilience as a blanket strategy to enhance societal preparedness for crises and disasters.[17] The financial crisis that affected the EU and its member states for years since 2010 and the COVID-19 pandemic that began in 2020 have demonstrated that member states must be prepared to cope with crises that can threaten the viability of state institutions and structures.

The adoption of the Lisbon Treaty ushered in critical steps (Boin et al, 2013; see also Box 4):

- The so-called Solidarity Clause prescribes that member states "shall act jointly in a spirit of solidarity" and "assist each other in the event of a natural or manmade disaster".[18]
- The European External Action Service developed capacity to facilitate a joint response to crises that happen outside the Union.
- The European Commission's Directorate General for Migration and Home Affairs has been developing policies on internal security.
- The EU now has a Commissioner for Crisis Management, responsible for the EU's Emergency Response Coordination Centre.

Box 4. Examples of the EU's growing competence as a crisis manager

According to the Lisbon Treaty, the European Union shall provide "ad hoc assistance and relief and protection for people in third countries who are victims of natural or manmade disasters" (Article 214) and "encourage cooperation between member states in order to improve the effectiveness of systems for preventing and protecting against natural or manmade disasters" (Article 196). In addition, the European Union must act in a spirit of solidarity (Article 222).

The Union Civil Protection Mechanism (UCPM) is the overarching coordination mechanism, established by decision no. 1313/2013. The UCPM has been amended several times, the latest in 2021, and now comprises of a wide range of different response and coordination initiatives. The European Council, with reference to Article 122, adopted a regulation providing economic emergency support within the Union (Regulation (EU) 2016/369).

16 For a theoretical discussion of the mechanisms that have given rise to the growing role of the EU in the arena of risk and crisis management, see Boin et al (2013) and D'Erman and Verdun (2018; 2022).

17 https://www.consilium.europa.eu/en/policies/eu-crisis-response-resilience/

18 Article 222, Treaty on the Functioning of the European Union. For an analysis of the Solidarity Clause, see Myrdal & Rhinard (2010).

A vast number of sector-specific and hazard-specific competences, mechanisms and institutions to manage, coordinate and prevent crisis exist in addition to more general competences:

- The Union's law enforcement agency, Europol, holds a particular mandate to prevent and combat terrorism and cyber-crime affecting two or more member states (cf. Regulation (EU) 2016/794 on the European Union Agency for Law Enforcement Cooperation (Europol) art. 3).
- Within the health sector, the European Centre for Disease Prevention and Control (ECDC) is responsible for protecting human health through, among other things, the prevention and control of human disease (cf. Regulation (EC) No 851/2004 establishing a European Centre for Disease Prevention and Control, Article 3). In response to COVID-19, a new emergency preparedness institution was established, the European Health Emergency Preparedness and Response Authority, with the purpose to "strengthen Europe's ability to prevent, detect, and rapidly respond to cross-border health emergencies".
- Critical infrastructure is addressed by the 2008 Directive on European Critical Infrastructures, setting out a procedure for the identification and designation of European critical infrastructures. Within this broader category of infrastructure regulation, a number of more specific responsibilities are to be found, including railways (e.g. Directive 2008/68/EC on the Inland Transport of Dangerous Goods), roads (e.g. Directive 2008/96/EC on road infrastructure safety management) and rivers (e.g. Directive 2007/60/EC on the assessment and management of flood risks).
- The Union has competences in terms of environmental threats. The Habitat directives in combination with Natura 2000 set out to prevent harmful development. A number of regulations specifically set out hazard-specific responsibilities in relation to floods (the flood directive under the EEA), forest fires (Regulation (EEC) No 2158/92 on protection of the Community's forests against fire), and, increasingly, climate extremes.

3.3. What capacity does the EU have in place?

The EU has built significant capacity to support and coordinate member state activities in the realm of risk, disaster, and crisis management. Available capacities and policies for various crisis types are scattered, but when viewed as a whole, they are rather detailed. For a first impression, see Boin et al (2013); Boin, Rhinard, et al (2014); Widmalm et al (2019).

In general, these capacities are not designed or useful to manage a crisis. The management of crisis and disaster remains a member state responsibility (with an exception of financial crisis management, which has increasingly become an EU responsibility). A common thread among the various mechanisms, regulations and practices is the strong emphasis on information management (collection and analysis), anticipation of risks and crises, and early warning systems (Boin, Ekengren and Rhinard, 2014). The underlying idea is that shared information leads to shared awareness, which facilitates a coordinated (joint) response.

We present an overview here of the most relevant capacities, organised in accordance with the domains in which they predominantly apply:

- capacities to assist a member state that is overwhelmed by disaster and requests assistance from other member states
- capacities to coordinate the response of member states to a transboundary crisis that unfolds within the European Union
- capacities to coordinate the response of member states to crises and disasters that occur outside the European Union

Figure 12 represents these capacities. The grey arrows signify previous influences or legacies.

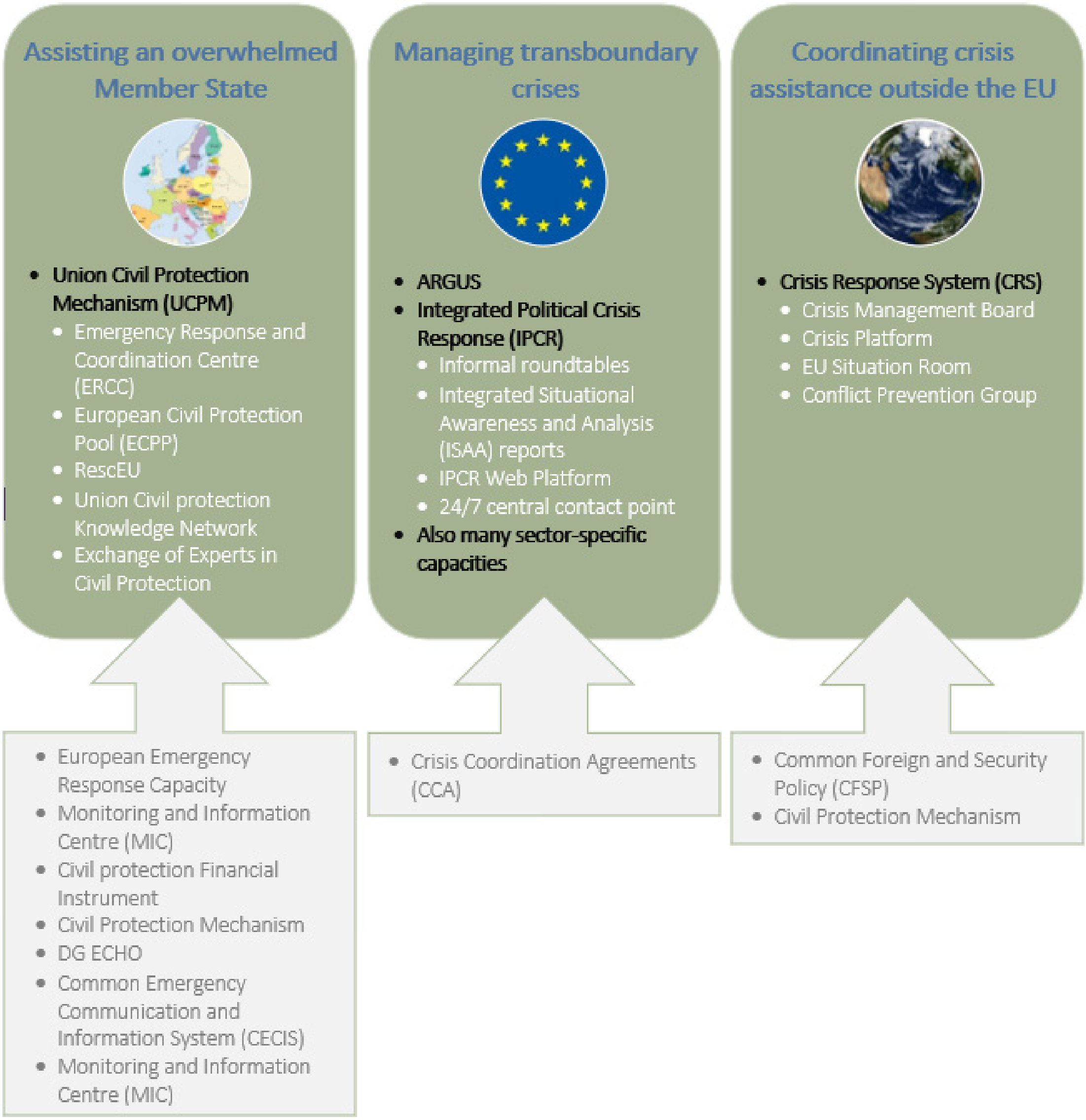

Figure 12. EU crisis management capacities
Authors: Lavinia Cadar, Arjen Boin

Capacities to assist the overwhelmed member state

Since the first cautious steps were taken in the 1970s, civil protection has developed into a veritable European policy domain (Stone Sweet, Fligstein and Sandholtz, 2001). The EU today has a rather well-developed set of capacities, policies and mechanisms in place to assist member states and European Economic Area members that are confronted by a crisis or disaster that overwhelms national capacities to deal with the impact of the threat. The overwhelmed state may request help from member states through the Civil Protection Mechanism.[19] The EU has a dedicated crisis centre, a coordination structure, and is now developing its own capacities (RescEU).[20]

The first Community Action Programme in the field of Civil Protection was adopted in December 1997 to strengthen protection against natural and technological disasters.[21] It aimed primarily to improve the preparedness of those responsible for civil protection in member states. It did not cover harmonisation of laws and regulations, or organisation of national preparedness.

Following a number of disasters affecting EU member states and neighbouring countries, the Council adopted the Civil Protection Mechanism in October 2001.[22] The mechanism was designed to coordinate the response of member states in the face of disasters.[23] The EU created a Monitoring and Information Centre (MIC) and a Common Emergency Communication and Information System (CECIS). The MIC became the primary unit to coordinate member state responses; CECIS enabled communication and information exchange between MIC and the national contact points. If a member state (or a state outside the Union) needs assistance, it can log its requests in the CECIS.

In the years after 2001, Europe faced a spate of natural and manmade disasters, from wildfires to earthquakes and terrorist attacks. The response facilitated by the Civil Protection Mechanism in answer to these emergencies led to an understanding that further improvements were required to improve its structure and procedures.[24] Discussions about upgrading analytical and assessment capacity were supplemented by the so-called Barnier Report, which proposed a European civil protection force.[25] The

19 The European Civil Protection Mechanism has increasingly been used to coordinate a joint response to overwhelmed countries outside the EU.

20 For a more complete history, see the factsheet in the accompanying Policy Landscape document.

21 Council Decision 98/22/EC of 19 December 1997 establishing a Community action programme in the field of civil protection

22 Council Decision 2001/792/EC establishing a Community mechanism to facilitate reinforced cooperation in civil protection assistance interventions.

23 Not only natural and technological disasters, but also radiological and environmental accidents (including marine pollution) taking place inside or outside the European Union.

24 Communication on reinforcing the Civil Protection Capacity of the European Union (COM/2004/200) and Communication on Improving the Community Civil Protection Mechanism (COM/2005/137).

25 Barnier, M. (2006) For a European civil protection force: europe aid. European Commission.

EU also initiated the development of interoperable civil protection modules, which are offered by EU member states.[26]

Following the adoption of the Lisbon Treaty, the Commission sought to establish a stronger, more comprehensive, better coordinated and more efficient disaster response capacity in the European Union.[27] According to the Lisbon treaty, the EU should "provide assistance, relief, and protection to victims of natural or manmade disasters around the world" (Article 214), as well as "support and coordinate the civil protection systems of its member states" (Article 196). Crucially, civil protection and humanitarian aid instruments were brought together under Directorate General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) in the hope that such merger would strengthen the internal structure and know-how.[28]

In 2013, the Council adopted a proposal to establish a Union Civil Protection Mechanism (UCPM).[29] The Civil Protection Mechanism and the Civil Protection Financial Instrument were merged under a single legal act. It established the Emergency Response and Coordination Centre, which merged the MIC and DG ECHO's crisis room for humanitarian assistance. This hub would be supplemented by the European Emergency Response Capacity, a voluntary pool of resources pre-committed by the participating states on standby, only to be used when called upon by the Commission.[30]

In 2019, amendments were adopted that required member states to step up their risk assessment and risk management planning. They also established the European Civil Protection Pool to replace and strengthen the legal framework of the European Emergency Response Capacity.[31] It introduced the RescEU reserve, a last resort for overwhelmed countries where existing capacities at national level and those pre-committed by member states to the European Civil Protection Pool are concentrated to enable an effective response to various kinds of disasters. In 2021, following the COVID-19 pandemic, a proposal was adopted to allow direct procurement of certain additional capacities for RescEU.[32]

Finally, the EU has in place the Union Civil Protection Knowledge Network and an Exchange of Experts in Civil Protection. These instruments are aimed at bringing together

26 Commission Decision 2010/481/EU.

27 Towards a stronger European disaster response: the role of civil protection and humanitarian assistance (COM/2010/600). It also led to the establishment of the European External Action Service (EEAS), which would eventually play a role in response to crises in third countries.

28 The Civil Protection Unit had until then been run under DG Environment.

29 Decision No 1313/2013/EU on a Union Civil Protection Mechanism

30 The implementation of this Decision was regulated by Commission Implementing Decision 2014/762/EU, adopted in October 2014.

31 Decision (EU) 2019/420 amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism.

32 Regulation (EU) 2021/836 amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism.

experts and organisations dedicated to civil protection at any stage of the disaster management cycle.

The Civil Protection Mechanism has been frequently adapted and strengthened over the years. The EU is now actively involved in the assessment of national risk analyses. Its organisational capacities have been strengthened, creating a crisis centre in Brussels that can monitor crisis situations and create situation reports. The EU has begun to assemble its own resources, which member states can request to avoid depending on the responsiveness of other member states.

But the real question — the elephant in the room — is how the Civil Protection Mechanism corresponds with national needs. The mechanism is not used often by member states (few countries have been overwhelmed by a disaster in the past decades). And when a member state finally, and desperately, called for assistance in the midst of a major crisis (such as Italy in the COVID-19 crisis), member states did not jump into action. This prompts the question as to what issue the mechanism aims to address.

Box 5. Case example: how the EU assists member states in the fight against wildfires

In June 1983, the European Commission tabled a draft Council Regulation aimed at establishing a scheme to provide forests across the Community with increased protection against fire. This was in recognition that aid should be provided for the acquisition of equipment to support member states in overcoming deficiencies, both in prevention and the fighting of forest fires. The aim was to enhance (voluntary) mutual assistance, in particular via training and harmonisation of firefighting methods. The Council adopted the proposed Regulation in November 1986.[33]

In May 1989, the Council established the Standing Forestry Committee.[34] This Committee aimed to encourage the permanent exchange of information between the member states and the Commission on situations concerning the forests. At the same time, the Council endorsed a draft Regulation setting up a European Forestry Information and Communication System, aimed at collecting comparable and objective information on the structure and operation of the forestry sector in the Community.[35]

The Commission also envisaged the creation of a system of information on forest fires. It aimed to promote exchanges of information, the evaluation of the impact of specific measures taken by member states and the Commission, the evaluation of the periods, degree and causes of risk, and the development of strategies for the protection of forests against fire, with particular emphasis on eliminating or reducing

33 Council Regulation (EEC) No 3529/86 of 17 November 1986 on protection of the Community' s forests against fire

34 Council Decision 89/367/EEC of 29 May 1989 setting up a Standing Forestry Committee

35 Council Regulation (EEC) No 1615/89 of 29 May 1989 establishing a European Forestry Information and Communication System (EFICS)

causes. In 1994, the Commission adopted a regulation for the implementation of such a system.[36]

In 1998, the Commission's Joint Research Centre set up a research group to work specifically on the development and implementation of advanced methods for the evaluation of forest fire danger and mapping of burned areas at the European scale. In 2004, the JRC started checking, storing and managing all the forest fire data provided by individual EU member states and other European countries within the European Forest Fire Information System (EFFIS).

In June 2006, a new action plan addressing the forestry sector was published by the Commission. Measures set out in this document included the further development of EFFIS, encouragement for cooperation between member states on understanding the regional problems with the condition of forests, and continuous financing of measures concerning fire prevention and restoration of forests, as well as studies on the causes of forest fires.

Forest fires as a risk have since been absorbed into a wider context addressing threats stemming from climate change and more widely threats causing environmental damage. The EU civil protection mechanisms became the default response to crises caused by wildfires, always assisted by EFFIS and also by financing mechanisms covering rural development, agriculture and the environment. EFFIS became part of the Copernicus Programme in 2015, in the framework of its Emergency Management Service (EMS). After the summer 2017 wildfires in Portugal, the EU established a reserve of EU response capacities called RescEU, integrated into the jurisdictional basis of the EU Civil Protection Mechanism. An assessment of the EU's wildfire management can be found in Chapter 8.2.

Transboundary crisis management capacities

European integration has made EU member states increasingly vulnerable to problems that originate in faraway places but develop to undermine the functioning of critical infrastructures (e.g. energy grids, cyber, transport networks, food distribution, financial flows). It only makes sense that the EU has begun to develop capacities to detect and monitor these transboundary threats and coordinate a transboundary response when necessary. These steps have been mostly sector-based (acting in response to disturbances in those sectors).

Looking across all the sectors, the conclusion must be that the EU has developed a wide variety of transboundary crisis management capacities (Ansell et al, 2010; Backman & Rhinard, 2018; Boin & Rhinard, 2008; Boin, Rhinard, et al, 2014). The EU has endowed its agencies with capacities to deal with specific crisis types in their sector. The use of these capacities is, however, curtailed by the limited legal remits of EU agencies (Groenleer, 2009). Finally, the EU has developed a large number of early warning and information management systems (Boin, Ekengren, et al, 2014).

36 Commission Regulation (EC) No 804/94 of 11 April 1994 laying down certain detailed rules for the application of Council Regulation (EEC) No 2158/92 as regards forest-fire information systems

In this section, we discuss two generic capacities, present an overview of capacities developed in two sectors (cyber and health), and introduce a set of most recent initiatives. This overview is not exhaustive.[37] Rather, the objective here is to present exemplary capacities that showcase and analyse what is in place in general, and in the two selected sectors in terms of coordination mechanisms and information management capabilities.

ARGUS general rapid alert system

The Commission has developed a combination of software system and coordination practice: ARGUS (2005).[38] This instrument was envisioned to link all Rapid Alert Systems for emergencies that require action at EU level. More specifically, it aims to:

- provide an internal platform enabling the Directorates-General and services of the Commission to exchange relevant information on emerging multisectoral crises or foreseeable or imminent threats, requiring action at EU level, whatever their nature
- make available an appropriate coordination process to be activated in the event of a major crisis
- provide the context to communicate effectively with citizens

The ARGUS system is run by the office of the Commission President. While it has been in place for years, it has not been used often. It remains under development.

Integrated Political Crisis Response (IPCR)

The Council has developed a mechanism to coordinate the political response of the member states: the Integrated Political Crisis Response.[39] This mechanism is increasingly used as transboundary crises appear to happen more often. Originally known as Crisis Coordination Arrangements (CCAs), IPCR originated in the political momentum among EU member states in the wake of the terrorist attacks and natural disasters that occurred in the early 2000s.[40] The Hague Programme adopted by the European Council (2004) established the need to go beyond stronger civil protection and vital infrastructure actions to achieve effective management of cross-border crises.[41] The CCAs were adopted in December 2005.[42]

37 The Commission has created overviews of these cross-sectoral capacities on several occasions.

38 Communication — Commission provisions on "ARGUS" general rapid alert system (COM/2005/662)

39 See the Policy Landscape document for more details.

40 Among these, the tsunami in southeast Asia (2004), the terrorist attacks in Madrid (2004) and London (2005), and Hurricane Katrina (2005). More widely, it was the result of the focus given to internal security matters in the aftermath of the terrorist attacks against the United States in 2001..

41 The Hague Programme: strengthening freedom, security and justice in the European Union

42 Council of the European Union, 29 November 2005: EU Emergency and Crisis co-ordination arrangements (15106/05)

In practice, the CCAs were never used. After a series of reviews, the CCAs were replaced by the IPCR.[43] Keeping subsidiarity at the core of this approach, the IPCR aims to reinforce member states' ability to make joint decisions when facing major emergencies requiring a response at EU political level. The Council Presidency leads the IPCR process, with the Committee of Permanent Representatives in the European Union (COREPER, ambassadors) gaining relevance as a central element in the process.

Features of the IPCR include:

- the capacity for informal roundtables, bringing together stakeholders from the European Commission, the European External Action Service, relevant agencies and external experts to support the Council Presidency in handling an emergency
- the development of Integrated Situational Awareness and Analysis reports to provide decision-makers with a clear, common picture of the situation
- the development of an IPCR Web Platform, owned by the Council, for information exchange and further data collection
- the establishment of a 24/7 central contact point.

Three levels within the IPCR were established, two of which lead to the activation of the mechanism:

1. Monitoring level
    - voluntary sharing of information about a crisis
    - does not activate the IPCR
    - does not trigger the production of ISAA reports
2. Information-sharing level
    - obligation to produce ISAA reports
    - dedicated crisis page on IPCR web platform
    - level can be triggered by Council Secretariat General, the Council Presidency, the European Commission or the European External Action Service
3. Full activation level
    - level can be requested by Council Presidency or member states
    - higher visibility to EU response
    - allows for extraordinary Council or European Council meetings
    - preparation of protocols for action, developed at the informal roundtables and presented to COREPER (ambassadors) and Council of the European Union

The IPCR mechanism was triggered for the first time in October 2015 to address the migration crisis affecting several EU member states and the EU's neighbourhood. In 2020,

43 Council of the European Union, 7 June 2013: Finalisation of the CCA review process: the EU Integrated Political Crisis Response (IPCR) arrangement (10708/13)

the mechanism was activated for the second time to address the COVID-19 pandemic, and a third time (presently) to deal with the crises triggered by the Russian aggression against Ukraine. In the meantime, its information-sharing mode has been used for information exchange on matters relating to external crises such as the Ebola pandemic and the conflict in Yemen, as well as matters relating to hybrid threats, cyberattacks and natural disasters.

Sectoral crisis management: the case of cybersecurity

The European Commission published its first specific strategy on Network and Information Security (NIS) in 2001.[44] It defined this as the ability of a network or an information system to resist accidental events or malicious events. The Communication proposed the establishment of a European warning and information system. In addition, it argued for the strengthening of national Computer Emergency Response Teams (CERTs) and improvements to coordination among them. In 2004, the European Network and Information Security Agency (ENISA) was established.[45] The agency was tasked with enhancing systematic cooperation on NIS between member states.

A series of cyberattacks against Estonia (2007), Lithuania and Georgia (2008), and breaks of transcontinental cables (2008), created a renewed sense of urgency, but new developments took time. A permanent CERT was set up in 2012 for the EU institutions, agencies and bodies (CERT-EU). The mandate of ENISA was strengthened and modernised in 2013.[46] That same year, the European Commission and the High Representative for Foreign and Security Policy published the first EU Cybersecurity Strategy.[47] As part of this strategy, the so-called NIS Directive was adopted in 2016 aimed at ensuring a high common level of network and information security.[48] It lays down obligations for member states to adopt national NIS strategies, it establishes security and notification requirements for operators of essential services and for digital service providers, and it lays down obligations for member states to designate national authorities, single points of contact and Computer Security Incident Response Teams.

44 Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions — Network and Information Security: Proposal for A European Policy Approach (COM/2001/298)

45 Regulation (EC) No 460/2004 of the European Parliament and of the Council of 10 March 2004 establishing the European Network and Information Security Agency

46 Regulation (EU) No 526/2013 of the European Parliament and of the Council of 21 May 2013 concerning the European Union Agency for Network and Information Security (ENISA) and repealing Regulation (EC) No 460/2004

47 Cybersecurity Strategy of the European Union: An Open, Safe and Secure Cyberspace (JOIN/2013/1)

48 Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union

In 2017, the Commission published a Recommendation focusing on response coordination in the event of large-scale cybersecurity incidents and crises.[49] The document speaks of an EU-level crisis when the disruption is too extensive for a single member state to handle on its own, or when it affects two or more member states with such a wide-ranging impact of technical or political significance that it requires timely coordination and response at EU political level. The Recommendation recognises that these crises may trigger broader crises beyond network and information systems, unfolding simultaneously across different countries.

The Recommendation produced a blueprint describing the objectives and modes of cooperation between member states and EU institutions, bodies and agencies in responding to large-scale cybersecurity incidents and crisis, and how existing crisis management mechanisms can make full use of existing EU-level cybersecurity entities.

Following the response to the WannaCry and NotPetya cyberattacks across Europe, the Council adopted the EU Law Enforcement Emergency Response Protocol in 2019.[50] Embedded within Europol's European Cybercrime Centre, this is a tool to support EU law enforcement authorities in providing immediate response to major cross-border cyberattacks through rapid assessment, secure and timely sharing of critical information and effective coordination of international aspects of their investigations.

In June 2021, the European Commission adopted a Recommendation on establishing a Joint Cyber Unit.[51] It is a component of the Commission's Security Union Strategy, Digital Strategy, and latest Cybersecurity Strategy.[52] The Recommendation calls for the establishment of synergies between the Joint Cyber Unit and the EU Civil Protection Mechanism. It also calls for the establishment of a structured link with the Integrated Political Crisis Response mechanism (for more background information on the relevant policy landscape, see the accompanying document on the Policy Landscape).

Issues of cybersecurity are also discussed in section 7.6, p.201 in the context of data sharing in times of crisis. A more in-depth assessment of cybersecurity threats is presented in section 8.4, p.223.

49 Commission Recommendation (EU) 2017/1584 of 13 September 2017 on coordinated response to large-scale cybersecurity incidents and crises

50 Europol: Press Release, 18/03/2019: Law enforcement agencies across the EU prepare for major cross-border cyber-attacks

51 Commission Recommendation (EU) 2021/1086 of 23 June 2021 on building a Joint Cyber Unit

52 The EU's Cybersecurity Strategy for the Digital Decade (JOIN/2020/18). This update to the strategy aims to bridge the four cybersecurity communities — civilian, law enforcement, diplomacy and defence.

Sectoral crisis management: the case of public health and health security

Public health is a competence shared between the EU and its member states (Article 168 TFEU). While member states define and deliver their national health services and medical care, the EU seeks to complement national policies by means of its health strategy.

Following the Ebola outbreak in Zaire (1995) and the plague in India (1996), the EU set up a network (in 1998) aimed at facilitating the epidemiological surveillance and control of communicable diseases.[53] In addition, the EU created an Early Warning and Response System (EWRS).[54] It aimed to facilitate the integration of the whole network with other rapid alert networks. It also established the Health Surveillance System for Communicable Diseases within the European Public Health Information Network as the operating system.

In October 2001, the European Council urged the preparation of a programme covering the detection and identification of infectious and toxic agents, as well as the prevention and treatment of chemical and biological attacks. It called on authorities to step up cooperation between the intelligence, police, civil protection and health services. The Health Security Committee was informally set up by the European Commission, bringing together representatives from the ministries of health of each member state. It was made responsible for raising the alert, rapidly exchanging information and co-ordinating health responses in case of a deliberate release of biological or chemical agents. The committee fostered cooperation on preparedness and response to biological and chemical agent attacks (also known as Health Security Programme or BICHAT).

The SARS outbreak provided yet another incentive for further consolidation of EU competence in public health. The European Centre for Disease Prevention and Control (ECDC) was created in 2004, covering surveillance, detection and risk assessment of threats to human health from communicable diseases and outbreaks of unknown origin.[55] It also progressively took over the operation of the Early Warning and Response System.

The COVID-19 pandemic kick-started yet another new phase of development, giving rise to a nascent European Health Union. A Communication published in November 2020 outlined the lessons learned from the first stage of the pandemic, and advocated the strengthening of existing structures and mechanisms.[56] It was accompanied by a legislative package which aimed to upgrade the Decision on cross-border health threats,

53 Decision No 2119/98/EC setting up a network for the epidemiological surveillance and control of communicable diseases in the Community.

54 Commission Decision 2000/57/EC of 22 December 1999 on the early warning and response system for the prevention and control of communicable diseases under Decision No 2119/98/EC.

55 Regulation (EC) No 851/2004 of the European Parliament and of the Council of 21 April 2004 establishing a European Centre for disease prevention and control

56 Building a European Health Union: Reinforcing the EU's resilience for cross-border health threats (COM/2020/724)

strengthening the mandate of the ECDC and extending the mandate of the European Medicines Agency.

A second package of initiatives was put forward by the Commission in September 2021 as new building blocks for the European Health Union. Crucially, the European Health Emergency preparedness and Response Authority was established as a service of the European Commission.[57,58] It was launched as a new European Commission Directorate General on 16 September 2021, in the aftermath of the COVID-19 pandemic. Its primary aim is to strengthen the EU's ability to prevent, detect, and rapidly respond to cross-border health emergencies, by gathering intelligence and ensuring the development, manufacturing, procurement, and equitable distribution of key medical countermeasures. The Commission also tabled a proposal for a framework aimed at ensuring the supply of crisis-relevant medical countermeasures in the event of a public health emergency at EU-level.[59] It also proposes the establishment of a Health Crisis Board to ensure coordination and integration of approaches to crisis-relevant medical countermeasures (for more information on the relevant policy landscape see the accompanying document on Policy Landscape). These sectoral crisis management mechanisms are discussed in the light of deliberate biothreats in section 8.4, p.223.

Capacities to deal with crises outside the EU

The EU has traditionally assisted countries and regions outside the Union that suffer from natural disasters. Financial assistance was typically run through the UN Office for the Coordination of Humanitarian Affairs, the World Health Organisation, and non-governmental organisations such as the Red Cross.

The Civil Protection Mechanism was made available to facilitate a more hands-on response by member states. In 2001, the Council adopted a Resolution[60] establishing a connection between civil protection cooperation and other strategic developments, including non-military crisis management in the framework of the Common Foreign and Security Policy.[61] Since 2003, the EU has undertaken scores of such missions.

57 Introducing HERA, the European Health Emergency preparedness and Response Authority, the next step towards completing the European Health Union (COM/2021/476)

58 Commission Decision of 16 September 2021 establishing the Health Emergency Preparedness and Response Authority

59 Proposal for a Council Regulation on a framework of measures for ensuring the supply of crisis-relevant medical countermeasures in the event of a public health emergency at Union level (COM/2021/577)

60 Resolution of the Council and of the representatives of the Governments of the member states, meeting within the Council of 26 February 2001 on strengthening the capabilities of the European Union in the field of civil protection

61 In May 2000, Council Decision 2000/354/CFSP had been adopted for the establishment of a committee for civilian aspects of crisis management, sitting with the Council of the European Union. This development took place in the framework of developments on the Common Foreign and Security Policy.

Over the years, the EU has also developed extensive capacities to respond to non-disaster crises such as conflicts and war (Ekengren, 2018; Jones, 2007; Norheim-Martinsen, 2013). The EU has built Common Security and Defence Policy civilian and military missions and operations that can be sent abroad to help maintain or build civil institutions. While the scale of these missions is decidedly limited, their complexity and scope has gradually increased over time.

These capacities are largely organised under the Council and the European External Action Service (EEAS). Established in 2010, the EEAS brings together a number of departments previously scattered between the European Commission and the Council and responsible for matters relating to external relations and diplomacy.

The Crisis Response System was designed to cover crises that might affect the EU's security and interests outside its borders, including those affecting the EU delegations or any other EU asset or person in a third country. The mechanism comprises a number of tools, such as a permanent Crisis Management Board to address horizontal aspects of EEAS crisis response, and a Crisis Platform to facilitate information-sharing among participants (representatives from the EEAS, Commission and Council General Secretariat) and provide a clear political or strategic objective for the management of a given crisis.

The EU Situation Room was inaugurated in 2011 as a worldwide monitoring and situation awareness hub. It was envisaged as the first point of contact for all information on crisis situations, bringing together input from relevant internal stakeholders such as EU delegations. It was seen as an information hub for all EU institutions (playing a role in the IPCR), an information source for the Crisis Platform and complementary to the analytical work conducted by the EU Intelligence Analysis Centre.[62] A Conflict Prevention Group gathers and reviews on a continuous basis early warning information on countries and regions at potential risk of conflicts and crisis. The mechanism also included exploratory and inter-service missions (composed of EEAS and Commission staff), launched at the request of the High Representative at short notice to quickly assess the situation on the ground, establish contacts with local interlocutors and help plan further EU action. The launch of these missions fell under the Crisis Response Department.

The crisis in Libya which erupted in February 2011 was a real test for the EEAS crisis response mechanisms. The Crisis Response System was also activated to help deal with the humanitarian consequences of the triple disaster (earthquake, tsunami, nuclear accident) affecting Japan in March 2011.

62 The EU Intelligence Analysis Centre (EU INTCEN) is the exclusive civilian intelligence function of the European Union. It started off as EU SITCEN (EU Situation Centre) in 2002 and brought under the authority of the HR Foreign and Security Policy following the Treaty of Lisbon. It became part of the EEAS in 2011. It was renamed in 2012. The Centre provides intelligence analyses, early warning and situation awareness to the EEAS. It does not have any collection capacity — the operational level is the member states' responsibility. The EU INTCEN focuses on strategic analysis.

In 2015, the Council of the European Union adopted a Directive determining when and how EU citizens in distress in a non-EU country can enjoy the protection of other EU member states' embassies or consulates if their own country is not represented.[63] In 2016, the EU Global Strategy was published. This document identifies an integrated approach to external conflicts and crises. It was followed in 2017 by a Joint Communication[64] identifying how a strategic approach to resilience can increase the impact of EU external action. This document recognised the need to move away from crisis containment to a more structural, long-term non-linear approach to vulnerabilities, with an emphasis on anticipation, prevention and preparedness.

Recent initiatives

In recent years, the EU has continued to invest in enhancing its crisis management capacities. Each Council meeting appears to give birth to new initiatives that can be classified in terms of crisis management. The Council conclusions of November 2021, for instance, noted that the "EU's response to future crises should also build on and strengthen as appropriate existing cross-border cooperation mechanisms'" It announced the imminent arrival of a contingency plan for transport. It welcomed the Commission's contingency plan on food supply and food security in times of crisis. On the 21st March 2022 Foreign and Defence Ministers adopted the Strategic Compass setting out a common strategic vision for EU security and defence with concrete actions and timeline. The Compass was endorsed by the European Council on March 25th. These steps and decisions show the growing ambitions of the EU in the security and foreign crises area.[65]

Recent initiatives in various policy arenas illustrate the growing ambitions of the EU:

- **Health.** The health sector has just seen a new version of the European Health Emergencies preparedness and Response Authority (HERA). It enhances preparedness through joint procurement and increasing stockpiling capacity. It also brings more capacities for the emergency phase. HERA will complement ECDC and EMA in both preparedness and crisis times, thus becoming a crucial pillar of the European Health Union with an anticipatory, forward-looking and response-focused dimension in terms of threat assessments and foresight. In the crisis phase, HERA would shift into operational mode, including swift decision-making and emergency measures.
- **Critical infrastructures.** This policy domain has seen new capacities being added incrementally since 2006. An amended Directive for the Protection of Critical

63 Council Directive (EU) 2015/637 on the coordination and cooperation measures to facilitate consular protection for unrepresented citizens of the Union in third countries

64 Joint Communication on a Strategic Approach to Resilience in the EU's external action (JOIN/2017/21). It built on a 2012 Communication on the EU approach to Resilience: Learning from Food Security Crises (COM/2012/586).

65 https://www.eeas.europa.eu/eeas/strategic-compass-security-and-defence-1_en

Infrastructures is expected in 2022. It will enhance resilience of critical entities, requiring improved risk assessments, clear-cut criteria for the identification of critical entities; improving joint situational awareness; setting rules and procedures in the event of a large-scale incident or crisis. There is a link with NIS 2.0, which aims to enhance cybersecurity (including aspects of crisis management). The EU is also focusing on securing critical supply chains.

- **Sustainable finance.** The EU aims to make the financial sector more resilient to climate-related risks that are systemic and not necessarily visible at the single asset level. The EU's 2021 *Strategic foresight report: Climate change and environmental degradation* recognises that the EU financial system needs to systematically integrate sustainability risks and impacts in financial decision-making, and integrate long-term risk management and disaster risk financing strategies.
- **Data governance.** The proposal for a 'GreenData4All' Directive offers updated rules on geospatial environmental data and enhanced access to environmental information. Data on climate-related risk and losses are crucial to improve the accuracy of climate risk assessment. Considering also systemic risks for the financial sector as a whole in conjunction with the European Central Bank.
- **Climate change.** The EU aims to forge a climate-resilient Europe, which means that member states and the Union should enhance their adaptive capacity, strengthen resilience and reduce vulnerability to climate change.
- **Financial crisis management.** Both the financial crisis and the COVID-19 pandemic had huge consequences for the financial stability of member states, threatening to undermine institutional structures and, perhaps most worrying, the legitimacy of democratic institutions and the EU itself. The EU has reacted to this emerging threat by enhancing the authority of EU institutions in the economic domain and by creating large-scale funds to enhance societal resilience (both in the short and long term) of member states. The Recovery and Resilience Facility exemplifies the political willingness of member states to support this aim.[66]

3.4. Where are the biggest gaps?

The overview of available crisis management capacities at the EU level does not lead to the identification of 'obvious' gaps. The problem is that we lack clear evaluative criteria that we might use to determine relevant shortages and absences. The Lisbon Treaty does not provide the EU with clear-cut competences for crisis management — at least, not as defined in this report. However, we can formulate some basic observations, which may prompt discussion.

66 Recovery and Resilience Facility | European Commission (europa.eu)

The EU has steadily built capacities to assist member states that are overwhelmed by disaster. However, few member states have been overwhelmed. As a result, the Civil Protection Mechanism has rarely been called into action by member states. As mentioned above, when it was called into action, it did not always provide member states with the resources they requested. At the same time, we have seen that the EU is further strengthening the assistance to member states through its RescEU initiative. It is too early to assess whether (much) more action is needed or desirable from a crisis management perspective.

The EU has claimed a role in the assessment of risk management plans that the member states deliver to Brussels. It is not clear whether or how this European assessment has improved national risk plans. Moreover, the EU has announced intentions to help member states enhance resilience. Again, it is not clear how this will be done and how one might measure the effects of such initiatives.

The EU has built a wide set of tools, mechanisms and administrative structures to facilitate EU-supported missions to foreign hotspots (including the assistance of EU citizens abroad). We have no measure to establish whether there are clear gaps here that should be resolved at the EU level.

Perhaps the capacities that remain most wanting — in light of the ambitions formulated in the Lisbon Treaty with regard to mutual assistance and solidarity (Articles 42 (7) and 222) — are found in the transboundary domain. As we have stated, transboundary crises appear to be on the rise, demanding a joint response from member states. The available capacities are scattered over policy domains and agencies (a current overview of such capacities is not publicly available yet). The ARGUS system is potentially the European Commission's most powerful initiative to operate across bureaucratic boundaries. but although a published scientific assessment of the system does not exist at this point, we have reason to believe the Commission is still encountering challenges in using it to its full capacity. The IPCR is the most promising and perhaps most effective tool at this point, but it is still used infrequently.

An argument could therefore be made to prioritise investments in the building and strengthening of transboundary crisis management capacities. The variety of threats seems to suggest that generic crisis management tools are preferable (as policy sectors are already developing threat-specific capacities). As these crises cannot be prevented, efforts should be focused on preparedness of EU institutions, and on facilitating a joint response through the development of information systems and coordinative capacities (see 7, p.172, for an overview of the data, intelligence and foresight capabilities in place).

In recent years, the EU has embraced resilience as a strategic priority. As indicated in 2, not surprisingly, the use of the 'resilience' term often lacks precision (see section 2.3, p.42) and guidance; this is the case with many 'resilience initiatives' that have been rolled out over the years. The adoption of the Recovery and Resilience Facility appears to be a promising deviation from that path to vagueness. The massive fund aims to significantly enhance the societal coping capacity of member states in the face of transboundary threats (Vanhercke & Verdun, 2022). The argument could be made that the EU could play a leading role in specifying and demonstrating how societal resilience could be effectively enhanced. A first step towards this goal can be found in the creation of 'resilience dashboards'.[67]

The biggest latent shortcoming may be the emergence of a 'performance gap' between public expectations and actual delivery of crisis management capacity. Recent survey data suggests that European citizens expect the EU to play a role in the management of large-scale crises.[68] If the EU cannot play a clear, mediating role in the management of crises that are widely construed as a consequence of economic integration — a key aim of the Union — public support for the European project may wane.[69]

Another shortcoming that has traditionally prompted comments from scholars and observers is the gap between the structures, processes and mechanisms of Commission and Council (Nugent & Rhinard, 2015). In recent years, much has happened to bridge this gap, however. The creation of the EEAS certainly helped, as did the increased reliance of IPCR operators on the information provided by Emergency Response and Coordination Centre officials. While tension between both sides is an inevitable shortcoming, it may not be an urgent one.

A final shortcoming that deserves to be mentioned is the absence of an EU institution that owns and drives the further enhancement of the EU's risk and crisis management capacities, or that serves as a central Hub for crisis management initiatives. Whether that is desirable is a question discussed in 9, p.240. To be sure, we are not talking about an EU crisis management authority that would take over from member states to manage a crisis; integration of all the activities and mechanisms described in this chapter may not be a good idea, as the experience with the US Department of Homeland Security has clearly demonstrated.[70]

67 https://ec.europa.eu/info/strategy/strategic-planning/strategic-foresight/2020-strategic-foresight-report/resilience-dashboards_en

68 https://www.europarl.europa.eu/news/en/press-room/20210504IPR03427/eu-survey-highlights-support-for-greater-crisis-management-role-at-eu-level

69 For an interesting perspective, see the discussion on 'backsliding': http://www.transcrisis.eu/wp-content/uploads/2016/08/D6.1-Mapping-Backsliding-and-Report-on-Workshop.pdf

70 For a discussion of the pros and cons of an EU crisis management agency, see Boin, Busuioc et al (2014). For a discussion on the difficult history of the US Department of Homeland Security, see Kettl (2007).

4. Risk management for the EU: current practice and potential for improvement

4.1. Summary and key messages

This chapter explores evidence on how to better integrate risk management within crisis management practices at EU level. It proposes options on how to improve EU crisis prevention and preparedness, including measures relating to risk management and resilience. More specifically, it offers science-based answers to the following questions in the scoping paper:

> What improvements can be made to the overarching EU-level crisis governance and operations that can apply to any type of crisis or threat, including unknown risks?
>
> Which types of known threats merit a classic risk-based approach at the EU level? How best [can we] integrate them in the above multi-hazard crisis management system?

This chapter is built on the rationale that effective, systemic and anticipatory risk management is the key to being better prepared for crises or disasters, and to improving resilience. Being prepared for a crisis, and having effective measures in place before society faces it, requires a thorough analysis of the various threats that can lead to a crisis. Therefore, management strategies have to be developed for different risk types or clusters. Traditional classifications of risk and hazards have become outdated with the rising complexity and new nature of crises and risks. Based on the literature on this topic and related governance or management manuals, this chapter offers a new taxonomy for risk and hazards:

- **System breakdown risks** are characterised by a break in a causal hazard chain. The main cause for system breakdown is the lack of governance capability and coherence in a highly interconnected system at different scales. Modern societies are characterised by an increasing vulnerability that will make system breakdowns more likely. To limit the catastrophic potential, the best that risk management agencies can do is to pursue a precautionary, resilience-based strategy.
- **Globally systemic and pervasive risks** cover those human activities that promote rapid environmental or cultural changes, without proper knowledge of all the trigger points that may lead to major system changes. All systems can cope with change if it is gradual enough to allow for adaptability, but the issue with these types of risks is either the speed of change or the effects of unknown or only suspected tipping

points, such as in the case of climate change. In response to this type of emerging risk, the EU policy tradition is to pursue the precautionary principle. There is a dilemma between the conflicting requirements for solutions that are fast enough to be innovative and slow enough to be reversible in the face of scientific uncertainty. While the EU has responded to this challenge by advocating responsible innovation, there is still a need to find better regulatory regimes that can balance speed of change with the necessity of innovation.

- **Socially induced risks** to society refer to the consequences of social actions that impact on human health and the environment or their perception, such as war or terrorism for example. Human violence may become a more prominent risk in modern interconnected societies. Addressing the underlying causes for social risks (such as growing inequities or people's increasing feeling of loss of agency) is crucial, along with a strengthening of cross-national cooperation for information exchange and transboundary prosecution.
- **Amplifier risks** originate as physical risks, but then cascade into the financial, political and psychological worlds. The physical impact of these risks may be low, but the way they are perceived by society might amplify its consequences and trigger dangerous or damaging societal behaviour. These risks are complex, uncertain and ambiguous, and until now EU risk management agencies have not adequately addressed these.

The chapter then moves on to a section on risk perception, tightly linked to risk communication. Complex risks are only understood by the public through a broad range of personal experiences and symptoms that remain mysterious for most observers, raise doubts about the proposed scientific explanations, and may even lead to widespread beliefs in conspiracy theories. This, in turn, can trigger more amplifier risks such as populist movements or anti-democratic protests. Therefore, the public's risk perception, and the mental models that nourish and reinforce those perceptions need to be understood and considered to make risk and crisis management decisions, particularly in a democratic society in which policymakers rely on public support for their policies and decisions.

Based on all this evidence, the chapter provides an assessment of EU risk governance, acknowledging the long tradition of risk assessment, reduction and management in the EU. Standard procedures of risk assessment and risk management have resulted in major risk reductions with respect to conventional and sectoral risks in Europe, such as occupational health risks and risks related to transportation and mobility. However, these procedures and associated tools are not sufficient for handling systemic risks that transgress domain boundaries, that are embedded in a complex relationship with socioecological, socio-technical or cultural transformations, and that tend to lead to a series of impacts (so-called systemic risks). For a better governance of systemic risks, a systems approach to risk governance is required, for example by identifying intervention points that have an impact on many related risk domains at the same time, such as in the energy-water-food nexus.

Based on these reflections, the chapter offers the following key messages:

- Four new clusters of risk categories increasingly require attention in risk management: breakdown risks; systemic risks; social risks and amplifier risks.
- The EU's capacity to manage risks focuses largely on traditional risk typologies with categories such as natural hazards or epidemics. The EU uses conventional risk management approaches, for example aiming at measuring likelihood of occurrence of an incident, exposure and elements at risk, or vulnerability or cost-benefit analyses. These approaches are less suitable to manage the new category of systemic risks.
- Information and analytics tools are designed to support this strategy, by providing static and sectorial information (see e.g. the newly launched Risk Data Hub in the Joint Research Centre).[71]
- There is less in place to manage systemic or breakdown risks, social risks and polycrises. All of these are characterised by potential feedback, amplifiers, and cascading effects across sectors or countries that need to be recognised, monitored and potentially mitigated.
- Focusing on impact potential, in the face of major system breakdown risks or cascading crises, a precautionary, resilience-based strategy would be advisable by (i) limiting the catastrophic potential and the hazardous arsenal (of chemicals, weapons, explosives) independent of the low probability of a catastrophic release, and (ii) decoupling interconnected risk-inducing activities.
- There is potential for the EU to effectively reduce social risks by focusing on the root causes. Further potential interventions concern improving security, e.g. by controlling transboundary criminal organisations, establishing anti-terrorist taskforces and including new forms of mediation and violence prevention in all member states.
- Adjusting the governance structure to ensure effective monitoring and intervention of systemic risks with potential transboundary consequences can be a way forward to integrate different sectors and countries. This could, for instance, be under the umbrella of an EU risk board or hub. This structure could be supported by risk management task forces that are embedded within the different institutions.
- Developing and implementing standards and protocols for assessing and monitoring transboundary, systemic risks could be a welcome step forward. In conventional sectoral approaches and insurance, there is a traditional focus on events that are of a (sufficiently high) likelihood. The precautionary principle and the prospect of potential breakdown risk suggest that these need to be complemented by approaches that are tailored for rare events and that consider indirect and cascading effects. These

71 https://drmkc.jrc.ec.europa.eu/risk-data-hub#/

new standards and assessment methods could be integrated in the respective information and risk monitoring tools.

- Major emphasis should be given to risk communication and education, in particular where risk perception is dominated by beliefs in fake news and even conspiracy theories. It is essential to understand the motives and mental models that trigger these perceptions and design effective communication programs that address the roots of these belief systems.

4.2. Introduction

As mentioned in 2, p.38, risk, resilience and crisis are closely related. A crisis occurs if the negative consequences that are associated with a given risk are either present or imminent. In a crisis, society is either facing or close to facing a disaster. Crisis management deals with measures to reduce impacts and return to stable conditions in due time, while risk management is either referring to preventing a crisis from happening, preparing for crisis situations in advance, or having measures in place that can mitigate or reduce the magnitude of harm associated with the risk.The increasingly protracted and long-term crises have blurred the boundaries between traditional risk and crisis management, and therefore we advocate for an integrated approach (see Figure 5, p.41, and Figure 10, p.53).

Effective and anticipatory risk management is the key to being better prepared in a situation of crisis or disaster and to improving resilience of the risk-absorbing system (see Figure 10, p.53). The term 'risk', rather than 'danger' or 'fate', implies that the severity of experienced harm depends on the causal relationship between a stimulus (a human activity or event) and the consequences on a risk-absorbing system (Klinke & Renn, 2002). As pointed out in 2, 'risks' refer to mental models about the connection between natural or human hazards (such as earthquakes, floods, explosions or pollution) and their impact on socially valued targets such as human health, buildings or ecosystems. Risk assessment is the scientific activity that explores the causal connection between the occurrence of a hazardous event or activity, and its likely consequences for all affected targets. The more vulnerable such a target (risk-absorbing system) is when it is exposed to the hazard, the more severe or detrimental are the consequences. Given that scientific analyses are able to improve our understanding of the causal relationships between hazards and their impacts, risk management efforts are required to prevent hazardous events or activities from happening, or to mitigate or reduce the impacts. Risk management is hence based on the non-fatalistic assumption that consequences can be altered by human interventions. If the vast majority of human beings assess potential consequences as unwelcome or undesirable, society is obliged to avoid, to reduce, or at least to control risks. If risk management is unable to prevent the occurrence of hazardous events, a crisis situation may occur in which crisis management is required to reduce adverse effects and restore system functionality.

Crises, emergencies and disasters are not new phenomena. While humanity has dealt with crises and emergencies small and large throughout its history, we begin here with the origins of formal methods to manage the risks that then can turn into crises. The historical origins of risk management in modern Europe are rooted in the revival of trade across the Mediterranean Sea during the late Middle Ages (11th to 14th centuries). After the long centuries of trade and economic contraction following the collapse of the Western Roman Empire, traders from the vibrant commercial hubs in southern Europe, such as Genoa and Venice, developed new and advanced economic institutions. The commenda, for example, an early form of limited liability partnership helped the traders to secure their highly risky overseas investments and allowed them to establish long-distance trade (Greif, 1994; Puga & Trefler, 2014). These institutions needed, in turn, political coordination across different entities to be effectively enforced. For this reason, a bottom-up process of institutional convergence in economic organisations took place, and it represented a long-run advantage for European societies (Greif & Tabellini, 2010).

In the 14th, 15th and 16th centuries, when recurrent epidemics hit the European regions and established a phase of high mortality in the continent (Livi Bacci, 2007), multiple health provisions were taken at the urban level to cope with the spreading of diseases and the increase in mortality (Cipolla, 1973). However, as long as these measures were taken in isolation, they usually failed to limit the plague waves. Instead, when measures coordinated among different political entities were put in place, the management of crises became more effective. For example, since the second half of the 17th century, several European states agreed on the mutual acknowledgement of bills of circulation, which attested the health of the individuals moving across boundaries. Similarly, very often political entities across Europe shared practices and knowledge used to cope with epidemic crises (Rawcliffe, 2013). Physicians and practitioners from the most hit southern European regions were often called to the Northern regions in the mid-17th century and their service and knowhow were used to reduce the incidence of epidemic episodes (Henderson, 2019).

Modern times, and in particular the 20th century, have seen the proliferation of episodes of shocks, crises and failed or successful attempts at coordinating the response across political entities. Since the beginning of the 1800s, coordinated efforts across national states to increase vaccination among the population effectively diminished the occurrence of deadly diseases. Moreover, the increasing public expenditure for improvement of the standard of living in the cities was fundamental for the capacity of political entities to cope with crises. In 1892, when an epidemic of cholera hit the northern regions of Germany, the city of Altona was relatively spared from the contagion thanks to the previous implementation of an effective public system for the sanitation of drinking water. Other cities in the region, which instead had not developed similar measures, were harshly hit by the epidemics (Evans, 2005).

During the 20th century, the European countries experienced devastating wars and the consequences of failing or succeeding coordination in coping with crises. Whereas the World Wars and the interwar period have mostly shown the negative impact of the lack of coordination across countries when managing either epidemic outbreaks or the post-WWI reconstruction, the years after WWII have shown a radically different historical pattern (Vonyo, 2020). In the last 70 years, the emerging supranational European economic and political institutions have succeeded in providing coordinated relief to shocks and crises, such as the large financial funds provided to Italy to support reconstruction after the devastating earthquakes in L'Aquila (2009) and Emilia Romagna (2012).

In sum, over time, in order to reduce or control risks, social institutions have been created and mandated to evaluate and manage risks. In the context of a crisis, these institutions have four major goals that link risk to crisis management (cf. Figure 10): (i) to prevent a crisis from occurring (prevention) (ii) to improve the capacity of risk-absorbing systems to maintain functionality or to rapidly recover and adapt in the case of a crisis (resilience management) (iii) to develop structures and processes that help to mitigate impacts once a critical situation has arrived (crisis management) and (iv) to develop emergency and contingency plans that could help crisis managers be more effective and timely in times of crisis (mitigation).

The following sections will describe what needs to be done at the EU level to meet the challenges related to this broad understanding of risk management and overcome deficits. All the insights developed are either based on evidence from the scientific literature or on long-standing experience of the chapter's contributors in serving as consultants to risk and crisis management institutions.

4.3. A new typology of risk and hazards

Being prepared for a crisis and having effective measures in place once society is faced with a crisis necessitates a thorough analysis of the various threats that can lead to a crisis. It is obvious that the nature of threats and the type of hazards that could lead to a crisis or disaster are important considerations for the development of appropriate management strategies. At the same time, society cannot deal with each hazard individually but can at best create management strategies for different risk or hazard clusters. These clusters need to be specific enough to be effective, efficient with regard to the main characteristics of the hazard to be addressed, and broad enough to cover a sufficiently large number of individual hazards.

One can identify numerous classifications of hazards and risks in the literature (Florin & Bürkler, 2018; Hohenemser et al, 1983; Liu et al, 2016). Most typologies use the nature or type of hazard as the main criterion for categorisation, as mentioned in section 1.4, p.30. However, as stated in the introduction to this report, societies are increasingly exposed to multiple risks and polycrises; they face combinations of natural and technological hazards, and cascading disasters starting in one domain of society or nature and extending to other domains (Homer-Dixon et al, 2022). It is therefore more appropriate to deliver a taxonomy of hazards and hazard management approaches according to clusters of risk and hazards, independent of their origin. Similar approaches have been undertaken by many risk and disaster management agencies or academic institutions, for example the OECD (2011; 2003), the World Economic Forum (2021), Swiss Re (2021), and Risk World (Löfstedt, 2003). The approach that we have taken here has not been published so far but is based on the literature on this topic and related governance or management manuals. Methodologically, this could be classified as a narrative meta-analysis.

Cluster 1: System breakdown risks

System breakdown risks are characterised by a break in a causal hazard chain, and this can occur within financial systems (as experienced in the 2008 crisis), communication network systems, public health infrastructure (e.g. COVID-19), natural hazard response or relief systems. The threat of system breakdown is a feature of an interconnected systems approach, and it exists at many levels, from local to global (Eusgeld et al, 2011). The main cause for system breakdown is the lack of governance capability and coherence in the context of highly interconnected localities and functional systems.[72] The coping mechanisms in place to manage these risks vary across countries and at global level.

System breakdown risks are increased by:

- the interconnectivity of hazardous systems, such as natural and technological systems (e.g. a water dam built in an earthquake-prone zone, or a nuclear reactor close to a flood-prone area)
- an increase of vulnerabilities by the interaction of many technological devices, where big consequences with low probability may result (such as a liquid gas terminal next to a chemical factory; other examples relate to digital threats, see Annex 1, p.294)
- the transfer of hazardous technologies in politically unstable or potentially violent societies
- an increased mobility of humans through migration, travels and tourism

72 Governance deficits were mentioned as the main cause of emerging risks in all of the analysed documents. An early version of this problem has been described in Castells, M. (2010).

- a move into impact dimensions that show non-linear patterns (Renn et al, 2020)[73], i.e., a seemingly small event (or combination of events) can lead to dramatic global consequences

There are four prominent examples in this field:

- **Increased threat of spreading infectious diseases.** Major sources for new infections may be the transfer of animal viruses to humans, as well as specialised bacteria that develop resistance against antibiotics (Murdoch & French, 2020). The spread of these newly developed microbes is facilitated and promoted through mobility (Garret, 1995; Global Preparedness Monitoring Board, 2019). Furthermore, global environmental change can transport infectious diseases in areas that have not been accustomed to this new threat before (Lipp et al, 2002).
- **Food supply for human consumption.** With more than 8 billion individuals that depend more and more on a limited variety of plant species (rice, wheat, corn), societies are becoming increasingly vulnerable (see also 'Box 2. Food systems, response diversity and EU policy initiatives', p.56). Concentrated reservoirs of eatable plants of course also attract non-human organisms that can feed on them (WBGU, 2000), such as microbes, fungi or insects. This threat is amplified by the continuous trend towards a decrease of plant species used for human consumption. At this point in time, almost 80% of all cereal food is confined to seven different plants (WBGU, 2000). Wheat and rice alone account for almost half of the world's cereal production. If any one of these central cereal species became infected by a new type of disease for which human ingenuity had no immediate cure available, the world would face a serious famine with catastrophic results.
- **Technical infrastructure** (Kröger 2008; The White House 2013; Rehak et al, 2018). Human activities have become more and more interconnected and mutually dependent (Kunreuther & Heal, 2003). Such networks are based on critical infrastructures such as transportation means, communication routes, energy supply and, most importantly, information and communication services. Many economic, political and social transactions rely on the availability and functionality of the existing infrastructure. As soon as infrastructural services are disturbed or are malfunctioning, the original activity is likely to collapse and may infect other systems that rely on the well-functioning of the affected system. A detailed example is provided below in Box 6, with the case of Social Smart Grids. The most prominent example here is

73 The last point deserves some more explanation. All cause-effect functions are linear if the increase is purely incremental and if the present location of the system on the cause-effect function is distant from possible non-linear thresholds (Ulanowicz 2013). Both conditions may be jeopardised in the face of more recent developments. First, many technological, economic and social changes occur more rapidly than in the past, making larger than incremental steps more probable. Second, human activities have the potential to affect the ecological, economic and social fabric of human existence more profoundly than in the past. Many analysts have called this the "intensity factor" (Gheorghe & Vamanu 2004). The intensity of impacts has grown and, along with the increased influence on the existing systems, the likelihood that societies are approaching non-linear thresholds increases as well (Burkholz et al, 2016).

the increasing emergence cyber-risks, including cyber-terrorism but also risks to privacy and civil liberties (Couce-Vieira et al, 2020; Neitzke et al, 2008; Scholz et al, 2018). Given the multitude of potential hazards that can affect infrastructure, including deliberate destruction by violence and war, resilience management plays a major role in making infrastructure more robust and organisations that manage them more adaptive and capable of coping with sudden stress situations (Bostick et al, 2018; see also Box 3 for further insights on infrastructure resilience).

- **Combination of natural, technological and social hazards.** The interaction of human activities and natural events can cascade into consequences that exceed the sum of each individual disaster or crisis (Berg, 2016; Scheffer, 2009). The effects of the tsunami on the nuclear power plant of Fukushima provides a vivid illustration of this interaction. Global climate change will make these natural disasters more likely and intense. The spread of hazardous technologies, and the exposure of vulnerable settlements to these natural hazards, can trigger a cascade of events that may lead to the breakdown of critical infrastructure or life-supporting systems. Another example may be solar storms that could lead to a major breakdown of all electrical transportation systems and technological devices sensitive to magnetic forces (Leiss, 2010).

Box 6. Social smart grids

An example of the abuse of information and communication technologies for malevolent attacks to technological systems arises from the 'smart grids' concept. Smart grids are systems of systems which integrate power grids with information and communication networks. Compared with traditional power grids, a Smart Grid provides real-time information on user behaviour. Consumers can readily know the system status, which enables them to optimise energy consumption and actively participate in demand response policies such as real-time pricing or time-of-use prices. Currently, the focus is mainly on the cyber grid that enables two-way communication, but some have started pointing at the social dimension of SGs (Y. Xue and X. Yu, 2017; p.C. Honebein, R. F. Cammarano, and C. Boice, 2011). With the integration of renewable energies and distributed residential chargers of electrical vehicles, end users are expected to be more active in smart grids, especially through social media and online social networks (Tang, Y. — p.Fang, E. Zio and J. E. Ramirez-Marquez, 2019). For this, the utility companies can develop apps or platforms for sharing information based on the widely used social networking sites, according to their needs and strategies.

Linking social networks and smart grids to build 'social smart grids' is becoming increasingly attractive to better coordinate supply and demand (I. G. Ciuciu, R. Meersman, and T. Dillon, 2012; M. Steinheimer, U. Trick, and p.Ruhrig, 2012; p.Lei, J. Ma, p.Jin, H. Lv, and L. Shen, 2012; Y. Huang, M. Warnier, F. Brazier, and D. Miorandi, 2015), but one must consider the impact that the integration of social networks can have on the resilience of smart grids, considering both the social and cyber dimensions. Lack of knowledge about how to respond to time-varying prices is a main barrier for demand response. For instance, experiments with a real-time pricing programme via phone or internet experimented in Chicago showed that few consumers actually respond to such a programme (C. D. Huang, Q. Hu, and R. S. Behara, 2008), partially due to the difficulty for consumers to constantly monitor the hourly prices.

Social networks allow real-time information exchange and, thus, provide a convenient and powerful way to influence consumers, where consumers learn from each other, get easy access to information such as future electricity prices, and change their decision-making on consumption. Users' behaviour can be guided to improve energy efficiency, reduce peak demand and facilitate renewable energy exchange. In the past few decades, various methods have been investigated to maximise the influence of social networks (W. M. Campbell, C. K. Dagli, and C. J. Weinstein, 2013; A. Che, Y. Zeng, and K. Lyu, 2016). Influence is motivated by our basic human need to be helpful by giving advice, and people share a common benefit in seeking out valuable information.

While increasingly active demand response in smart grids can bring about many benefits, it also makes them vulnerable to malicious attacks. Studies have been made on the impact of altering power demand through injecting false information to smart meters and compromising or fabricating price signals through the Internet (A.-H. Mohsenian-Rad and A. Leon-Garcia, 2011; J. Giraldo, A. Cárdenas, and N. Quijano, 2017; X. Zhang, X. Yang, J. Lin, G. Xu, and W. Yu, 2017). Yet very few studies have considered such load-altering attacks coming through social networks. Attackers might publish false electricity prices and spread them on their social networks and there is a lack of knowledge on how the personality characteristics and the content of the messages may influence the consumers' behaviours in the information-propagation process in residential power distribution systems (Mishra et al, 2017; Pan et al, 2017).

The extent to which social network actors are influenced by information and the extent to which they are willing to propagate the information to their social neighbours are determined by factors like the structure of the social network, the content of the message, and the personality of the human being behind the social media account (D. M. Romero, W. Galuba, S. Asur, and B. A. Huberman, 2011; B. Voelkl and R. Noë, 2008; J. Hornik, R. S. Satchi, L. Cesareo, and A. Pastore, 2015; S. Vosoughi, D. Roy, and S. Aral, 2018; K. Moore and J. C. McElroy, 2012). For electricity users who have social media accounts, when they receive (false) future prices on social networks, they may spread the information, while rescheduling their own consumption. By rescheduling the consumption, a part of consumers' loads is shifted from high prices to low prices, which may lead to unexpected high loads at certain moments. Some distribution lines may be overloaded due to the high loads, resulting in extended failures of power grids.

In the development of smart systems and infrastructures, with growing interactions among the hardware, software, cyberware and human elements, it is important to adopt a holistic system-of-systems approach. Smart grids are systems of systems integrating power grids with information and communication networks for active participation by end users, which introduces a focus on the cyber grid but also on the social dimension. It seems relevant to consider the impact that the integration of social neworks can have on the resilience of such grids, considering both the social and cyber dimensions.

Modern societies are characterised by an increasing vulnerability that will make system breakdowns more likely. The 11 September 2001 attack on the World Trade Center showed that with very limited weapons (carpet knives), technologies can be diverted to create major disasters. There is now a competition among many countries and institutions to improve the resilience of all kinds of systems (Linkov et al, 2014; Biggs et al, 2015). For example, the US Defence Department has protected its system by creating isolated islands where sensitive information is physically disconnected from the system, rather than using firewalls for protection. But this lack of connectivity could create its own risks, as the new system will only work if it is entirely self-sufficient. It is also a great risk to hold critical information in a bounded system.

The implications for risk management are substantial. The potential costs of breakdown disasters are beyond the scope of what even reinsurers are able to pay. Around 13 million people die every year from infectious diseases (primarily measles, pneumonia, cholera, AIDS, tuberculosis and malaria) (Neitzke et al, 2008). The cost of COVID-19 is still adding up and may soon exceed 3 trillion euros (Jorda et al, 2020; Caggiano et al, 2020). Failures of infrastructure, particularly in dams and high-rise buildings, cost thousands of lives each year. Some analysts estimated that a total collapse of the Three Gorges Dam presently built in China could kill as many as 1.3 million people (WBGU, 1999). A series of risk assessments across the world demonstrates an increasing rather than decreasing potential for catastrophe over the last two decades (Barret, 2014).

The probability of such damages occurring is difficult to calculate. This is particularly true for new health threats, since mutations occur completely randomly, even if the likelihood of the threat to materialise is likely to increase. Even calculating the failure probabilities for critical infrastructure has become increasingly difficult, due to the dependencies of failures stemming from operational error, sabotage or terrorism. This makes it hard for risk management institutions such as insurers or regulatory agencies to deal with breakdown risk. In addition, such risks may percolate through almost all types of conventional risk governance policies, starting with individual health insurance to liability legislation and social security systems. The best that risk management agencies can do is to pursue a precautionary, resilience-based strategy (i.e. to limit the catastrophic potential independent of the low probability of a catastrophic release and the decoupling of interconnected risk-inducing activities).

Cluster 2: Globally systemic and pervasive risks

These risks cover those human activities that promote rapid environmental or cultural changes without proper knowledge of all the trigger points that may lead to major system changes. Trial and error, the usual method of testing human interventions into the environment, may be unacceptable because the error is so costly in terms of human lives or money that nobody is prepared to pay for them (for example, experiencing a meltdown of a nuclear power plant or allowing the global temperature to exceed 2 degrees Celsius within a century). In addition, due to the complex nature of these risks, outcomes can often not be associated with direct causes. Therefore, impacts are simulated with computer models as a means to avoid the real trial and error experience. The validity of such modelling efforts, however, remains contested (Keys et al, 2019; Zio, 2018). Such risks are inherently both uncertain and unpredictable. All systems can cope with change if it is gradual enough to allow for adaptability, but the issue with these types of risks is either the speed of change or the effects of unknown or only suspected tipping points (Helbing, 2013; Renn, 2021b; Steffen, Richardson et al, 2015).

The best example is global climate change and other global environmental threats (EASAC, 2013; National Research Council, 2010; Steffan, Broadgate et al, 2015). There is increasing evidence that many natural disasters are being caused or promoted by human-induced global change, in particular climate change. Allowing the mean global temperature to exceed 2 degrees or more will induce severe changes with uncertain but potentially catastrophic outcomes for human civilisation (Arnell et al, 2019). Climate change is only the spearhead of a class of risks that can be characterised as global interventions of humans in natural cycles. The problem here is that the resulting effects are still widely uncertain, but there is also hardly any way for society to avoid being affected in the worst case scenario.

A second example is related to basic technological innovations such as new tailor-made pharmaceuticals, neuro-transmitters, quantum computers or various applications of nanotechnology (Shatkin, 2013). It is a truism that the risks and benefits of new technologies are uncertain as long as the scope of the impacts is still unclear. Problems occur, however, if as stated above, the usual path of trial and error cannot be followed because the error is beyond what societies are willing to pay in terms of a risk premium. This price is determined by two components:

- the preferences of (affluent) societies to tolerate new unknown risks (aversion factor)
- the potential intensity of impacts that might be expected from these new technologies

With respect to nanotechnologies, analysts such as Bill Joy (2000) have warned the public that the impact of these new technologies in terms of social costs will far outweigh the potential benefits (Joy, 2000). Many analysts have been concerned about the prospect of using large geo-engineered interventions to combat climate change (solar radiation management or creating negative emissions), as the negative side-effects might be more disastrous than the desired effects of preventing climate change (Lawrence et al, 2018). Annex 5, p.309, provides an overview of threats and examples of undesired side effects of digital technologies, highlighting potential misuses, dual uses, systemic risks, and potential accidents.

In response to this type of emerging risk, the EU policy tradition is to pursue the precautionary principle or, better framed, the precautionary concept (Aven, 2019; Leonelli, 2020). An ideal institutional management mechanism would be based on the understanding that the precautionary approach does not only regulate according to the potential side-effects, i.e. the known or suspected impacts, but also according to the speed of change. It is not always possible to have control over this speed, and it would take a very courageous effort to pay special attention to slowing down processes, even where the negative impacts are not (yet) noticeable.

The precautionary principle, if well understood, provides an institutional means for increasing reversibility if the processes are found to be more negative than initially perceived (Bennet, 2000). The more ubiquitous, persistent and accumulative a risk appears to be, the more a precautionary approach becomes necessary (Renn et al, 2009). Ubiquity, persistence and accumulations are indicators for irreversibility, and should the alarm be sounded, risk regulators should be mandated to ensure controllability and reversibility. For example, the European regime for nanoparticles in food and cosmetics has not banned their use but has tried to ensure that a gradual introduction into the market will allow for the possibility of retreat should the risks turn out to be damaging (Hellmann-Grobe et al, 2008). Simultaneously, they have introduced financial subsidies to develop new detection and risk assessment methods.

A major constraint with the adoption of the precautionary principle is the potential for arbitrary judgements (Charnley & Elliott, 2000). There is a dilemma between the conflicting requirements for solutions that are fast enough to be innovative and slow enough to be reversible in the face of scientific uncertainty. There are no simple negative/affirmative decisions, but there is a need to develop a set of good criteria for resolving the trade-off between caution and innovation (Kegge & Drahmann, 2020). The EU has responded to this challenge by advocating for responsible innovation (Genus & Iskandarova, 2018). However, the EU still lacks concrete criteria concerning the potential trade-off between innovation with uncertain impacts, and precaution with constraints on uncertain risks. There is a clear need to find better regulatory regimes that can balance speed of change with the necessity of innovation.

High uncertainty risks demand management efforts that are based on incentives and pricing. Private insurance companies may play a significant role here. In addition to judging risks according to the usual parameters of damage potential and probability, other criteria such as ubiquity of hazard, persistence, and reversibility need to be considered (Renn & Klinke, 2016). Such a multi-criteria-analysis can be modelled in principle, yet all insurance companies will have problems with risks where the uncertainty analysis does not provide reliable probability estimates. The central questions for this cluster are: how can society deal with the multi-dimensionality of a hazard, or a combination of hazards? And how can trade-offs be negotiated that are acceptable to most interest and value groups in pluralistic societies?

Cluster 3: Socially induced risks to society

Socially induced risks are understood in this context as the consequences of social actions that impact on human health and the environment, or their perception (excluding genuine social risks such as a lack of education or shelter). The most prominent risks here are war, violence, crime, terrorism and sabotage. These risks have become particularly prominent since the invasion of Ukraine in 2022 and the terrorist attack on the World Trade Center in 2001. Many analysts believe that, apart from infectious diseases, most lives are lost due to human-induced violence (around 13 million fatalities annually due to infectious diseases; 79 000 fatalities annually due to natural hazards; 8000 fatalities due to technological hazards; 2–5 million fatalities each year through violence).[74] Human violence may become even a more prominent risk in modern interconnected societies, given that the infrastructure offers more opportunities for inducing breakdown damages with relatively little effort. Large water reservoirs for drinking water, high buildings, locally concentrated chemical facilities, mass-flow transport lines, large-scale technologies and many other new developments increase the overall vulnerability of societies. Such vulnerabilities invite potential terrorists to take advantage of this situation (OECD, 2003). The probability of terrorist attacks is likely to increase due to (Moghaddam 2010):

- the widening of the gap between the 10% richest and 10% poorest countries (and the same is true for income classes within societies)[75]
- the political tensions due to hegemonial power struggles after the Cold War
- an increase in fundamentalist positions in the world
- the dissatisfaction of particular groups with globalisation and digitalisation processes
- a lack of social integration for a growing number of migrants, refugees and internally displaced people

The attack on the World Trade Center has already been a major challenge to risk management institutions, in particular re-insurance companies (Hartwig, 2002). Most of the targets that are attractive to terrorists represent the 'accomplishments' of capitalist economies. In most cases, these targets are well-insured. The premiums, however, were calculated on the assumption of a low probability of terrorist attacks, if included at all.

Other human-induced risks may be overlooked beyond the deep shock caused by invasions and terrorist attacks. Yet civil war, crime, and anomy (absence of legal

74 Data on natural, technological and health hazards in OECD (2003), pp.14–15; data on violence in Richardson (1990) and Codevilla & Seabury (2006).

75 The Institute for Policy Studies tracks the gap between U. CEO's and American worker The average ratio between salaries for a chief executive and American worker ranges around 350 to one. The average pay in the United States is about $ 20 per hour. The CEO of Wal Mart earns $ 30-million a year, which is $ 15 000 per hour: about the wages of a year-round minimum-wage worker. Taken from: http://chronicle.com/blogs/brainstorm/economists-fail-to-justify-obscene-ceo-pay/25500, (access: July 15, 2014).

enforcement) cost many more lives than terrorism (Lozeno et al, 2013). Most of these risks are not addressed by any risk governance regimes, but the impact of violent behaviour produces many indirect effects, such as an increase in infectious diseases, famines, technological failures and social unrest.

What can be done to develop a suitable strategy for dealing with social risks? The EU institutions should start a clear policy initiative to address some of the underlying causes for social risks, such as growing inequities or the persistent feeling of many people that they have lost agency over their own life (Habermas, 1973; Renn, 2021a). These issues are also explored in this report (6, p.129), looking at principles of equality, trust and participation linked to crisis management. At the same time, risk management institutions should develop a common and proactive strategy to reduce social risks by controlling transboundary criminal organisations, establishing anti-terrorist task forces and including new forms of mediation and violence prevention in all member states. Controlling and implementing regulation on violence and crime is still performed by individual states, but transnational cooperation beyond the common practice of joint efforts to persecute criminals through information exchange and transboundary prosecution is already in place and should be further optimised.

Cluster 4: Amplifier risks

Amplifier risks originate as physical risks, which then cascade into the financial, political and psychological worlds. The effects of these risks might not have as high a physical impact as other risks, such as breakdown risks, but they share the attribute of having a highly symbolic value (Homer-Dixon et al, 2022). These risks tend to become amplified in the form described by the theory of social amplification of risks (Kasperson et al, 1988). The physical impact may be low but the quality or the circumstances of these impacts amplify these consequences in the perception of the observers and move them into behavioural activities that pose a serious damage to society as a whole. They may trigger political repercussion such as the rise of right-wing populism (for example as a response to COVID-19 regulations), social movements (fighting the risks of alleged or real criminal behaviour of migrants) or fearing non-existent or low side-effects of exposure to pharmaceuticals or chemicals (for example, from vaccination).

Amplifier risks are usually characterised by high complexity, uncertainty and ambiguity (Klinke & Renn, 2021):

- **Complexity** refers to the difficulty of identifying and quantifying causal links between a multitude of potential candidates and specific adverse effects (Marshall, 2013). The nature of this difficulty may be traced back to interactive effects between these candidates (synergism and antagonisms), long delay periods between cause and effect, inter-individual variation, intervening variables, and others. It is precisely these complexities that make sophisticated scientific investigations necessary since the cause-effect relationship is neither obvious nor directly observable. Complexity requires systemic assessment procedures and the incorporation of new mathematical tools such as Bayesian statistics, non-linear regression and fuzzy set theory.

- **Uncertainty** is different from complexity. It comprises different and distinct components. They all have one feature in common: uncertainty reduces the strength of confidence in the estimated cause and effect chain (SAPEA, 2019). If complexity cannot be resolved by scientific methods, uncertainty increases. Even simple relationships, however, may be associated with high uncertainty if either the knowledge base is missing, or the effect is stochastic by its own nature.
- The last term in this context is **ambiguity** or ambivalence (Renn & Klinke, 2016). This term denotes the variability of (legitimate) interpretations, based on identical observations or data assessments. Most of the scientific disputes in the fields of risk analysis and management do not refer to differences in methodology, measurements or dose-response functions, but to the question of what all this means for human health and environmental protection. Emission data is hardly disputed. Most experts debate, however, whether an emission of x constitutes a serious threat to the environment or to human health. Another question in this context is: should regulation be confined to avoid significant health effects, or should it be expanded to any measurable effect that could cause some still unknown damage? Again, high complexity and uncertainty favour the emergence of ambiguity, but there are also quite a few simple and almost certain risks that can cause controversy and thus ambiguity.

The main feature of amplifier risks is that complexity, uncertainty and ambiguity are all associated with this type of risk. The causal chain is highly complex, encompassing different types of consequences ranging from loss of human lives to financial losses. Second, the risks are linked to high uncertainty, even indeterminacy. Thirdly, the consequences are evaluated differently depending on social position, status and economic wellbeing. These damages include consumer boycotts, stock devaluation, removal of trust and confidence in risk management agencies and others.

Until now, EU risk management agencies have not adequately addressed these new amplifier risks (Renn, 2022). What is clearly needed is a holistic and systemic concept to characterise, assess, and evaluate these risks. In addition, risk managers need to clarify what type of procedure is demanded for obtaining effective, efficient and politically feasible risk reduction results for coping with this special risk cluster.

How can the EU deal with these amplifier risks? An idealised societal response to these risks would be the formation of cross-disciplinary risk management taskforces, situated within existing European institutions such as the Integrated Political Crisis Response or the European Food Safety Authority. These taskforces would be required to link the physical, financial and political (governance) links between the risks. The socially and culturally amplified risks cannot be addressed in isolation from the physical impacts, but without the assessment of their social and cultural repercussions the risks would pass unnoticed. Institutional fragmentation and disciplinary thinking pose constraints on this type of societal risk management structure. In addition, the rationality of decision-makers and risk managers tends to underestimate the symbolic value of certain risks.

4.4. Risk perception

Many risks that modern societies face are complex, difficult to detect by human sensory organs, and often outside of the realm of everyday experience. These risks get prominence in society by processes of risk communication; experts and risk managers inform the public about these risks and there are multiple commentators from different interest and value groups in society that contribute their assessment and evaluation, as part of the public discourse. This plurality of knowledge claims (including fake news) and the lack of familiarity create a discourse context in which individual and social risk perceptions become more and more important, particularly in a democratic society in which policymakers rely on public support for their policies and decisions.

Research on risk perception provides insights into the mental models of individuals and the processes related to the judgement of risk acceptability. Policymakers need to integrate the public's risk perceptions and concepts of acceptability into decision-making in order to make effective, efficient, fair and morally acceptable decisions about risk (Renn & Schweizer, 2009; Rosa et al, 2014; Schweizer & Renn, 2019).

Firstly, it is important to state that the concerns of the affected public need to be considered in the decision-making process and that these concerns should be the leading principle for collective action (Renn, 1998). This is also stated in the Aarhus Convention,[76] which mainly argues that: "[member countries should] give the public the opportunity to express its concerns and enable public authorities to take due account of such concerns". In reaching towards this objective, research on risk perception helps in identifying public concerns, feelings, and perceptions on various levels. Different factors such as the message, its source, the channel through which it is sent, and the target of the message can have a strong impact on risk perceptions. To design proper and effective risk communication as well as decision-making process under risk, insights from risk perception should be considered (Williams & Noyes, 2007). Risk perceptions represent the values and preferences of the public concerning risk and safety. Therefore, they must be included in decision-making processes within democratic societies (Pidgeon, 1998).

76 https://ec.europa.eu/environment/aarhus/

Secondly, risk perceptions in the public are diverse. Risk-related policymaking requires trade-offs (i.e. relative weights of different evaluation criteria such as health impacts, environmental harm, economic losses or targets such as capital assets, ecosystems, buildings, social equity and others) which depend on the context and the nature of the hazard (Renn, 2008). Risk perception studies are a significant step towards choosing different aspects that raise concerns. For instance, the 'knowledge deficit model' suggests that if people have more knowledge about a certain technology or activity, they are more likely to accept it. This implies that factual knowledge suffices for risk acceptability. It has been argued, however, that knowledge is not a significant predictor, or that it is a very weak predictor of risk acceptability (Retzbach et al, 2011). In fact, multiple factors influence risk perception and acceptability. Policymakers must take account of the multidimensionality of risk perception.

Thirdly, risk perception studies are crucial for designing and evaluating risk communication programmes (Renn, 2008). When communication does not address the concerns of the targeted audience it may contribute to a reduction of public trust in scientists and risk managers, who may be seen as ignorant of the needs of laypeople (Fischhoff, 2012). To address this complexity, risk perception studies and results can assist risk communication professionals in becoming aware of and responding to the concerns of the information receivers, which could then result in creating or restoring trust. Furthermore, risk perception research can bring forward useful additional information from the different perspectives of laypeople in order to co-produce an overall superior risk analysis (Pidgeon, 1998).

Fourthly, risk perception studies can serve as the foundation of more inclusive risk governance models for determining the acceptability of risks (cf. Renn and Klinke 2016; Renn and Schweizer 2020). The US National Research Council has addressed the issue of combining perceptions and collective judgements on the acceptability of risks and recommended a combination of analytic rigour based on comprehensive peer review and deliberative argumentation among a broad representation of stakeholders and representatives of the various publics (National Research Council, 1996; 2008). The concept of analytical-deliberative processes is one suggestion for overcoming the technical, as well as the issue-related biases of risk perception, by suggesting policymaking processes that are based on the inclusion of experts, stakeholders and the general public (Hajer and Waagener, 2003; NRC, 2008; Renn, 2008, pp. 284ff; Klinke and Renn, 2014; SAPEA 2019). Such processes could serve as a tool for understanding the complexities of risks, hazards and policy decisions relating to 'wicked' problems (Sprain & Black, 2018).

Fifthly, risk perception can also help to add local knowledge and context information to formal risk assessments and to make risk management more adaptive to local conditions (Renn 2010). If risk management relies on local capabilities and resources abstract assessment and management models may not be as effective as anticipated. Using the case of Katrina, Frickel & Vincent (2007) demonstrated that ignoring local risk perceptions by disaster experts and emergency planners can aggravate disaster impact and alienate local residents.

In order to bring together risk analysis and deliberation, it has been suggested that analysts and policymakers work together by using participatory modelling as a tool (Mendoza and Prabhu, 2006; Wiek et al, 2012). Thus, scientific knowledge (e.g. computer modelling and simulations) can be fused with stakeholder/lay knowledge (e.g. what needs to be modelled) for creating models that stakeholders can use for designing their own suggestions or proposals for policymaking (Squires & Renn, 2011). Participatory modelling contributes to improved collective decision-making by combining social and technical elements, thus fostering mutual understanding, creativity, and social learning (Henly-Shepard et al, 2015).

4.5. EU risk governance: the need for better management strategies to cope with systemic risks

Risk assessment and management have a long tradition within the EU, as reflected in the Better Regulation Toolbox (2021). They are carried out in numerous domains, across the Commission and EU agencies like the European Food Safety Authority, the European Medicines Agency, the European Union Aviation Safety Agency and the European Union Agency for Cybersecurity, to name but a few, often with the support of the Joint Research Centre (JRC), which recently produced its *Recommendations for National Risk Assessment for Disaster Risk Management in the EU* (2021) and has built numerous tools including INFORM.[77] A JRC Disaster Risk Management Knowledge Centre was also recently created to provide scientific support for policy development and implementation.

Broad descriptions of the methodologies employed are included in the two recent documents mentioned above, mostly relying on the standard ISO31030. However, a tendency to use more qualitative and semi-quantitative versions like risk matrices is appreciated (Vlek, 2013); although it requires more sophistication and effort, the high stakes involved would suggest the more frequent use of the more quantitative probabilistic versions, as further explained in 7, p.172. In addition, a somewhat too fragmented risk management picture emerges within the EU, suggesting further integration to be necessary, for example between the foresight and risk management initiatives recently introduced.

77 https://drmkc.jrc.ec.europa.eu/inform-index

Looking at risk management performance in the EU in recent decades, there has been clear progress in risk reduction. Many risks which had threatened human wellbeing during the past decades have been identified and reduced significantly, such as occupational health risks and those related to transportation and mobility (Renn, 2015). These conventional risks and can be regulated effectively within a specific regime that is contained in time and space and linked to a specific sector. Consequentially, casualties related to occupational risks, car accidents, technological incidents or other safety failures decreased significantly. The largest declines in risk exposure from 2010 to 2019 were among a set of risks that are strongly linked to improvements in social and economic development and more effective regulation, such as household air pollution and unclean drinking water (Lucas, Renn, Jaeger et al, 2018). Global declines also occurred for tobacco smoking and lead exposure (Vos et al, 2020). Along with medical advances, risk analysis has been successful in developing public regulations and institutions that have been able to reduce risk so considerably that most countries in the world still experience a year-on-year increase in life expectancy. Between 2000 and 2016, global life expectancy at birth, for both sexes combined, increased by 5.5 years, from 66.5 to 72.0 years (WHO, 2019). In Europe, these numbers are even more impressive; in 2020, life expectance has increased to 78 years for male and 83 for females.[78]

Familiar procedures of risk assessment and risk management have thus resulted in major risk reductions with respect to conventional risks. However, these procedures are not sufficient for handling risks that transgress domain boundaries, that are embedded in a complex relationship with socioecological, socio-technical or cultural transformations, and that tend to lead to a series of secondary and tertiary impacts. Those risks provide a major challenge to scientific methods of risk assessments as well as to effective measures for risk management and regulation. They have been subsumed (as mentioned earlier) under the category 'systemic'. Systemic risks are complex, transboundary and nonlinear risk phenomena with potential tipping points (Lucas, Renn, Jaeger et al, 2018; Renn et al, 2020). They are likely to cause cascading events that lead to negative effects across various societal domains (Kaufman & Scott, 2003). This feature has been particularly highlighted by analysts of the financial markets and their collapse in 2008 (Liow et al, 2018). Part of the challenge also is that there is often a lag in public perceptions and regulatory effort, despite the potentially devastating effects of systemic risks (Schweizer, 2019).

Systemic risks endanger the functionality of systems of critical importance to society and their scope in time and space. The impacts may extend beyond the system of origin to affect other systems and functions (Renn, 2016). They include functionality losses at the macro level involving multiple agents at the micro level. In technical systems, agents may be part of a technical infrastructure, such as generation, transmission and control units in

78 https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220427-1

the electrical grid. The systemic risk in this case is, for example, the breakdown of the grid as a whole or the release of toxic material due to the failure of electric security systems. In ecosystems, agents such as harmful chemicals interacting with a fish population in a river constitute a systemic risk of irreversible destruction of the population. In the global climate system, interacting agents comprise solar radiation, clouds, greenhouse gases, the oceans and the earth's surface, which in conjunction with each other constitute the systemic risk of climate change (Renn et al, 2021). In social systems, humans are the agents interacting with each other and with the system´s environment, with systemic risks manifesting themselves in radical movements that lead to social unrest and revolutions (Helbing, 2013).

Given these properties of systemic risks, managers and regulators of systemic risk face a series of wicked challenges. Firstly, due to the uncertainties and complex causal structures, it is extremely difficult and often impossible to quantify cause-effect relationships, in particular when estimating the potential effect of human intervention into complex and dynamic natural systems (Schill et al, 2019). Often, well-meant interventions turn out to be useless or even counterproductive, because side effects were not known or not considered. This often leads to either inaction (since we do not know what works) or blind activism (something will work in the end).

The dominance of deep uncertainty gives rise to a multitude of competing knowledge claims and models that may contradict each other or lead to conflicting policy implications. Risk managers and regulators face a hard time to legitimise costly action when the science appears as being ambiguous and multi-faceted (Cairney & Oliver, 2020). The need for justifying measures to reduce systemic risks contrasts even more with the occurrence of fake news and post-factual confusion which has led to a lack of consensus on political priorities and a de-legitimization of political action (Perl et al, 2018).

Since systemic risks are closely coupled with risks in other domains, small incidents in one of the coupled systems can lead to major repercussions in another domain (Cozzani et al, 2005). These outside triggers are often unknown or were located out of the boundaries of one's own assessments so that they tend to be ignored.

While in linear risk fields (such as car accidents or toxic substances) there is normally a limited list of triggers that could produce major harm, systemic risks can be caused by many potential (unrelated) causes, of which each one is rather unlikely to occur (Allen & Carletti, 2013). However, there is high probability that one of the many unlikely events will happen within a reasonable timeframe. One could claim that there are at least a million events with a probability of one in a million that have the potential to cause major systemic damage. Since each of these are difficult to detect and observe, risk managers have little or no experience with them and are forced to monitor the environment with great care and scrutiny to register small changes that could lead to major disaster.

Similarly, in highly interconnected systems, the likelihood that several triggers occur at the same time is rather high (polycrises). So risk managers and regulators need not only look for unexpected small changes in system-environment-interactions but also for simultaneous failures in different systems that are functionally connected (Pearson & Mitroff, 1993). For example, a natural disaster might coincide with a breakdown of the communication system, which actually occurred during the Bhopal crisis (Bowonder, 1987).

Deep uncertainties, non-linear causal relationships and, in particular, the occurrence of tipping points render the dominant human learning mode of trial and error as ineffective for managing systemic risks. Until the tipping point is reached, the feedback is mostly positive and rewarding, but when the tipping point is exceeded, the damage is often irreversible and learning comes too late (Renn, 2021b). However, market economies and representative democracies are by design based on trial and error. Companies go bankrupt if they offer the wrong product, politicians lose elections when they do not deliver what voters demand. Why should a company put major efforts in producing a CO_2-free product when competitors can sell their CO_2-rich product without any problem to the customers? Why should a politician place constraints on human consumption when the negative impact of climate change will occur much later than his or her time in office? To date, we lack a policy framework that stipulates learning and adaptation before negative effects become visible.

Finally, risk managers and regulators face an increasingly pernicious societal context for decisions about risk: in addition to the confusion about the factual nature of truth claims, there is an increasing loss of trust in the problem-solving capacity of governments, doubts about the trustworthiness of regulatory agencies, and questioning of the moral integrity of the main actors involved in risk analysis and management (Mewes et al, 2021; Siegrist, 2021). These problems can shift the burden of taking necessary steps towards handling systemic risks properly onto decision-makers in corporate and public risk management.

4.6. Requirements for good governance of systemic risks

Risk governance denotes both the institutional structure and the policy process that guide and restrain collective activities of groups, societies or international communities to regulate, reduce or control risk problems (Florin and Nursimulu 2018). During the last decades, risk governance has been shifted from traditional state-centric approaches, with hierarchically organised governmental agencies as the dominant space of power, to multi-level systems in which the political authority for handling risk problems is distributed to separately constituted public bodies with overlapping jurisdictions (Skelcher 2005; Klinke and Renn 2021). Institutional diversity can offer considerable advantages when systemic risk problems need to be addressed because, firstly, risk problems that impact several domains can be managed at different levels; secondly, an inherent degree of overlap and redundancy makes non-hierarchical adaptive and integrative risk governance systems more resilient; and thirdly, the larger number of actors facilitates experimentation and learning (Renn, 2008). Disadvantages refer to the possible commodification of risk; the fragmentation of the risk governance process; costly collective risk decision-making; and the potential loss of democratic accountability.

Given the challenges mentioned above, risk governance is trapped between two contrasting dimensions: (i) integration versus specification and (ii) leadership versus popular support. The first dimension addresses the trans-sectoral and transboundary aspect of systemic risks and its complex intricate structure (Homer-Dixon et al, 2022). On the one hand, advanced interdisciplinary expertise is required for understanding, modelling and governing each systemic risk separately and, on the other hand, each risk cannot be fully grasped without understanding its connection with its environment. The challenge of literacy and efficacy in both tasks may overstretch any assessment team or risk management agency. The second dimension relates to the democratic legitimisation that is required to promulgate and enforce risk regulations. If systemic risks are underrated in the public and trial-and-error methods prove to be unfit for taking regulatory actions, there is not much chance of getting widespread approval for any risk reduction programme. However, if political leaders step forward without public support and take on a leadership role, they may be ousted from office at the next election.

However, these dilemmas are not insurmountable. Firstly, the distinctive interconnectivity of systemic risks is not only a problem but also a great opportunity. If risk experts can locate intervention points that have impact on many related risk domains at the same time, they can trigger a positive risk reduction cascade that reinforces itself (Sharpe & Lenton, 2021). Such powerful trigger points are, for example, located at the nexus between energy, water and food. Using solar energy and digital control measures for pumping and reusing water resources for irrigation of land that produces climate-adjusted food with little emission potential could benefit climate, world nutrition, planetary health and biodiversity at the same time. It would produce income for farmers and could provide support for countries of the Global South.

Given these opportunities, effective risk governance requires a systems approach that makes a major investment into a better understanding of the fabrics of complexity and stochasticity in order to identify powerful intervention points with positive risk reduction cascades. New tools developed by experts of complexity sciences and systemic risk analysts include 'black swan scenarios' for testing the robustness of risk-absorbing systems (Batrouni et al, 2018), morphological-permutation studies that systematically explore possible interactions between the causal factors and test the sensitivity of each scenario (Homer-Dixon et al, 2022), and reverse stress tests that start with the analysis of multiple vulnerabilities as a conceptual tracer for potential interventions (Grundke, 2011).

To establish a framework for good EU governance in these new clusters of risks and disasters, a stringent, logically well-structured and promising approach is required. Risk and crisis managers need substantive but flexible guidelines that provide coherence and effectiveness throughout the EU, but allow a flexible response on regional and national levels. Good governance seems to rest on three components: knowledge, legally-prescribed procedures and social values (Berg-Schlosser, 2004). It has to reflect specific functions, from early warning (radar function), to new assessment and management tools leading to improved methods of effective risk communication and participation. Criteria for good governance have been discussed in many contexts (Biswas et al, 2019; Hubbard, 2000). They need to be transferred to risk-related issues and operationalised so that best practices can be identified and recommended. Central items to be addressed are sound scientific expertise, consistency and the coherence of management measures, non-discrimination, proportionality and examination of cost-benefit. In addition, governance structures should reflect criteria such as transparency, openness, accountability, effectiveness, and mediation of different or conflicting interests (van Doeveren, 2011).

The promises of new developments and technological breakthroughs need to be balanced against the potential evils that the opening of Pandora's box may entail. This balance is not easy to find as opportunities and risks are merged in a cloud of uncertainty and ambiguity. The dual nature of risk as a potential for technological progress and as a social threat demands a dual strategy for risk management and regulation. It will be one of the most challenging tasks of the EU as well as national risk and disaster management institutions to investigate and propose more effective, efficient and reliable methods of detecting early signals of these risk clusters while, at the same time, ensuring the path towards new innovations and technical breakthroughs.

5. Science advice in times of crisis

5.1. Summary and key messages

The scoping paper asks for ways to improve science advice during crises. It also requests evidence about the impact of regional research and innovation on EU crisis management.

In response, this chapter covers three main areas:

- the function of science advice, especially during a crisis
- the needs of policymakers
- means of improvement in science advice

Broadly, science advice has three main functions, each with its strengths and shortcomings:

- **Analytic advice** is the classic form, providing policymakers with knowledge and factual insights.
- **Goal-oriented research** is knowledge that policymakers can use as means to achieving pre-determined goals or solving problems. It informs policymakers about the likely effects and side-effects of different policy options for reaching a specific target or benchmark.
- **Catalytic advice** involves science advisors gathering diverse knowledge sources and performing the role of 'honest broker'; they design optimal communication and participation processes to facilitate necessary transformation. It means that advisors present knowledge in a comprehensible form and facilitate discourse between stakeholders, including policymakers and the general public.

These three functions should complement each other in highly transdisciplinary processes, to strengthen crisis preparedness and management.

In considering the needs of policymakers during a crisis, it is useful to distinguish five functions, or types of needs. These are:

- **Enlightenment:** being informed about the state-of-the-art on factual issues and causal/functional relationships that form reliable knowledge
- **Orientation:** gaining a more in-depth understanding of a challenge or a problematic situation, including how it is shaped by circumstances and context and how it is expressed in visions and plans for future actions

- **Strategic planning:** providing strategies for reaching a predefined goal or objective, and ensuring the side-effects of each strategy is transparent to the decision-maker, including the uncertainties and ambiguities (trade-offs)
- **Integration:** bringing various forms of knowledge into a coherent framework and composing a consistent framework for action
- **Co-creation of knowledge:** engaging stakeholder representatives (science, civil society, politics, private sector and the affected public) in designing new insights or options for innovative solutions to a given problem or challenge.

In a crisis, scientific expertise can be used in several ways. These can include identifying problems or situations that demand collective action; generating options or instruments that are proven to be effective in dealing with a specific problem; investigating the implications of various policy options; and informing policymakers about the potential side-effects of each option.

In a crisis, speed of response is crucial, yet the collection and processing of data can be extremely challenging. It is therefore crucial to start with crisis preparedness before a crisis occurs There are still no commonly-shared European infrastructures or platforms with data standards for collection and sharing, or for the sharing of tools, models and insights. Nor is there a common standard on what constitutes 'evidence'; this report therefore provides a working definition (see section 1.4, p.30).

Crisis preparation is key. However, establishing structures that make best use of expertise and knowledge before crisis strikes (preparedness) is a major challenge for the EU. Each member state has its own emergency and disaster concepts, and there is no common understanding among and between European countries on how to best organise crisis preparedness and management beyond national boundaries. It would be advisable for the EU to develop a pre-crisis consultation board, in which scientists and experts from different fields form a major component.

Finally, in response to the scoping paper, this chapter points out that although there are many EU-funded research programmes on crisis management and related areas, the evidence about their impact is highly project-based and sectoral. There is little evidence on the impact of regional research, and this would need its own dedicated project.

This chapter offers the following key messages and ways forward:

- There are a number of shortcomings in terms of research and infrastructure related to crisis management. They include: a lack of European transdisciplinary research on the interlaced issues of modern crises and inter — and transdisciplinary advice for policymaking; a lack of funding for rapid disaster research in the immediate aftermath of crises and disasters, with important data gaps that hamper policy advice; a lack of transdisciplinary infrastructure and standards by which to formulate robust policy advice across different sectors or disciplines.

- The policy-science nexus requires continuous normative reflection on a number of issues. They include: what is at stake and what is desired; the integration of the five essential functions of scientific knowledge into policymaking; the inclusion of non-scientific knowledge and values; and the creation of appropriate discourse space for designing effective, efficient, resilient and socially-cohesive solutions.
- To assure a consistent, coherent and credible approach to a transboundary disaster,that respects context-specific crises, a network of regional disaster study institutes and advisory boards, collaborating with EU bodies, may be a challenging yet promising way forward. Major scientific institutions can play a role in strengthening the policy-science nexus for crisis management, by arranging highly interdisciplinary, transdisciplinary, cross-sectoral, groups of advisors.

5.2. Introduction

In a crisis, policy can be informed by science through existing published research and by soliciting science advice through specific mechanisms that bring together scientific expertise. Given the multitude of EU-funded research programmes on crisis management, cybersecurity, risk and resilience as well as organisations such as the Joint Research Centre, the Scientific Advice Mechanism and SAPEA, European and national Academies and numerous science associations, it is difficult to specify the nature and structure of science advice to the EU governing bodies with respect to risk and crisis management. There have been significant investments into regional and European research (e.g. via the Secure Societies programme). Yet the evidence about the impact of these programmes is very project-based and sectoral, where the different research projects result in specific websites, platforms, tools or applications. There is currently too little comprehensive evidence to show how and in how far regional research has impacted the EU's crisis management. To understand how the results of these projects has influenced the EU's policies, there would be a need for a dedicated review and evaluation which is beyond the scope of this paper.

In addition, the EU comitology provides the specific expertise of national agencies on various European challenges including natural disasters, food crises, environmental risks and many other risk and hazard related topics. All of these organisations have in common that they provide advice on three major levels: (i) analytic insights, via empirical research and scientific modelling and simulation; (ii), goal-oriented advice, based on developing scenarios, simulations, models or horizon-scanning activities for reaching predefined political goals and (iii) process-oriented, catalytic advice for facilitating consensual agreements and institutional support within a complex web of vertical and horizontal decision-making structures (SAPEA 2019; Renn 2021). These three generic functions apply to all kinds of scientific advice to policymakers, but they are specifically important for situations of crisis and risk management. Given the high level of uncertainties in dealing with risk and crisis, the time constraints (particularly in crisis situations) and the need to integrate scientific, practical and local knowledge in designing appropriate strategies and responses, it is crucial for the consultation process that scientists are fully aware of the role they are supposed to play: either to provide causal and functional knowledge about triggers and likely impacts, to inform policymakers about the effects and side-effects associated with risk or crisis management options and to design appropriate implementation and communication strategies to make policy responses effective, efficient and fair. These three basic functions are further explained in what follows.

5.3. Background: policy advice

The analytical function of policy advice for crisis management

The first function of policy advice is based on a classical understanding of scientific insights for understanding causal and functional relationships. The goal is to convey valid knowledge about complex relationships between drivers or causes of disaster or crisis, consequences of crises and intervening variables. The assessment of cause-effect relationships is particularly tricky when multiple causes and many intervening variables need to be considered. Threats such as pandemics, multiple environmental stressors or violent behaviour defy simple causal explanations but demand sophisticated modelling and simulation. By uncovering causal or functional relationships, policymakers gain a better understanding of the factors that cause, aggravate, attenuate, mitigate or reduce crises. Policymakers are thus provided with the necessary background knowledge to inform themselves on factual insights and become acquainted with the state of systematic knowledge in crisis and disaster research. This enlightening function of science is based on the ideal of value-free advice, abstracting from interests, social preferences, and political contexts. This should not be seen as a sign of 'ivory tower' thinking, as it is so often caricatured in the public media or critical reviews of science, but as a necessary and indispensable corrective against wishful thinking and ideological blinkers (National Research Council, 2012; OECD, 2015). Science is capable of producing findings independent of political beliefs, ideologies and interests that help to prevent unpleasant surprises for all those involved.

In the natural sciences in particular, the aim is to analyse causal or functional processes and mechanisms that illuminate the complex relationships between natural activities (such as earthquakes, floods) and human intervention and actions (such as planning and implementing settlements, releasing greenhouse gases). Analogously, social scientists seek to better understand interactions between the behaviours of people, organisations, and societies and to identify functional relationships between triggers of crisis, and institutional as well as behavioural responses. The humanities are more concerned with interpretations within the context of the meaning of historicity and culture; but even in the humanities, there is a canon of recognised methods such as hermeneutic or reasoning by analogues for deriving findings and insights in a methodologically stringent manner. So, all disciplines can contribute to crisis and disaster research and provide policy advice. This is also in great demand since almost all complex problems or questions in the context of crisis and disaster research cannot be understood on the basis of one discipline alone. Rather, an integrative approach is required that simultaneously illuminates the various aspects of the phenomenon to be understood and, above all, captures them in their interactions.

The results of classical research provide important insights into causal or functional processes that policymakers need to know in order to assess the magnitude of the risk or the pending disaster and evaluate the effectiveness of potential countermeasures.

The problem with the classical understanding of research is primarily that, in the case of complex and stochastically interacting relationships, no clearly causal nor even a functional understanding of the relationships is often scientifically accessible, even with new methods of social data-mining (Spiegelhalter & Riesch, 2011). In addition, even knowledge about functional interrelationships rarely allows a direct translation into social or political action. For example, one might be able to identify the particularly effective incentives for mitigating climate change through experiments in the laboratory. However, when transferred to everyday political life, these incentives may not be effective at all, because the framework conditions do not match the experimental context conditions or because there are other political efforts that weaken all the selected incentives in their effect. Finally, in a concrete implementation process in the context of a multi-level crisis, there are always many actors working simultaneously in different contexts, whose interaction can usually only be inadequately described or even less be predicted by scientific methods.

The goal-oriented function of policy advice

To overcome the shortcoming of the lack of political implementability, there is a second concept of scientific advice, which can best be described by the term 'goal-oriented research' (advocacy or instrumental science) (cf. Nelson & Vucetich 2009; Meyer et al, 2010). The result is knowledge that policymakers can use as strategies for achieving goals or solving problems. Particularly in crisis situations, policymakers need a quick and reliable assessment of the effects and side effects of various intervention options, as well as scenarios about what is likely to happen when different strategies are pursued. The goal is either to provide science-based solutions to reach specific targets or to address specific problems that emerge during crisis situations. Goal-oriented scientific advice depends on a consensus about the goals and objectives that policymakers associate with problem solving or crisis management.

In many cases, this may be based on an implicit consensus of society or may have been negotiated as part of a political discourse (for example, specific goals for dealing with the side-effects of pandemics). The common characteristic of goal-oriented research is to provide options or proposed solutions for policymakers from areas of politics, business and civil society that, as far as possible, meet specified goals within the specified timeframe or help solve specific problems in a way that is appropriate to the subject and compatible with the desired state of affairs. Ideally, not only are the various options researched, but also their possible (positive and negative) side-effects, in order to identify conflicting goals for the policymaking bodies to consider and to design possible compensatory measures in the event of unavoidable negative side-effects. Scenario methods, horizon-scanning, simulation and other forms of future options creation and assessment are the most popular tools to do this. Thus, science here is no longer driven by curiosity alone, but is intended to provide strategic or instrumental knowledge that helps decision-makers achieve given goals as effectively and efficiently as possible (Horton et al, 2016).

The problem with the goal-bound concept of research is the tight corset of goal-setting. It is possible that there are other objectives that, at a higher level, could better implement the intentions associated with the objectives. One could imagine, for example, that replacing potentially catastrophic technology might be a better alternative than optimising the safety precautions of the technology.

At the same time, there is always a danger with the target-based variant that, in the conflict between the achievement of the target and scientific research, loyalty to the targets will carry more weight than loyalty to the methodological rules of knowledge discovery in the respective sciences. This is compounded by the fact that goal-oriented research is often carried out by scientists who themselves share these goals. Even with the best will, there is always the danger that the respective research teams will pick out the signals and results from scientific research that support the predefined goals, and will studiously overlook the negative or ambivalent signals or downplay their significance (Koslowski, 2013; Nielsen, 2001).

The catalytic function of policy advice

The third and last contribution of science for policymaking is best described by the metaphor of 'catalysis' (Renn, 2021c). The term is common in the natural sciences, especially in chemistry, to describe the influence of a substance, the so-called catalyst, on the reaction rate (positive or negative) of a chemical reaction process, without itself entering into the reaction result. Transferred to a science advice context, the advisors assume the role of the 'catalyst'. Their task is to systematically collect the knowledge necessary for a solution, from science and also from other sources of knowledge, to reorganise it and to process it for the purpose of facilitating mutual understanding and orientation for action (Godemann 2008). Above all, the aim is to identify potential conflicts, to reveal the underlying knowledge assumptions as well as the associated values, interests and preferences, and to develop joint approaches to solutions based on robust knowledge, generally accepted normative principles and legal provisions, and a fair negotiation of interests (Bammer et al, 2020). The catalytic understanding of science is more than just a new orientation of the social sciences, and especially the communication sciences, toward conflict management and discourse. It places science in the role of an 'honest broker', a mediator between competing truth claims, options for action, and moral justifications of distribution options for public goods and burdens (Pielke, 2007; SAPEA, 2019). Such a role is particularly crucial in risk and crisis management, since interventions in both fields will affect groups interests, often imply restrictions on personal freedom and necessitate reallocation of public resources. In such situations of conflicting values, interests and convictions, scientists can plan an integrative role, discerning fake news from real news and assessing the impacts of different policy options. Furthermore, the systematically-gathered elements of knowledge are transformed into a form that is understandable and comprehensible to all policymakers, so that an appropriate and value-based discourse can be conducted. In this discourse, the various knowledge carriers meet with the knowledge users and discuss the initial situation, jointly reflect on the different views of the problem (frames) and develop appropriate solution options that are factually correct (within the boundaries of uncertainty and ambiguity) and aligned with consensual values of society. It is precisely this task that is central to the successful design of a policy style that is based on evidence and comprehensible normative justification, as expressed in the concept of analytical-deliberative discourse, which combines the methodological rigour of scientific research with the argumentative rationality of deliberative judgement (National Research Council, 1995; Renn, 1999; SAPEA 2019). Catalytic contributions specify the most appropriate institutional policy designs, initiate and propose effective forms of stakeholder and citizen involvement programmes and mediate between science, policymaking and the general public.

The catalytic science team then acts as an impartial, but competent designer of a discourse with all those parties who can either contribute their own knowledge to the problem under discussion or who as users want to use this knowledge. Ideally, with the help of the catalyst, a better, possibly innovative solution can evolve which is understood by all knowledge bearers as being compatible with their own understanding of the issue and which is judged to be particularly desirable compared to other options. The special contribution of catalytic research is the development of promising communicative methods and practices that systematically prepare scientific knowledge for a successful understanding between science policymakers and society and support a co-generation of knowledge in deliberative discourse (Chambers, 2003).

The concept of catalytic research also has a number of problems and deficits. First of all, it only collects factual knowledge without contributing to it itself. Catalytic research thus relies on at least one of the other two concepts (analytical or goal-based) to bring appropriate expertise to the process. Furthermore, the question of successful moderation and conflict management is not only a question of knowledge based on scientific methods, procedures and testing methods, but also of communicative competencies and skills that non-scientific actors can contribute just as well or perhaps even better.

In short, all three concepts of scientific research (analytical, target and catalytic) complement each other and have overlaps at the edges, but are clearly distinct in their functions.

Transdisciplinarity: integration of the three concepts

The implementation of an evidence-based and, at the same time, democratically-legitimised model of scientific advice for policymaking requires an active integration of the three scientific contributions in order to adequately consider scientific knowledge, experiential knowledge, and societal values and interests in designing appropriate policies. This is exactly the goal of transdisciplinary research (Wickson et al, 2006; Hirsch Hadorn et al, 2006). It involves three important impulses:

First, it is crucial for the societal discourse on crisis prevention and management to use the authority of science to test truth claims and differentiate 'fake news' from 'true news'. This requires teams of researchers working analytically to equip policymakers with the appropriate factual knowledge and answer questions according to scientifically-accepted standards. Here, the ideology-critical function of science is required to uncover misconceptions based on wishful thinking, intuitively plausible but often misleading rules of thumb and plausibility assumptions (McIntyre, 2018.).

Secondly, policymakers need experts who can identify realistic ways of achieving the EU-wide goals of crisis and disaster management, in order to meet these goals as effectively and efficiently as possible, using legal instruments and focusing on those options with the least number of negative side-effects. The desired expertise here is closer to the problems to be solved and, especially in complex and uncertain decision contexts, helps to design scientifically-robust courses of action and assess their compatibility with legal requirements and their vulnerability with respect to possible negative side effects (Bunders et al, 2010).

Third, political decision-making processes are increasingly based on a discursive treatment of problems and their possible solutions with the participation of stakeholders and the affected publics. This discursive treatment is useful and necessary because of the uncertainty and complexity of scientific problem description and analysis, in particular related to complex risk and disaster scenarios. In addition, the increasing diversity of assessments, interpretations and value assignments requires a discourse within society that promotes integration. This is where the catalytic form of policy advice comes into place.

Ideally, the three concepts of scientific research complement each other. The integration of the three contributions of science (analytical, targeted and catalytic) form the core of a successful and effective cooperation between scientific bodies (national as well as European) and the policymaking arenas, at all governance levels. This could lead to improved processes of eliciting structured expert judgement and a policy advice mechanism that develops the necessary tools for crisis preparedness and crisis management.

5.4. The role of scientific expertise and R&I in crises: lessons learned

The role of evidence

Scientific expertise is essential for assisting policymakers in assessing options for crisis management and emergency planning (Parkhurst, 2017; SAPEA, 2019). First, scientific expertise can identify problems or situations that demand collective action, even on the scale of major disasters or crises. A good example was the observation of ozone depletion due to the release of chlorofluorocarbons into the stratosphere, a process that was basically unrecognisable for non-experts and relied on scientific instruments and methodologically-driven research. Second, scientific expertise can assist in generating options or instruments that are proven by rigorous methods of testing to be effective for dealing with a specific problem. A good example here is the development of vaccines against a pandemic such as the COVID-19 crisis. Third, scientific expertise can be used to investigate the implications of various policy options and to inform policymakers about the potential side-effects of each option. An example here might be a comparative review of flood management options, ranging from building higher levies and dams to resettling people out of the danger zones.

Scientific advice rests on the assumption that all insights from science are based on proven evidence. It is widely recognised that, to be rational, decision-making must be well informed (Poot et al, 2018). This usually means that it must take account of the evidence of past events and the experience of managing them. As a fully-fledged concept, evidence-based practice originated in medicine (Reynolds, 2000). Clinical decisions need to be made in awareness of previous histories of whether procedures worked, what caused particular pathologies and syndromes, and so on. Medicine needed to learn from both its past successes and its mistakes. Other fields of human endeavour soon adopted the same approach and began systematically marshalling evidence, synthesising and analysing it, and feeding the results into the decision-making process. In crisis management, which is characterised by highly dynamic evolution of the situation, and by the involvement of multiple disciplines, there is still no common standard on what constitutes evidence. Therefore, a working definition of evidence in this report is provided in section 1.4, p.30.

The functions of scientific evidence for crisis management

In a policy arena, scientific experts are called upon to use their skills and knowledge for identifying, selecting, assessing and evaluating different courses of collective action. Since such advice includes prediction of the likely future consequences of political actions, experts are also in demand to give advice on how to cope with uncertain events and how to make a prudent selection among policy options, even if the policymaker faces uncertain outcomes and heterogeneous preferences (Cadiou 2001, p.27). In addition, scientific expertise is required as an important input to designing and facilitating communication among the different stakeholders in debates about technology and risk.

In order to make this range of contributions to policymaking more tangible in designing the interplay between science and policymaking in the context of crisis management, it is useful to distinguish five functions that reflect the needs of policymakers with respect to scientific input (SAPEA 2019):

- **Enlightenment:** being informed about the state-of-the-art of factual issues (descriptions) and causal/functional relationships that form reliable knowledge (for example, the effectiveness of different vaccinces for protecting individuals against COVID-19)
- **Orientation:** gaining a more in-depth understanding of a challenge or a problematic situation, including how the challenge is shaped by circumstances and context and how it is expressed in visions and plans for future actions (for example, addressing the crisis of heatwaves due to climate change by providing scenarios or foresight assessments of the problem)
- **Strategic planning:** providing strategies for reaching a predefined goal or objective that meet the purpose and for making side-effects of each strategy transparent to the decision-maker, including uncertainties and ambiguities (trade-offs) (for example,

developing and assessing various strategies to make people and regions more resilient against heatwaves)

- **Integration:** bringing various forms of knowledge — scientific, experiential, anecdotic, local, indigenous — into a coherent framework and composing a consistent framework for action (e.g. including the knowledge and perspectives of different social groups for designing effective and socially responsive regulations for evacuation and sheltering during natural disasters)
- **Co-creation of knowledge:** engaging representatives of science, civil society, politics, private sector and/or the affected public(s) in designing new insights or options that facilitate the creation of innovative solutions to a given problem or challenge (e.g. developing a new understanding of how to design a smart urban environment that is more resilient against external stressor than conventional building codes).

All these functions are embedded in the meta-function of legitimisation, i.e. using scientific knowledge and advice as an instrument to justify policies or decisions, such as finding good arguments to justify new migration policies. Politicians often seek scientific assistance in order to enhance the legitimacy of their positions and actions (Lentsch & Weingart, 2011; Weingart, 2018). This is not intrinsically unethical (it is even necessary in a democratic system), but if scientific input is used selectively to justify interest-driven positions or to find support for otherwise questionable activities, it can become an ethical problem. In particular, the practice of cherrypicking, i.e. selecting scientific information and arguments that support a previously selected conclusion, is a popular strategy of policymakers to use the reputation of scientific expertise while keeping their own interest in the driving seat. Neither 'greenwashing' nor 'whitewashing', which use a veneer of scientific legitimacy to hide questionable practices, can be in the interest of science dedicated to the common good, or to the general public.

Particular attention needs to be given to the time dimension of expert advice in crisis situations. During a crisis, fast and flexible responses are required that do not lend themselves to expansive and intensive deliberations with experts, let alone stakeholders and affected publics. As Donovan (2021) pointed out, the necessity to respond rapidly increases the risk that science advice is instrumentalised for legitimising often unreflected policies or that scientists are pushed into the front seat to communicate the 'bad' news about unpopular interventions. Donovan suggests to distinguish between four tasks when organising science advice to policymaking: locating expertise, representing expertise, contextualising expertise and governing expertise. These four tasks can be seen as orthogonal to the three major functions of scientific advice (analytic, goal-oriented and catalytic). A matrix can be drawn specifying the four tasks within each function.

Policies to implement these four tasks need to be implemented prior to a crisis. The first task includes the selection of an interdisciplinary group of experts that can be quickly convened if crisis occurs. The second task is to make sure that representatives of all relevant disciplines but also major stakeholders with local and experiential knowledge are addressed. The third task includes exercises to understand the potential implications of a crisis in different regions and contexts and, lastly, the fourth task requires a formal structure of institutional settings and processes that are automatically activated during the course of a crisis. All four tasks rely on an effective inclusion of scientific as well as civic epistemologies in advance of potential crises in order to make all relevant knowledge accessible, even under severe time pressure. In addition to increasing the effectiveness and efficiency of crisis management, such broadly-based advisory bodies could also be crucial for identifying problems of equity and social justice and suggest policy measures that promise to compensate inequitable distribution for burdens and costs (Aranzales et al, 2021).

Building upon the four tasks described by Donovan, Pelling et al (2022) developed a protocol of how to improve crisis management with respect to pandemics. The key to successful crisis management is seen in the organisation of co-creative processes involving scientists, crisis managers, civil society actors and affected publics. Such processes need to be organised before crisis strikes and deliberation among these knowledge groups could be centered on simulations and disaster scenarios. The authors stress that such a integration of different types of knowledge may reveal conflicts with respect to knowledge as well as values, but addressing these before the crisis helps to be better prepared and more effective during the crisis.

Organising such pre-crisis structures for making best use of expertise and knowledge is a major challenge for the EU. Each country has its own emergency and disaster concepts and there is no common understanding among and between European countries of how to best organise crisis management and preparedness (Schweizer & Chabay, 2022). In spite of these wide discrepancies in crisis management, it would be advisable that the EU develop a pre-crisis consultation board as suggested in 4, in which scientists and experts from different fields form a major component.

Timing: Crucial for successful crisis management

Along with the COVID-19 pandemic, there has been a surge in scientific evidence and experts advising policymakers across the EU. Undoubtedly, the many investments especially in health research that led to the rapid development of vaccines is one of the success stories of the pandemic. At the same time, both policymaking and science are under extreme pressure in crises. While conventionally, scientific research takes time, in sudden-onset crises, pace is key.

The required pace is also driving — and at times hampering — the methodologies in crisis and disaster research. Although there has been considerable progress in methods for data collection in (near-)real-time, approaches to disaster science and research are still evolving and sometimes lack scholarly agreement and consistency based on theory, best practices, and indicators of research success. Compared to conventional policymaking contexts, disasters make the collection and processing of data extremely difficult, given the limited access to potentially affected areas, or the lack of data at the onset of a disaster (Oulahen et al, 2020). Crucially, to understand especially sudden onset disasters, researchers conventionally need to mobilise within a couple of hours or days.

The National Science Foundation in the US has established rapid grants for situations characterised by "a severe urgency with regard to availability of or access to data, facilities or specialized equipment, including quick-response research on natural or anthropogenic disasters and other similar unanticipated events".[79] While there have also been rapid calls in Europe under the Horizon 2020 programme in response to the COVID-19 pandemic, these calls were largely relatively late, and generally focused on medical interventions rather than the many other sectors affected. For other disasters and crises, there have not been yet any corresponding programmes, leaving questions about the rapid collection and availability of data that crucially must underlie all research in the case of the next disaster.

While there are several efforts to make data available publicly and openly (as far as privacy allows), there is still no common established infrastructure or platform that sets standards for data collection and sharing, and facilitates the exchange of approaches, tools, models and insights across the different research communities (see 7, p.172). We observe an increase in specialised institutes and organisations dedicated to the future of health crises specifically, but what is missing is the cross-cutting infrastructure and capacity to address the many issues that are common to all crises, such as governance and coordination, communication and (mis-)information, critical infrastructure disruptions and cascading effects, and logistics.

From a science perspective, it can be challenging for researchers to develop advice at short notice, especially as evidence collection, data analysis or the parametrisation of models can take months. Here, careful communication is needed to explain what can and cannot be deduced from scientific evidence. In particular, the communication of uncertainty remains a continuous challenge (Fischhoff & Davis, 2014). Here, the flooding of Germany, Belgium and the Netherlands in July 2021 have starkly illustrated that the challenges in the communication of potential impact and uncertainty in the meteorological and hydrological forecasts, in combination with an extreme event that had not been experienced before. Even though the rainfall and associated floods had been correctly predicted, the related actors and federal state and local level misinterpreted the warnings and thought the situation was under control. This led to important delays and

79 https://hazards.colorado.edu/resources/recent-awards/nsf-rapid-awards

errors of judgement in the evacuation decisions — and this failure to evacuate eventually cost dozens of lives.[80] Political advice and misinterpretation also contributed to the casualties after the L'Aquila earthquake (see Box 7 below). Here, training and guidance is needed on both sides, along with standard toolkits and formats to represent science advice in crises. In 7, p.172, we will expand on this point and highlight that training and education in crisis management — especially rapid decision-making and coordination — needs to go beyond emergency services and crisis management professionals. Rather, this example highlights the need to train all decision-makers that hold responsibility during crises.

Box 7. L'Aquila earthquake, 2009

The L'Aquila disaster of 6 April 2009 in the Abruzzo region of central Italy was a magnitude 6.3 earthquake that formed part of a seismic sequence which began during the previous October and lasted until the following summer. On 6 April, foreshocks occurred at 00:30 and were followed by a violent main shock three hours later. In all, 309 people were killed and 1500 were injured, 202 of them seriously. As the regional hospital in L'Aquila was seriously damaged, casualties had to be airlifted to hospitals outside the disaster area, which comprised at least 57 municipalities in the mountainous part of the central Apennines.

Damage was widespread and the earthquake was unusual in that more people died in the collapse of modern reinforced concrete buildings than in traditional stone ones (Alexander & Magni, 2013). L'Aquila city had undergone a building boom in the 1960s and 1970s, but at the time it was only placed in the moderate seismic risk category. Despite this, active faults run under part of the city, topographic amplification of seismic waves can occur there, and foundation failure is a problem during ground shaking. L'Aquila municipality (population 68 200) includes not only the city but also 52 villages and separate districts. One of these, Onna, situated on soft alluvial terrain in the Aterno River Valley, suffered almost complete destruction in the 2009 quake and 40 of its inhabitants lost their lives. Buildings constructed within the previous decade performed well, thanks to improvements in the seismic classification and associated construction practices.

In total, 67 500 people were made homeless by the earthquake, some because their houses had been damaged and some because the entire city centre of L'Aquila had to be cordoned off due to the danger of spontaneous collapse. As the summer was approaching, about two thirds of the evacuees were accommodated locally in tents and one third were sent to hotels requisitioned on the Abruzzo region's Adriatic coast. For the latter, this left them 80–120 kilometres from their city.

In the meantime, transitional housing was hastily erected. Some 54 sites were populated with standard wooden prefabricated buildings. The sites included both 'brownfield' and 'greenfield' locations and the encampments varied from pocket enclaves on the periphery of the city to extensive 'villages'.

A more radical solution involved creating 19 so-called 'new towns' as part of a project called CASE (Complessi Antisismici Sostenibili e Ecologici). Despite the name, the

80 https://www.climatechangenews.com/2021/08/20/lesson-german-floods-prepare-unimaginable/

project was controversial in terms of whether the buildings really were antiseismic, sustainable or ecologically sound (Contreras et al, 2018). Only one of the 'towns' was situated in L'Aquila and the other 18 were distributed around the area at distances of up to 18 km from the centre. The aim was to preserve a green-belt around the city. The largest CASE sites accommodated up to 2500 people. Seven designs of buildings were used. All were blocks of small apartments, three storeys high and located in each case upon a base plate supported by 40 columns equipped with 'pendulum' seismic isolators. These comprised a Teflon-coated 'ball-and-socket' designed to amortise the shaking during an earthquake. Most of the buildings were ready for occupation within six to seven months of the earthquake, hence before the harsh mountain winter set in.

Criticisms of the CASE project included the following. First of all, the cost was very high, amounting to an average of €280 607 per dwelling, two-thirds of which went on urbanisation and one-third on the building itself (Calvi & Spaziante 2009). The costs were met largely from European structural funds, and the European Court of Auditors (2012) issued a critical report about the costs involved, although it found no evidence of corruption. The second problem occurred when it was discovered that some of the seismic isolators did not perform as expected. Tests conducted in California suggested that in an earthquake they would stick, which was worrying as the buildings above them were not constructed to antiseismic standards, since they relied on the seismic isolators (Castaldo et al, 2017). Judicial enquiries found evidence of malpractice in the design, certification and construction of these devices. Other problems involved lack of maintenance of the buildings, shortage of public transport and basic services in the 'new towns', and destruction of the social fabric leading to loneliness and isolation. Meanwhile, full reconstruction stagnated as a result of the complexity of restoring a historic urban environment and the bureaucracy involved. The involvement of mafias in the process also had to be combated.

Shortly after the earthquake, seven members of the National Major Risks Commission were put on trial for disseminating inaccurate information about earthquake risks (Alexander, 2014). The accusations referred to a meeting of the Commission that took place in L'Aquila a week before the main earthquake and was convened to evaluate the risks associated with the seismic sequence that was then underway. The Commission concluded, on the flimsiest of evidence, that there was "no risk of a main shock as seismic energy was being released incrementally in small bursts".

The trial had repercussions all over the world and was very widely misunderstood (Yeo, 2014). The American Association for the Advancement of Science interpreted it, quite mistakenly, as involving the pillorying of scientists for "failing to predict an earthquake". In reality, a policy decision had been made not to recommend the population to take action in the event of alarming tremors. This was acted upon by civil protection authorities in the three hours between the foreshocks and the main shock. The prosecution alleged that 29 people had died by taking official advice to "return home and relax". The defendants were largely exonerated on second appeal, but mainly because of the difficulty of proving the connection between advice and actions.

The L'Aquila earthquake embodies several lessons for European policy. One is that timely, accurate, well-informed communication with the public is a prime requisite, a principle that COVID-19 has constantly underlined. Another is that post-disaster transitional housing policy needs scrutiny and debate. The solution in L'Aquila was virtually designed to be semi-permanent, in spite of the need to strengthen and adequately finance measures to achieve permanent reconstruction. It therefore detracted from the urgency of planning and achieving permanent reconstruction. A third lesson is that attention needs to be devoted to areas of Europe that have both high hazard and high vulnerability. Finally, there is an imperative to strengthen local civil protection capabilities for preparedness, response and recovery.

In the later stages of a protracted disaster, such as the COVID-19 pandemic, more and more models, approaches and at times even predictions can become available. This surge of models and predictions can sometimes be overwhelming, and may seem like science adds uncertainty, rather than resolving it. Yet running ensembles of models, and comparing the results of different tools and approaches is an important part of providing robust advice. While as such peer review should be the standard for any model that is used for policy advice, member countries such as the Netherlands still use a single model that is not peer-reviewed to determine possible scenarios for the spread of infections as the basis for policy advice.[81]

5.5. Implications for the EU science-policy nexus

What are the implications for the nexus of science and policymaking at the EU level? In light of the deficits explained above, a major reform of the institutional structures and academic procedures is overdue. Several deficits have been identified that need to be addressed in due time:

- There is a lack of European transdisciplinary research that studies the interlaced issues of modern crises and provide interdisciplinary and transdisciplinary advice for policymaking.
- There is currently a lack of funding for rapid disaster research in the immediate aftermath of crises and disasters, leading to important data gaps that hamper policy advice.
- There is a lack of transdisciplinary infrastructure and standards to formulate robust policy advice across different sectors or disciplines.

Turning to the most urgent procedural changes, it is crucial to understand the policy-science nexus as a continuous effort of normative reflection about what is at stake and what is desired, of integrating the five essential functions of scientific knowledge to policymaking, of including non-scientific knowledge and values, and of creating the appropriate discourse space for designing effective, efficient, resilient and socially-cohesive solutions (Renn. 2014; SAPEA, 2019).

81 See e.g. https://www.nrc.nl/nieuws/2022/01/19/oproep-modelleurs-nederland-heeft-recht-op-een-second-opinion-a4081121

At the beginning of the consultation cycle within the science-policy nexus, there is a need to jointly identify and frame the problem space. This process can be done neither by politicians alone nor by scientists alone. The interconnectivity of the many domains that are affected by crisis preparedness and emergency planning requires the inclusion of the various actors that are affected by the causes or the consequences of the envisioned policies (Donovan, 2021; Fung & Wright, 2001; Hirsch Hadorn et al, 2006). The discourse itself needs to be designed such that it provides sufficient space for normative reflection, problem framing, and producing creative, out-of-the box solutions to complex threats and problems. It is essential that all policy options are thoroughly investigated in order to assess if they are as effective as claimed and what kind of negative side-effects are to be expected when implemented. Finally, an effective form of deliberation and conflict resolution is required that ensures a fair and comprehensive discussion of conflicting goals and the assignment of unavoidable trade-offs (OECD 2020).

How can such a process be integrated into the existing EU structure? First of all, the major EU scientific institutions such as the academies of science or the European universities need to be proactive in developing this sophisticated and comprehensive route towards providing scientific advice to policymaking, by arranging mixed groups of advisors that represent a diversity of disciplinary traditions and schools of thought, acknowledging the many cross-sectoral implications of crisis management measures for policymakers' needs (even if some policymakers may lack awareness) and the right combination of interdisciplinary expertise for exploiting the full potential of what science can offer to society (Godemann & Michelsen 2008). As much as plural knowledge carriers need to be included in the process, scientific institutions need to stress their unique contributions to the policy process. Evidence-based insights are crucial to determining priorities, distinguishing ideologies from facts and pointing to the potential side-effects of certain desired policy actions (McIntyre, 2018).

Second, all advisory committees on crisis management should be based on an interdisciplinary composition of experts, even if special hazards such as viruses or natural hazards are targeted (Kockelman,s 1979; van Wehrden et al, 2019). Problems are rarely covered by one discipline alone and, if potential side-effects are being investigated, the full range of environmental, economic, social and psychological impacts need to be included in the analysis to ensure that multidisciplinary evidence is being delivered to the right targets (DFIR, 2021). If complex problems are addressed, transdisciplinary designs are required, since other types of knowledge are also crucial for understanding the problem context and exploring the solution space (Zierhofer & Burger, 2007). Both interdisciplinary and transdisciplinary approaches are often outside of the established forms of advisory bodies. However, they are crucial for dealing with multiple crisis and complex disasters.

Thirdly, advisory bodies and councils should particularly focus on the co-production of knowledge with the diverse sectors and elements of society (Polk, 2015; Chabay et al, 2021; Donovan, 2021). In the current rapid and encompassing acceleration of change in all domains of society, a more proactive view, which includes potential futures that cannot be derived linearly from the present situational dynamics, needs to be included in emergency and contingency planning.

Finally, research is not bound by national borders or geographic boundaries. Many insights from science are independent of space and time, others are limited to boundary conditions but still valid for a wide variety of cases. Traditionally, science has placed most emphasis on gaining universal knowledge that can be applied everywhere. Notwithstanding the importance of such universal knowledge, responses to crisis and emerging threats demand predominantly context-related insights that are suited to be in line with the contextual conditions in which the crisis emerges (van der Leeuw, 2019). This would mean that the EU should encourage the development of regional disaster study institutes and management boards that are all part of a larger network that collaborates with EU governance bodies on crisis management. Such regional study centres could be affiliated with national or subnational government authorities. However, the main requirement is to assure a consistent, coherent and credible approach to a transboundary disaster. This is not easy to accomplish. It would presuppose a network learning exercise that defines common rules and principles for disaster response, with sufficient free space and flexibility to adjust to local conditions.

Meeting all four requirements would call for a comprehensive reform of the present science advisory system for crisis and risk management in the EU. This could be initiated top-down by the EU and national governments, or bottom-up by regional initiatives for building crisis response networks. The process would certainly speed up if bottom-up and top-down approaches were launched simultaneously.

6. Equality, trust and participation in European crises

6.1. Summary

This chapter considers the issues of equality, trust and participation, reviews the related scientific literature and proposes science-based answers to the following questions in the scoping paper:

> How can EU policies in crisis management mitigate impacts that increase inequalities among regions and social groups?
>
> How do social inequalities within the EU impact crisis management at the EU level?
>
> What can be achieved at the EU level to promote the trustworthiness of crisis management mechanisms, and citizen participation?

The chapter opens by underlining that equality, trust and participation are very closely interlinked. They form fundamental principles that mutually reinforce each other and constitute key elements for any successful policy implementation.

We first explore the interlinkages between social inequalities and crisis management in the EU. Everyday structures and social interactions shape how crises and disasters unfold, and where the impact of the crisis is most felt. Evidence shows that the marginalised sections of the population are the most vulnerable to crises and that crises tend to exacerbate already existing social inequalities. Crises disproportionately impact people with low income and wealth, whereas the economically well-off are more likely to remain unaffected by a crisis. The chapter provides an overview of economic, social and spatial inequalities in the EU, highlighting that there are many types of intersecting social inequalities that need to be considered for effective and just crisis management in the EU. Any policy or action that does not consider social inequalities is likely to perpetuate the existing patterns of marginalisation in the population. Policies and actions will also be ineffective if they are not adapted to the diverse realities encountered on the ground. Crisis management should, then, serve to both alleviate and exacerbate the various social inequalities. The example of housing is taken to illustrate these interlinkages. The values that determine prevention, insurance and compensation policies also illustrate the complexities and trade-offs linked to crisis management, and the way existing inequalities can be reinforced or ameliorated. Although there is no panacea to devise fair crisis management, it is important to consider how marginalised people are represented in crisis management, paying particular attention to governance scales, places and territories, and types of hazards.

The chapter continues with a review of the links between trust and crisis management in the EU. It first focuses on citizens' trust in public institutions. In the context of crisis management, trust ensures compliance and cooperation without coercion, increases citizen compliance with government regulations, and encourages citizens to use more prosocial options in social dilemmas. Trustworthiness of institutions is the main manageable antecedent of trust, and institutions can inspire citizens to trust them through their ability, benevolence and integrity. However, in crisis situations, citizens have little to no choice in whom to select as a trustee. If citizens are unwilling to accept this, it may seriously hinder crisis management actions.

Lack of trust, or low trust, does not necessarily hinder the implementation of policies. In these groups, actions focusing on improving the perceptions of these institutions' competence, benevolence and integrity may help to increase the level of trust. But distrust, as an active state of suspicion and defence, may make the implementation of certain policies almost impossible. Here, addressing 'legitimate distrust situations', for example by introducing powerful third parties, may be an option. Literature on trust has commonly found that citizens tend to trust more the institutions that are closer to them, but evidence is rather mixed regarding supranational institutions. Moreover, some studies indicate that citizens care more about the way in which they are governed than by whom they are governed. As a consequence, it may be that more efforts on highlighting and communicating EU contributions to the wellbeing and welfare of citizens is a promising avenue to promote confidence in the EU.

This chapter also presents findings on the importance of institutions' trust towards citizens. Existing studies acknowledge that is beneficial to citizen-government interaction that there is mutual trust, that government's trust in citizens and citizens' trust in government are linked and that there are benefits arising from institutions' trust in citizens.

The last section (6.5, p.153) focuses on some scientific findings specifically linking trust to crises. Swift trust is a very particular form of trust that may emerge in temporary settings where the time pressure is high, in situations where the typical foundations for trust are unavailable. This initially concerns temporary teams that are brought together in an emergency response situation, for example. The ability to facilitate the emergence of swift trust, through transparency and improved information sharing, enhances crisis management capabilities for institutions. Evidence also shows that higher trust is positively correlated with the willingness to engage in preventative measures.

The chapter finally reviews the role that participation can play in managing crises. Citizen and stakeholder participation is understood as all procedures and instruments in which individuals in their role as citizens and organisations, as stakeholders,actively participate in collective decision-making, which can be legally mandatory or legal informal procedures. There are many areas where requirements for public dialogue or participation are specified in the EU, for example on climate protection, infectious diseases or energy transition. However, there exists little EU legislation on public participation directly related to crisis management, and the nature of public participation in emergency and crisis management-related EU legislation is inconsistent. To strengthen participation, we refer to literature on the foundations for political legitimacy, that are usually handled by different actors within our society. Legitimate measures for crisis management need to be:

- effective, based on best available evidence
- efficient ("economic"), in order to be aware of existing scarcities of resources and time
- resilient, so that enough capacity is created to cope with multiple stress situations
- sensitive to social requirements of fairness, proportionality and cultural identity

These functional requirements can best be met when all relevant actors in society cooperate, and feel jointly responsible for the implementation of each of the four criteria.

Digitalisation opens new opportunities for citizen participation. Traditional disaster response is organised in a hierarchical, top-down way, but the widespread availability of smartphones and other technologies can complement this traditional approach. It can increase response capacity, empower citizens to help themselves and support each other, and produce multiple synergy effects, trust and solidarity in the community networks of civil society. It supports the creation and development of tools and forums that promote participatory resilience in crises situations. The nature of volunteering has also changed with the arrival of ICTs and taking advantage of social media has become another novel form of participation. Overall, integrating citizen-led initiatives and facilitating their participation in the crisis management processes requires time, resources and reorganisation of practices. Despite this challenge, participation in crisis management and response constitutes one key element in (re)building trust between public institutions and citizens at an uncertain and tense time. This can be facilitated by digital tools that can tackle information and communication issues during crises.

Stakeholder and citizen participation are key pillars for inclusive governance in crisis management in the EU. Analysing and managing risks cannot be confined to private companies and regulatory agencies. It should involve a wider array of actors: political decision-makers, scientists, economic actors, and civil society actors. Scientific expertise is an essential element of stakeholder involvement and a crucial pillar of all formats for stakeholder involvement. This can be done in any European country. However, stakeholder involvement and public participation are particularly suited and needed for the EU as a whole. To achieve that, the model of analytic–deliberative participation is presented as one of the most promising suggestions for developing an integrative approach to inclusive risk and crisis governance, based on the engagement of experts, stakeholders and the general public, where scientific expertise, rational decision-making, and public values can be reconciled.

6.2. Introduction

Social inequalities are entangled with both the causes and consequences of crises. Understanding them is a precondition to effective and just crisis management. The marginalised people in and across societies, those facing the hard end of social inequalities, are often also the most likely to require support in a case of crisis. While equality has been shown to foster trust in authorities and crisis management organisation, often the most vulnerable and marginalised are the ones that may trust the crisis management institutions the least, as these institutions may not be perceived to act in their interest. This is especially true for supranational institutions such as the EU that may be perceived as far removed from the al context. At the same time, trust is an important requirement for participation and representation of people. Engaging those who are facing adverse impacts of social inequalities, to crisis management is important for effectively addressing the crises, thereby increasing equality and equal opportunity. The three guiding principles of this chapter (equality, trust and participation) are therefore very closely interlinked.

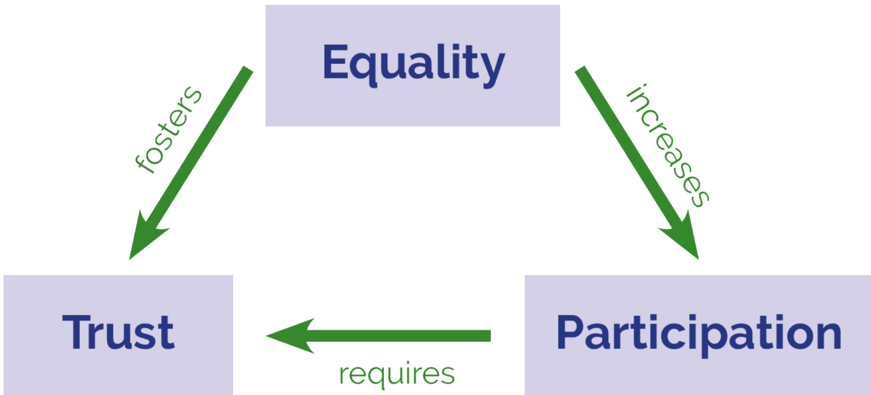

Figure 13. Links between principles of equality, trust and participation in crisis
Source: Tina Comes

European powers have shaped both the build-up of crises, and the patterns of crisis management, in other parts of the globe as well. Interrogation of social inequalities, trust, and participation in the context of crisis management undertaken by EU countries outside its borders would also be extremely important, but this falls outside the scope of this report. One way to justify this is to view the EU as a 'liberal' state and to speak separately of political and humanitarian responsibilities (Meriläinen et al, 2020; Voice, 2016). While towards their own citizens, liberal states can be seen to have both humanitarian (providing the basic resources to support citizens' autonomy in a situation of crisis) and political responsibilities (providing the institutions that allow for democracy to work for the citizens), outside their borders liberal states should limit their support to a humanitarian role, respecting the political autonomy of the other states (Meriläinen et al, 2020; Voice, 2016). In the following, both the political and humanitarian aspects are discussed in an entangled manner, and the approach would necessarily be different when discussing EU crisis management taking place outside its borders, where the EU should not be imposing its institutions.

6.3. Social inequalities and EU strategic crisis management

Social equality refers to an absence of “major disparities in people’s resources, political and social power, wellbeing and of exploitation and oppression” (Bakan, 1997, p.47). Social inequalities discussed here are structural, embedded in social systems and exist irrespective of individual choices or specific institutional policies or actions (Young & Nussbaum, 2011). This does not mean that policies should not address these social inequalities — quite the contrary — but it is important to understand that the structural inequalities cannot be isolated and targeted with a single policy. Furthermore, an effort to address structural social inequalities, such as economic ones, is not a call for cultural sameness or sameness of identities. However, theoretical approaches to social inequality strike differing balances between emphasising redistributive (economic) politics and recognition of difference (see Squires, 2009).

Everyday structures and social interactions shape how crises and disasters unfold and where the impact of the crisis is most felt. As discussed in previous chapters, a disaster or a crisis is a result of a hazard (such as an earthquake) coming together with vulnerabilities. The marginalised, facing the harder end of social inequalities, are usually the most vulnerable (Gibb, 2018; Hewitt, 1983). Meanwhile, those in a society that are least marginalised are typically either able to isolate themselves from disaster impacts, or even benefit from them (Collins, 2010; Nygren, 2018). While the inequalities are most clear between the most marginalised and the least marginalised, social inequalities shape the whole of society. Furthermore, various types of social inequalities intersect.

For EU crisis management to work, it needs to work for everyone — and thus it needs to not only remain attuned to the existing social inequalities, but also be prepared to address them. If social inequalities are not considered in crisis management and resilience policies, crises can threaten the functioning of societies and communities (Cretney, 2014; Vale, 2014). Crisis management policies considered unfair — such as anticipatorily relocating marginalised people from their homes in terrains considered risky, and the reconstructing of high-end property in the very same spot — are likely to provoke justified resistance and weaken the commitment to a shared society (see e.g. Klein, 2007; Vale, 2014). Even the most minimal understandings of a state’s purpose (e.g. “night-watchman state”) involves a need to protect society from threats considered as exceptional. A state — or a supranational arrangement such as EU — that does not address a crisis facing people may be challenged and its rule may grow illegitimate (see e.g. Pelling & Dill, 2010). The fact that contemporary crises are rarely external and natural, but themselves products of structural social inequalities, means that the states' role, perceived and actual, is crucial.

The types of social inequalities relevant to EU strategic crisis management

Capitalism is the contemporarily dominant socioeconomic system (Fraser & Jaeggi, 2018). Within this system, income and wealth are treated as key proxies for social (in)equality (see e.g. Hickel, 2017; Neckerman, 2004). The economic inequalities are particularly visible at the margins. In the OECD, 20% of the highest paid people receive more than 5.4 times the income of the lowest paid 20% (OECD, 2020a). However, the inequalities in wealth are particularly concerning. In the OECD, 10% of households possess over half of total household wealth (OECD, 2020a). Furthermore, the overall extent of wealth disparities is difficult to assess, as the wealthy can use various instruments to insulate their possessions from oversight, such as the use of tax havens (see e.g. Alstadsæter et al, 2018).

In high-income countries, economic inequality has been on the rise over the past few decades (Piketty & Goldhammer, 20114; Stiglitz, 2012). In the European OECD countries, every fifth household is struggling to make ends meet (OECD, 2020a). The growing wealth inequality is particularly alarming. It threatens people's wellbeing, and many authors and institutes have warned about the links between our current capitalist/neo-liberal system, crises and social inequalities (Chowdhury & Żuk, 2018; see also *The IMF and Income Inequality*[82]). Recent developments have called for renewed scrutiny of unequal social relations under capitalism, and updates to classical class analysis (Adkins et al, 2019; Lazzarato, 2012). As ownership of assets such as housing has become more concentrated, social inequalities have grown starker between those that own assets, and those that rely on wages for livelihood and need to rent assets such as housing (Adkins et al, 2019). Over the past decade in the EU, housing policies favouring home ownership and low interest rates have favoured homeowners, with renters increasingly struggling to find affordable housing (Elfayoumi et al, 2021).

Economic inequality is a central factor contributing to unequal crisis impacts and management, as in the capitalist system the available financial means correspond to anything from safety of one's home to the capacity to evacuate (see e.g. Fainstein, 2015; Stephens et al, 2009). However, economic inequality also intersects with other social inequalities. For instance, various degrees of precarity and insecurity complicate the picture further. Within the OECD, 36% of the population is financially insecure — that is, if

82 https://www.imf.org/en/Topics/Inequality

they would suddenly lose their income, their liquid assets would keep them above the poverty line for less than three months (OECD, 2020). Within the EU, in Latvia, Greece, Slovenia and Poland more than half of the population is financially insecure (OECD, 2020). Economic precarity is tightly connected to, and manifested in, precarity and insecurity over housing and land. Globally, 1 in 5 adults fear losing rights to their home or land within five years (Prindex, 2020). While regionally these figures are the lowest (12%) in Europe and Central Asia, the various types of housing insecurity are worthy of paying attention to in the EU as well. For instance, in France a third of the population rents their housing and 28% of them feel insecure about their housing.[83] Economic inequality also correlates with energy poverty, and for instance the capacity of households to keep their homes adequately warm (Galvin, 2019).

'Informality' is another facet of precarity, connected to various aspects of (urban) life from housing to livelihoods (see e.g. Devlin, 2018). Residents living in informal settlements often lack safe access to many basic services and infrastructure, and face impermanence and lack of tenure (Desai et al, 2015; Martin & Mathema, 2009; Varley, 2013). While informality often associates with countries of the Global South, the phenomenon is increasingly topical also in the Global North and within EU countries (Devlin, 2018; Jaffe & Koster, 2019). Elements of informality relevant to the EU encompass, but are not limited to, Roma settlements and informal refugee camps (Devlin, 2018; Sandri, 2018), undocumented people (Spencer, 2016), homelessness (Gosme, 2014), red light districts, and participatory infrastructure projects (Jaffe & Koster, 2019). Beyond being a manifestation of precarity and vulnerability, informal practices can be considered as innovative or necessary ways of organising (Jaffe & Koster, 2019; Lombard, 2014), particularly for the marginalised.

Spatial inequality here refers to the ways in which space, place and territory are connected to the production of structural inequalities (see e.g. Lobao et al, 2007; Perrons, 2004). Approaches attuned to spatial inequality are also typically sensitive to how phenomena unfold on different scales. In the European Union spatial inequality encompasses for instance the inequalities between regions. Regions can, depending on the media and issue at hand, be defined for instance as "Northern" and "Southern" Europe, and between Western European states well established in the EU and fairly new EU member states in the Eastern Europe. Not only are these regions different, but between them lie social inequalities "major disparities in people's resources, political and social power, well-being and of exploitation and oppression" (Bakan, 1997, p.47). The policies and institutions of the European Union can serve both to reduce and exacerbate these inequalities. Similarly, regions within and across countries have developed differently amid urbanisation, with 'rural' places losing both population and services, while people and resources concentrate on urban regions. However, these patterns of urbanisation and

83 https://www.prindex.net/data/france/

the associated inequalities within the EU are influenced by EU policies and structures, and should not be thought of as only an external force.

Given the limited space available in this report and its given scope, the section focuses particularly on economic and spatial inequalities. However, various other facets of social inequality are also important to consider when striving for effective crisis management. As crises tend to exacerbate social inequalities, policies and actions that do not consider social inequalities are likely to perpetuate the existing patterns of marginalisation. These policies and activities are also ineffective as they do not correspond with the diverse realities on the ground (see e.g. Kantola, 2010).

The types and facets of social inequality most relevant to crisis management in a given context vary, but Table 2 summarises some of the social inequalities worth considering. These include gender inequality, "racial" or ethnic inequality, age inequality, inequality associated with disabilities, and finally information and digital inequality. These inequalities should not be seen as separate concerns influencing distinct groups of people, but as intersecting social inequalities (Lombardo & Verloo, 2009). While within the EU often the term "multiple discrimination" has often been mobilised to describe discrimination on multiple grounds, intersectionality better describes how the grounds and causes are entangled (Schiek & Lawson, 2016). The list is not complete, and for instance social inequalities related to sexual orientation and health are recommended to be considered.

The interconnections between social inequalities and EU crisis management

Crises typically reinforce the long-term social inequalities, with the direst consequences of the crisis suffered by those who are marginalised (see e.g. Oliver-Smith, 1990; Reid, 2013; Wisner et al, 2004). The following illustrates a variety of ways in which the different types of social inequalities outlined in the previous section are interconnected with crises and crisis management. Social inequalities shape the vulnerability to crises, and crises typically exacerbate social inequalities. Crisis management can serve both to alleviate or exacerbate the various social inequalities.

A focus on economic inequality and the associated precarity exposes how crises and even crisis management may exacerbate existing social inequalities. The economically marginalised are likely to be disproportionately impacted by the crises, particularly in the long-term (Tovar Reaños, 2021). In the following, the housing question illustrates the ways in which the economic inequalities, crises, and crisis management are entangled in complex ways. Housing is where the private and public spheres meet, and social inequalities take a very concrete form.

Firstly, housing areas and accommodations of people with low income and wealth are disproportionately exposed to hazards (see e.g. Braubach & Fairburn, 2010; European

Environment Agency, 2018). The "affordable" land upon which housing for low-income people is constructed may be particularly risk prone, and the use of cheap construction materials may lead to additional risks (see e.g. MacLeod, 2018). Relatedly, the interests and concerns of people with low income and social capital in the socioeconomic system may further be omitted in public decision-making, and the crisis risks facing them are not appropriately addressed (Begg et al, 2018; Fainstein, 2015; MacLeod, 2018; Vale, 2014). The disaster risk is further exacerbated in informal housing situations and refugee camps, as the land available to them is typically risk prone (Doberstein & Stager, 2013; Rush et al, 2020). Fire, for instance, is a major threat in informal settlements and refugee camps (Rush et al, 2020). Lightweight, dense construction, and lack of basic services such as trash collection add to disaster risk (see e.g. Reszka & Fuentes, 2014). For instance, in the Moria refugee camp on the Greek island of Lesbos, both fire and COVID-19 have spread fast (Jackulikova et al, 2021; Raju & Ayeb-Karlsson, 2020). Housing precarity and homelessness further expose people to other crises — even if for the homeless the everyday precarity may be of higher concern than natural hazards, for instance (Gaillard et al, 2019). Housing is a central social determinant of health, and in the COVID-19 pandemic homelessness has been associated with high vulnerability (Owen & Matthiessen, 2021).

Secondly, the already precarious housing situation of people with low income and wealth is exacerbated in a crisis. Due to a hazard, disaster-affected people may lose their income, while facing costs of damage and additional bills. For instance, due to the COVID-19 pandemic and associated crisis management policies, an increasing share of households (a fifth) in European OECD countries reported having difficulties in making ends meet during the pandemic (OECD, 2021). The insecure income and lack of wealth resulted further into housing and food insecurities (Elfayoumi et al, 2021; OECD, 2021). While a hazard such as a fire or flood might disproportionately physically destroy the homes of low-income residents, the economic stress resulting from other aspects of a crisis may make residents unable to pay their rents or mortgages. For instance, in the aftermath of the financial crisis of 2008, people were foreclosed and evicted from their homes in EU countries at unprecedented rates, a development that came with a heavy human toll, including a disproportional risk of homelessness and suicide (Mateo-Rodríguez et al, 2019; Rojas & Stenberg, 2016; von Otter et al, 2017). While various EU countries did impose eviction bans in the early COVID-19 pandemic, if these are not continued and combined with "rental assistance and debt relief", the aftermath of the pandemic will hit the marginalised hard (Owen & Matthiessen, 2021, p.175). Overall, the need for affordable housing in the EU is likely to intensify as a result of COVID-19 (Elfayoumi et al, 2021).

Crises disproportionately impact people with low income and wealth, while the economically well-off are more likely to either remain unaffected by a crisis or may even economically benefit from one (Collins, 2010; Nygren, 2018). For instance, while 99% of the world population have seen their incomes sink due to the pandemic and recovery will be slow, just nine months into the pandemic billionaires' wealth had bounced back

(Ahmed et al, 2022; Berkhout et al, 2021). After a few years of the pandemic, wealth has concentrated further (see e.g. Ahmed et al, 2022). As wealth concentrates into fewer hands, so does the ownership assets such as housing. Even in a crisis, property owners are likely to make decisions that optimise the financial value of their assets (exchange value), rather than appreciating the necessity of housing for the residents (use value) (Fainstein, 2015).

Thirdly, crisis management is very much entangled with the unequal disaster dynamics, having the potential to both alleviate or exacerbate the unequal crisis impacts and the existing economic inequalities. Often the trade-offs of crisis management activities are between the wellbeing of disaster-affected people and capital interests. For instance, in the recovery phase it might be in crisis-affected people's interest to return to their neighbourhoods after a disaster, but often they are instead relocated to urban peripheries that lack employment, networks of solidarity, as well as basic services including public transport (see e.g. Barrios, 2017; Letelier & Irazábal, 2018; Saraçoğlu & Demirtaş-Milz, 2014). Meanwhile, their former neighbourhoods are developed for and by others that do have access to capital for rebuilding (see e.g. Green et al, 2007; Letelier & Irazábal, 2017; Saraçoğlu & Demirtaş-Milz, 2014). However, this does not need to be the case, and crisis management can and should strive to address the suffering of those most vulnerable to and affected by a disaster.

The crisis management trade-offs are obviously more complex than simply choosing between assisting the most vulnerable people versus favouring capital interests. An illustration of the different crisis management mechanisms, and their impacts on economic and spatial equality, is provided by EU flood management. Floods can impact several EU countries simultaneously and are growing increasingly frequent and intense over the coming decades (Jongman et al, 2014; Surminski et al, 2015). To reduce flood risk, public ex ante risk reduction is essential, from building flood defences to devising and overseeing appropriate land-use policies and building codes (ibid.). However, when losses do occur and need to be compensated, the debate over choices is often pitched between insurance mechanisms on the one hand, and public or state compensation on the other (ibid.). The options for compensating losses are entangled with values and ideals, such as tensions between equality and responsibility (ibid.). Countries and people most vulnerable to extreme events are likely to be those that cannot reasonably afford insurances that would lead to appropriate compensations. Equality and solidarity would require the rest of society — and the EU — to step in, for instance through mechanisms such as the EU solidarity fund (Jongman et al, 2014). However, the counterargument to these public measures typically is that public loss compensation may not appropriately incentivise taking responsibility over mitigation and prevention (ibid.). While at a state level this is more relevant as they can decide over construction of public infrastructure such as floodwalls, particularly when it comes to marginalised people the argument becomes problematic. Insurance schemes may privatise responsibility disproportionately to the marginalised that are exposed, while de-incentivising public investments to protect populations (Collier, 2014; Grove, 2012).

As illustrated by the previous example on floods, across the EU different places have differing exposures and vulnerabilities to crises. The differing physical geography of regions and states itself shapes the exposure of places, but many of the uneven risks are socially constructed, as is the uneven response to them (Cannon, 2008; Kelman, 2020). For instance, while in Europe areas near rivers are likely to be susceptible to flooding (Blösch et al, 2020), how emergency management and urban planning integrate these risks is a matter of choice (see e.g. Fekete & Sandholz, 2021; Goh, 2019). Similarly, most migration routes used during the "refugee crisis" (or rather the "refugee reception crisis") from 2015 onwards led first to Southern European EU countries (Ambrosini et al, 2019). However, it was very much a political decision as to whether countries elsewhere in the EU chose (not) to alleviate the pressure facing Southern European countries such as Greece and Italy (Ambrosini et al, 2019).

Here, considering the spatial inequalities within the EU can be helpful. Different areas and regions within the EU have differing crisis exposures and vulnerabilities, but also different resources and capacities to respond to them. There are many reasons to considera more solidary and joint approach to crisis management within the EU, but to receive support, such an approach would need to take spatial inequalities seriously. Consider, for instance, how the financial crisis was handled on the terms of the 'Northern' European countries, while the economies and people of the 'Southern' Europe and 'European periphery' more broadly suffered a greater toll from the austerity policies that followed (Della Porta & Portos, 2020). Meanwhile, in comparison to urban centres with a high population density in an area impacted by a hazard, sparsely populated 'rural' regions may be more threatened by 'natural' hazards like wildfires, while less likely to possess the adequate resources to deal with them across the broader region. Furthermore, while in urban centres reconstruction is likely to happen, though unevenly and not necessarily for the previous residents, the economic system might not support the reconstruction of small rural villages where property prices are low or in decline. If the management of crises is considered unfair, this can feed anti-EU sentiment (Chowdhury & Żuk, 2018).

Table 2 below revisits the types of social inequalities relevant for crisis management introduced in the previous section. The table provides a few illustrations on how social inequalities and crisis management are entangled in the European Union. The examples relate, for instance, to how a type of social inequality is contributing to exposure and vulnerability to crises, and how crisis management can exacerbate or alleviate the social inequalities. Given the limited space and differences across the various national and other contexts within the European Union, the following should not in any way be considered a complete list, but merely indicates a type of social inequality to pay attention to in crisis management. Furthermore, while crises in specific countries might be lifted up as examples, it is worth recognising that the types of social inequalities described are likely to be present in other EU countries as well, though perhaps in a different form.

Table 1. Interconnections between social inequalities and crisis management in the European Union

Type of social inequality	Description	Interconnections between the social inequality and crisis management
Economic inequality	See discussion above, including in connection to precarity, insecurity and informality.	See discussion above, including in connection to precarity, insecurity and informality.
Spatial inequality	See discussion above.	See discussion above.
Gender inequality	Gender persists as a basis of inequality between people, with socio-economic structures typically privileging men over women (Ridgeway, 2011). The European Union has a significant impact on gender (in)equality: for instance, in policy "men's employment patterns are 'normal' and women can be seen as an atypical workforce" (Kantola, 2010, p.4).	The impacts of crises are gendered. Crises are likely to demand a vast amount of reproductive labour, from soothing children to acquiring food stocks, which tends to fall disproportionately on women (see Bradshaw, 2001; Fodor et al., 2021; Hoffman, 1999). While crises and crisis management may even reduce the total workload of women, the resurfacing of 'traditional' gender roles associated with domestic labour can lead to women losing their livelihoods (see e.g., Hoffman, 1999; Levine, 2020). For instance, the politics of austerity that followed the 2008 financial crisis hit particularly women's livelihoods (Wöhl, 2017). However, it is important to note that men are also impacted by disasters, and can play a role in addressing marginalisation based on gender (Enarson & Pease, 2016). While men, both soldiers and civilians, are much more likely to die in armed conflicts than women, war also adds dramatically to the excess mortality of women, for instance due to disproportionate maternal mortality (Brunborg et al., 2003; Urdal & Che, 2013). Furthermore, gender-based domestic and sexual violence faced by women and girls is typically exacerbated in moments of crisis (IFRC, 2015), and gender and sexual minorities are likely to face difficulties amidst crises (Barrios, 2017; Dolan, 2014). For more, see relevant bibliographies by the Centre for Gender and Disaster (2020; 2021).

Type of social inequality	Description	Interconnections between the social inequality and crisis management
'Racial' and ethnic inequality	'Racial' and ethnic inequality relate to discrimination on the basis of constructed 'race' or ethnic identity. The framings are highly context dependent and entwined, but 'race' is socially constructed more in connection with biology, while ethnicity appears more in connection to "culture and geographical roots" (Bell, 2009; Verloo, 2006, p.218). The framings of 'race' and ethnicity are problematic and essentialising (Verloo, 2006), and the idea of biological 'race' in particular is a false construction that served to legitimise imperialism, slavery and the Holocaust (Bell, 2009). While in the United States 'race' has been very explicitly used to unpack and contest social inequalities grounded on constructions of 'race', in Europe critical takes on 'race' and 'racism' have been much less prominent (Möschel, 2014). However, as 'race' operates in Europe as a ground for social inequalities, researchers advocate for serious engagement (see e.g., Möschel, 2014). 'Racial' or ethnic inequality are also connected to other factors, such as religion.	Racism and discrimination on the ground of ethnicity have not disappeared from Europe. That is, those that may even be the most exposed and vulnerable to a crisis may not only be omitted in crisis management, but they may even be treated as if they were the enemy or source of the crisis. There are some very recent examples of how racism not only is present in crises, but is exacerbated, possibly for extended periods of time. COVID-19 has imposed disproportionate risks on the Romani people, but instead of trying to address the structural vulnerabilities that put the Romani at risk, many countries adopted crisis management actions that sought to further stigmatise and isolate the Romani (Matache & Bhabha, 2020). In Greece, the "refugee and the pandemic crises reveals how the global pandemic has been used to intensify racist migration policies in Greece (and globally) by naturalising and medicalising 'race'. Just as the individual body needs to be protected from the invasion of the virus, so too the national body needs to be protected from the 'influx' of migrants and refugees" (Kallio et al., 2020, p.9). Meanwhile, the contemporary news reporting on Ukraine during the Russian invasion of 2022 shows how people of colour face not only face disproportionate challenges in trying to evacuate, but also outright racist attacks (see e.g., Coakley, 2022; Tondo & Akinwotu, 2022). In the context of the same crisis, critical commentators have been pointing out how different the responses have been to the ('white') Ukrainian refugees (see e.g., Bejan & Bogovic, 2022) than to the racialised refugees during what was framed as the "migrant crisis" of 2015 (Maneri, 2020). Relating to ethnic inequality, people's religious needs and convictions are often taken unequally into account in crisis management. This becomes perhaps particularly obvious when humanitarian actors from one religious and cultural context are providing aid to a disaster-affected community in another (see Korf et al., 2010; Binder & Baker, 2016). However, crisis management in and across EU countries should also pay attention to the differences within their constituencies to provide assistance that is appropriate, and supports those in vulnerable positions. See e.g. European Network Against Racism (2021) for reflections on the climate crisis, colonialism and racism.

Type of social inequality	Description	Interconnections between the social inequality and crisis management
Age inequality	Age is a central aspect of being in a society and working in organisations (Hearn & Parkin, 2020). While ageing is common to all people, the ways in which age is constructed divide people and create inequalities (see Hearn & Parkin, 2020; Riach & Kelly, 2015). The analyses of age inequality should not focus only on those considered either 'old' or 'young' for a given norm, but those who are in the 'middle' (see Hearn & Parkin, 2020; 2021).	Age relates to both exposure and vulnerability to crises, and crisis management policies should consider their impacts on associated social inequalities. Often those considered "old" (e.g., "elderly") (e.g., Campbell, 2019; Daddoust et al., 2018) or "young" (e.g., children) (e.g., Pfefferbaum et al., 2018) are framed as more vulnerable to crises than other age groups. Old age, furthermore, can be associated with impaired abilities and higher vulnerability (see Alexander, 2015). However, it is important not to associate the vulnerabilities with a lack of social and other resources (see e.g., Campbell, 2018; Pfefferbaum et al., 2018). The COVID-19 pandemic provides an illustration of how advanced age can both reduce and increase the overall crisis impacts faced in comparison to other age groups. The COVID-19 disease was particularly threatening to older age groups' health, and in many countries the crisis management activities isolated these groups from the rest of the society (D'Cruz & Banerjee, 2020). In this regard, age correlated with negative crisis impacts. However, compared to younger age groups, adults aged 51 and above were likely to have more wealth and financial security (OECD, 2020a). This meant that the younger age groups were economically more precarious, and more severely impacted by lockdown crisis management policies. For more, see e.g. Campbell (2019); Daddoust et al (2018).

Type of social inequality	Description	Interconnections between the social inequality and crisis management
Inequality associated with disabilities	Many societal spaces are designed with a narrow idea of people's abilities and health in mind. As a result, "dominant, non-disabled values and practices constitute vast tracts of space as no-go-areas" for people with disabilities (Hughes & Paterson, 1997, p.325). The 'social model of disability approach' prevalent in contemporary organisational research is helpful also in devising crisis management, as the framing draws attention not to the medical details and "physical and psychological limitations", but on how societal policies, barriers and practises influence the people with disabilities (Hughes & Paterson, 1997; Mik-Meyer, 2016). While the medical details in themselves do not produce the social inequalities associated with disabilities, there are different ways to categorise disabilities and different in abilities relevant to crisis management (often medically). The disabilities relate to, for example, restricted mobility, inabilities to see and/or hear, problems with communication, and cognitive or psychiatric disorders issues (see Alexander, 2015; Alexander et al, 2012).	People with disabilities are typically marginalised in crisis management, with crises likely to increase the level of discrimination they face (Alexander, 2015; Alexander et al, 2012). As a recent example, in the 2021 German floods, some 12 of the 180 that lost their lives were people with disabilities from just one home (Fekete & Sandholz, 2021; State News Service, 2021). The image of a person in a wheelchair, with restricted mobility, is a stereotypical idea of what disability looks like in a crisis (see Alexander et al, 2012). A person in a wheelchair may, for instance, struggle to shelter and require support in evacuating buildings. However, disabilities are not limited to physical mobility, nor are they in many cases visible. For instance, those with impaired hearing or sight might not register alarm signals used in crisis management (Alexander 2015), and the wellbeing of people with mental health issues might further deteriorate in a crisis. Crises are not only likely to exacerbate social inequalities faced by people with disabilities, but crises and disasters also cause disabilities (Alexander, 2015). As a recent example, the COVID-19 pandemic and the associated crisis management measures contributed adversely to mental health issues, while there were challenges and changes in providing care for those facing previous psychiatric issues (Thome et al., 2021). For more, see e.g. Alexander et al (2012); Kelman & Stough (2015).

Type of social inequality	Description	Interconnections between the social inequality and crisis management
Information and digital inequality	Access to reliable and up-to-date information is always crucial, but particularly so amidst a crisis response when people need to re-orient themselves rapidly to a changing situation. Inequality in accessing information can be down to a variety of issues, from language used to technology available. Here digital inequality is lifted up as a key illustrations of contemporary information inequality. Social, societal, and economic activities are increasingly facilitated by digital technologies and the Internet (Dimaggio et al., 2004; Zheng & Walsham, 2021). Digital technologies not only reproduce the existing social inequalities, but also create new ones. At its most simplistic, digital inequalities manifest in the differentiated access to the Internet and digital platforms in a context where social services have been taken online.	In a crisis, access to relevant and up-to-date information is important, from details on evacuation procedures to how reconstruction aid might be accessed. The inequalities access to information in a crisis can depend on various aspects, such as the language of information provided to relevant social connections. Here, we use 'digital inequality' as a contemporary illustration of information inequality in the case of crisis. In crises, digital technologies and the Internet can be compromised, as both hazards and intentional activities can threaten their functioning. However, digital technologies and the Internet facilitate not only basic societal activities in the status quo, but they also work as part of crisis management. Social media apps, for instance, can serve functions as diverse as providing air strike warnings to fostering communication and trust between residents and local authorities (Appleby Arnold et al., 2019). Thus, those who have limited or lacking access to appropriate technology and internet — say, those who do not have a portable smartphone — risk being isolated at moments of crisis. During the COVID-19 pandemic, various digital inequalities became visible also in a different way, placing different groups of workers at different levels of risk. Where 'essential workers' could not isolate to protect themselves, other groups of workers started working online with the help of the internet and digital technologies (Gkeredakis et al., 2021).

Conclusions

This section has discussed the role of social inequalities in EU crisis management. Social inequalities shape the exposure and vulnerability to crises, and crises further exacerbate social inequalities. Crisis management has the potential to both alleviate or exacerbate the various social inequalities. If crises and crisis management exacerbate inequalities and states fail to redress these patterns, this may lead to a severe dent in a state's, and the EU's, legitimacy to govern.

The emphasis in this section has been on economic and spatial inequalities, as these two types of inequalities are helpful for explaining and illustrating the broad strokes of social inequalities influencing crisis management in and across the EU. The economic system is globalised to such a degree that the broad strokes of income and wealth inequalities are illustrative of developments in various EU countries, while spatial inequality framing works well to illustrate the uneven territories of crisis management. However, it is important to note that inequalities also very much exist on the ground of gender, sexuality, 'race' and ethnicity, age, ability, and digital access, to name a few. Many of these social inequalities intersect with one another. For instance, the COVID-19 crisis response involved shutdowns of whole sectors. The economic impacts of the policies were unequally felt, with existing inequalities related to income-levels, gender, ethnicity, and age being exacerbated (Blundell et al, 2020).

There is no panacea or a clear set of boxes to tick when striving to devise socially equal crisis management. It is important to consider how the marginalised are represented in crisis management, but ad hoc participation at the moment of a crisis will not ensure that the long-term nature of social inequalities is properly taken into account. The key message is that those devising crisis management policies and actions must consider the inequalities that apply to the situation in question in three respects:

- governance scale
- place/territory
- type of hazard

The types of social inequalities listed above gives some indication of what to consider when striving to develop crisis management policies and activities that are equal.

6.4. The impact of trust on EU crisis management

Citizens' trust in public institutions

Citizens' trust in public institutions is vital for contemporary complex social systems to work (Cook & Schilke, 2010). There is a widely accepted view that higher levels of trust are linked to better economic and democratic performance, including less corruption, more compliance, more transparency, more accountability and more participation (Bjørnskov, 2012; Knack & Keefer, 1997; Putnam, 1993; Whiteley, 2000). In particular, trust helps to foster an effective public sector (Oomsels, 2019; Van De Walle & Six, 2014). It plays a key role in the formation of public policy and in its implementation (Levi-Faur et al, 2021; Ruscio, 1996).

The pivotal relevance of trust in public institutions in the context of crisis management lies in its ability to ensure compliance and cooperation without coercion, to increase citizen compliance with government regulations, and to encourage citizens to use more prosocial options in social dilemmas. The effectiveness and efficiency of specific governance regimes rests heavily on their ability to generate trust, which means a willingness of the governed to accept the potential for government-caused harm (Hamm et al, 2019, see also Mayer et al, 1995, Rousseau et al, 1998). This trust then facilitates the acceptance by citizens of increasing the authority of governance entities, which is crucial to crisis management efforts.

Trust helps to promote the successful implementation of policies in various areas of social life (Cook et al, 2005; Sztompka, 1999), including crisis management. For citizen participation in crisis management mechanisms, both the mechanisms and the institutions which design and execute them must be trusted. How to create and cultivate such trust? In a basic trust relation, A trusts B to do X under conditions Y. Factors related to all four variables in this process may influence trust. They can be linked to features and experiences of the trustor A; features, intentions and behaviour of the trustee B; characteristics of issue X; and elements of context Y. Hence, in the case of citizens' trust towards institutions, four drivers of trust can be distinguished:

- trustor-related drivers that reflect the personal characteristics, experiences, attitudes, social and cultural background of a trusting individual
- trustee-related drivers, which refer to the trustworthiness of an institution that is to be trusted
- issue-related drivers that define the area of activity where the crisis is happening
- context-related drivers, which include in particular the legal and cultural background, as well as the industry where the crisis situation occurs

Out of these four, trustworthiness (the trustee-related driver) is the main manageable antecedent of trust (Baer & Colquitt, 2018; O'Neill, 2018) — the key to building trust is to improve the trustworthiness of those who want to be trusted. Trustworthiness is a multidimensional construct reflecting the perceptions of the trustee's task-specific skills (ability), concern for the trustor (benevolence), and values (integrity) (Mayer et al, 1995). Institutions can inspire citizens to trust them through signalling trustworthiness across these three dimensions. While signals related to all three dimensions may be relevant in raising the trust profile of an institution, each may have different weight and importance when considering the specific situation and context. However, since in the relationship between citizens and institutions there are very few face-to-face encounters, the knowledge base for trust is reduced and other sources of information gain importance. The role of media, facework[84] and communication activities becomes more pronounced because they mediate the trustworthiness signals from institutions.

An important characteristic of trust relationships between citizens and institutions in crisis management is that trustors (citizens) have little or no choice in whom to select as a trustee (institutions). This absence of alternatives may mean that citizens have little choice but to accept government action in the short term. But such situations are often unsustainable. Thus, when citizens are unwilling to accept their vulnerability to governance entities — that is, when they distrust — they tend to resist increases in vulnerability and may actively work

84 "Facework translates interpersonal into institutional and system trust through the conduct of representatives who are seen to draw on institutionalised rules and resources" (Kroeger, 2017).

to reduce it (Citrin & Stoker, 2018; Levi & Stoker, 2000; Miller, 1974). This may seriously hinder crisis management actions.

There are differences in levels of trust between countries within the EU, but what these differences consist of and what their drivers are is largely a black box. International comparative studies such as World Value Survey or Edelman Trust Barometer are usually based on one-item declarative measures ("Do you trust institution X?" with answer options of Yes/No, or "How much trust do you have in institutions X?"). One-item measures do not differentiate between trust and distrust — they interpret low scores on trust question as distrust, which is incorrect, as recent literature illustrates (Uslaner, 2015). Trust scores, even if low, still reflect the attitude of positive expectations (or lack of expectations). While trust helps governments to implement policies, or to find support for policies, a mere lack of trust, or low trust, does not necessarily hinder their implementation. Distrust, however, may make the implementation of certain policies that infringe upon people's lives almost impossible.

This is because distrust is not a mere absence of trust, it is an active state of suspicion and defence (Cho, 2006; Schul, Mayo, Burnstein, 2008). Distrustful citizens are a risk factor for governments, because their basic attitude towards public institutions is one of distrust, when communication and action of government is perceived with scepticism and doubted by default (Van De Walle & Six, 2014). The problem with distrust is that it goes in two directions. Distrust in institutions makes these institutions less effective, but also negatively impacts the quality of life of those who distrust, limiting their social options. Distrust of institutions yields a range of negative societal outcomes. It reduces trust between strangers, within-group cooperation, commitment, and prosocial behaviour, and increases prejudice, intergroup conflict, polarisation, and extremism (van Prooijen et al, 2022). These effects of distrust are particularly negative for effective crisis management as they impede social mobilisation and coordination in ad-hoc unexpected events.

Finding 'solutions' for distrust is harder than finding 'solutions' for low trust. In a case of low trust, the basic disposition towards government is still one of trust. In the case of distrust, this basic trusting disposition is no longer present; all government actions are interpreted from a basic disposition of suspicion, which influences attitudes and perceptions. Even well-intended actions by government are then either not perceived at all, or perceived as malevolent. Trustful and distrustful attitudes are different across countries and this affects the scope of policy alternatives available to governments.

The consequence of differentiating between trust and distrust for designing policies to promote trustworthiness and improve trust is that two types of strategies should be developed. One should be targeted at communities where trust (even at low levels) towards institutions does exist. In such groups, the challenge is to find the best strategies by which to improve this existing trust. Such trust-building actions should focus on improving the trustworthiness of specific institutions, i.e. perceptions of their competence, benevolence and integrity. The other strategy should be developed for communities where distrust is dominant — the goal then should be first to reduce distrust to a level where basic confidence is assured and communication becomes possible. This can be done by addressing "legitimate distrust situations" (Lindenberg, 2000), for example through introducing powerful third parties that guarantee the trustworthiness of the initially distrusted institution (Nooteboom, 1999).

The EU governance regime is characterised by complex interdependencies across different levels. The literature on trust within this type of institutional architecture has commonly found the positive impact of closeness: citizens exhibit a clear tendency to trust more the institutions that are closer to them. However, trust is conditional on the perceived performance of institutions (Fitzgerald & Wolak, 2016) and local institutions are trusted more than more distant ones only as long as they are perceived as well-functioning.

As regards the supranational level, the evidence is rather mixed. Whether citizens trust national or EU institutions seems more to depend on the national context and on the period under investigation; in some countries and at some points in time, citizens have trusted EU institutions more than national ones, while in others the reverse has been true (Levi-Faur et al, 2020). Regarding the interactions between levels of governance, the research is also inconclusive. Evidence on trust in the European Parliament indicates that at an individual level, citizens' trust is positively related to trust in both national and European institutions; however, at country level, higher average levels of trust in domestic political institutions undermine the support for European bodies (Muñoz et al, 2011). There is some evidence that citizen trust towards the EU may remain for an important part beyond the direct control of the EU. This stems from the recognition that trust mainly results from general life orientations deeply rooted in culture on the one hand, and from individual experiences on the other. Object-specific evaluations are secondary.

The concept of the externalisation of trust explains the initially high levels of trust towards supranational institutions that are rather distant to citizens in transition societies (Sztompka, 1999). When authorities in the home country are seen as untrustworthy, corrupt and ineffective, there is a tendency to place trust in external organisations. This trust is founded on hope that such organisations may influence and improve the quality of institutions in the home country.

Some studies indicate that the notion that citizens care passionately about who governs them is secondary to the way in which they are governed (Harteveld et al, 2013). As a consequence, it may be that more focus on highlighting and communicating EU contributions to the wellbeing and welfare of citizens is a promising avenue to promote confidence in the EU.

Institutions' trust towards citizens

The analysis of citizens' trust in government is incomplete without exploration and explanation of government's trust in citizens. As Margaret Levi (1998, p.93) notes, "perception that a government is untrustworthy is a function not only of its failure to fulfill promises but also of evidence that government agents distrust those from whom they are demanding cooperation and compliance". Existing studies acknowledge that it is beneficial to citizen-government interaction when there is mutual trust (Yang, 2005; Dashti et al, 2009) and when the government's trust in citizens and citizens' trust in government are linked (Vigoda-Gadot, et al, 2012; Yang, 2005). Public servants' trust in citizens is a necessary ingredient for the successful functioning of governmental agencies (Vigoda-Gadot et al, 2012). Yang (2005, p.276) conceptualises this public servants' trust in citizens as "administrators' beliefs that the citizens who are affected by their work (or whom they are serving), when they are involved in the administrative (or governing) process, will act in a fashion that is helpful (or beneficial) to administrators' performance (or goal fulfillment). It is based on administrators' beliefs in citizens' competency (knowledge, skills, and judgement), honesty (integrity), and benevolence".

The trust/distrust by government officials towards citizens is shaped by social and individual influences. It is created through various sources such as encounters with citizens, professional education, media reports, friends, family, media and art (Yang, 2006). On a social level, civil servants emanate more abstract government attitudes towards citizens (Keulemans & Van de Walle, 2020). In their dealings with clients, public sevants are bound by bureaucratic regulations (Lipsky, 2010). From a trust perspective, bureaucratic rules are a double-edged sword. On one hand, they guarantee transparency and impartiality. On the other hand, research shows that rigid rule-following is interpreted as a manifestation of distrust, and rule-bending as a sign of trust (Yang, 2005; Tummers et al, 2015).

There are three main benefits arising from institutions' trust in citizens. First, exhibiting trust or distrust is likely to inspire citizens to reciprocate with the same or an even stronger attitude, triggering a self-amplifying cycle. In other words, when public servants show trust, citizens are likely to respond with trust as well (Sztompka, 1999). Second, when institutions are trusting citizens, there may be a lower need to control their activities and statements. This is because, generally, a party that feels trusted assumes the responsibility of truly being trustworthy. Therefore, showing trust towards citizens may be an important building block in transforming societies towards more empowerment and participation. Third, trust is practical. Nowadays, the monitoring of citizens is an important part of work done by numerous governmental agencies. Trust may reduce red tape, freeing the time of public servants and making their operations more flexible and less costly.

In the context of a major event, the way public institutions, governments, and public stakeholders tend to trust, and engage with, fellow citizens constitute a key element for a successful response to the crisis. Nevertheless, this collaboration still needs to be built from both sides. While digital tools constitute new means to engage this collaboration, they also challenge governmental and professional culture and practices.

Promoting the trustworthiness of crisis management mechanisms in the EU

Crisis moments become more frequent these days so it is crucial to focus on building trust in the long run so it could support effective crisis management; but also to promote mechanisms for the ad-hoc emergence of trust in critical situations. What should also attract attention is the danger of instrumentalising crises for short-term political gain, undermining social trust by deepening social divides, increasing polarisation, stifling fruitful debates and silencing critical voices.

Strategies to build trust

Among actions that promote trust between citizens and institutions, participation (which we discuss in section 6.4, p.146) occupies a key position. Furthermore, equal access to policymaking and representation are regarded as common conditions for improving trust. Striving for more equal societies, EU and governments might be able to rebuild trust by giving citizens more opportunities to have real impact on the political process. This needs to go beyond elections, such as (for instance) randomly-selected citizen assemblies, among other recently proposed innovations. Efforts should be undertaken to increase social integration, social mobility and dialogue between various groups within societies of the EU. This can take place on forums that cut across national divides, for example on a regional level and within professional communities.

As regards countering distrust, ways to highlight skills, competence, and good performance are some obvious and uncontested measures, as is increased contact between institutional representatives and citizens (Van Prooijen et al, 2022). Furthermore, when distrust is based on perceptions of unethical practices and injustice, it is important to focus on promoting shared notions of fairness and reinforcing the visibility of monitoring mechanisms (Bertsou, 2019). Consequently, it is essential to build and promote a common culture of risk, allowing both citizens and public institutions in charge of crisis management to anticipate, act and engage together at the time of a major event (Courant et al, 2021)

Swift trust

Crises are characterised by their temporality (see p.32), their unexpectedness, and the need to initiate immediate and competent actions. Particularly in the dynamics of a sudden-onset crisis, which is often characterised by an initial phase of chaos, 'swift trust' is important to rapidly achieve coordination and cohesion (Meyerson et al, 1996; Blomqvist and Cook, 2018). Swift trust is a form of trust that may emerge in temporary settings, in situations where the typical foundations for trust, such as familiarity, shared experiences and demonstrations of goodwill, are unavailable. As such, swift trust is especially important in situations where the time pressure is high (Mishra, 1996).

Temporary teams are units where individuals are brought together to complete specific tasks. They may be new to one another and may not interact again; they have a short timeframe in which to accomplish the task, and they need to begin action immediately. This temporary setup appears to correspond particularly with sudden-onset crises, where organisational structures are non-existent, weak or extremely volatile because of disruptive events, and where complexity and uncertainty are prevalent. Temporary teams are a common form of organising in emergency response teams, for instance.

The ability to facilitate the emergence of swift trust enhances crisis management capabilities for institutions. In particular, it improves coordination among temporary team members and strengthens their commitment to the accomplishment of shared goals (De Jong & Elfring, 2010). Research shows that conditions influencing the formation of swift trust include third party information, dispositional trust, establishment of rules categories, and roles (Tatham & Kovács, 2010). Swift trust needs to be maintained actively, so norms of communication and behaviour, such as standard-setting, are of great importance. Even though there may be doubts whether swift trust leads to the same level of commitment as relationships that evolve over an extended period of time, research has shown that swift trust leads to greater commitment in crises, and that transparency and improved information sharing are some of the main prerequisites for the formation of swift trust (Dubey et al, 2019). Other authors have highlighted the importance of respect, openness and humility, especially if teams need to be coordinated that cover multiple nationalities (McLaren & Loosemore, 2019).

Information

While these are important lessons for coordination among different crisis management authorities, organisations or teams, much less is known about the role of swift trust among citizens or communities. What is known are important links between trust, (mis-) information and the willingness to engage in preventive behaviour. Research both on Ebola (Vinck et al, 2019, Blair et al, 2017) and COVID-19 (Guo et al, 2022) highlight that higher trust is positively correlated with this willingness. In other words, trust is an important requirement for citizens to adjust their behaviour. Generally, local authorities were more frequently trusted than higher levels of government, which was suggested to reflect levels of access, visibility, and direct delivery of services (Rizza, 2022; Vinck et al, 2019).

Because of the important role of information, there are increasing concerns that social media especially can be weaponised to sow distrust by spreading misinformation and fake news. It is important here to differentiate between rumours and misinformation. While rumours have been part of crises and the uncertainty they drive, misinformation and fake news are voluntarily spread in order to destabilise a state or a government (Starbird, 2021). The risks of misinformation range from false information about COVID-19 that impact public health (Limaye et al, 2020) to attempts to influence elections (Guess et al, 2018).

Importantly, when it comes to social media, the role of authorities changes. While authorities have traditionally had specific functions or expertise, increasingly citizens trust individuals within their peer network as authorities — even though, or maybe precisely because, most of these individuals do not follow any established protocols for information verification or validation. Here, in our democracies, one important measure may include the engagement and regulation of social media companies to flag and remove misleading or dangerous information as well as ways to explain false argumentation and highlight the existing scientific consensus (Cook et al, 2017). It is important that private companies and media conglomerates should not exclusively handle the responsibility of defining what is true from what is false by themselves; neither should they have the sole authority to decide upon freedom of speech by banning (or not) individuals or content. It is necessary to provide specific legal frameworks to balance this regulation and ensure that freedom of speech and thought is still possible in our digital and usual public spaces.

There is also a need to better understand distrust, as opposed to low trust. It has been shown that polarisation, the separation of social groups, is associated with distrust in democratic institutions (Turcotte et al, 2015). However, less is known about how disinformation fuels polarisation and distrust, or whether it is a product of distrust (Humprecht, 2019). Yet if disinformation and misinformation limit opportunities for dialogue and an exchange of views, they thereby reduce trust and reinforce distrust.

6.5. Participation in EU crisis management

Stakeholder and citizen participation usually take place within open consultation processes. If appropriate, these processes can also be co-determined by legal decision-makers and the relevant public. Within specific legal boundaries, participants involved in the process create new options and evaluate existing ones. The co-designing of decisions is the most empowering participation process (Mosleh & Larson, 2021). There is no uniform definition of the term 'citizen or stakeholder participation': in some cases, democratic procedures such as elections are already counted as citizen participation, while in other cases communication campaigns by politicians are also considered a preliminary stage of citizen or stakeholder participation (Frewer & Rowe, 2005; Stender-Vorwachs, 2012). In this report, citizen and stakeholder participation is understood as all procedures and instruments in which individuals and organisations actively participate in collective decision-making, independent of a political mandate or the authorities and institutions assigned to the mandate (Benighaus & Renn, 2016). If people are involved in their function as citizens, one refers to citizen participation. If they are requested as representatives of organisations or institutions, one refers to stakeholder participation (Renn, 2008).

In order to achieve acceptance of the results of the participation process among stakeholders, participation requires an open consultation process in which participants take a position on problems and options and contribute to the process of collective decision-making directly in dialogue or indirectly through written expert opinions (Landwehr, 2012). Depending on the type of participation, the degree of involvement and thus acceptance varies. It ranges from mutual exchange of preferences and assessments to co-design of options for action.

In addition to the differentiation between stakeholder and citizen participation, participation procedures can be distinguished according to whether they are legally mandatory for certain policymaking processes or whether they are used as legally permissible informal procedures. A distinction must therefore be made between formal procedures, which are prescribed by law, and informal procedures, which are not. In the case of both procedures, there is no legal entitlement to adopt the results of the participation procedures in the form of a co-decision. In the case of formal procedures, however, there is a legally anchored obligation to take them into account and to allow them to flow into consideration processes. A similar obligation does not exist for informal procedures. However, it is also expected here that the recommendations are considered as policy advice by the political decision-makers and, if possible, also integrated into the political decision-making process.

Participation in EU crisis management: state of affairs and gaps

The European Commission is required to hold extensive public hearings to ensure the coherence and transparency of all EU actions, but this ultimately does not guarantee a right of stakeholders or the general public to be directly involved in decision-making.[85] There is little EU legislation on public participation directly related to crisis management. There are many areas of systemic risks where requirements for public dialogue or participation are specified, but these requirements are predominantly addressed in the context of specific directives regulating, for example, climate protection, infectious

85 Art. 11 (3) TEU; made concrete by the European Commission's legally non-binding guidelines on better regulation SWD(2017) 350 final..

diseases or energy transition. For example, Article 10 of the Governance Regulation requires each member state to ensure "that the public is given early and effective opportunities to participate in the preparation of member states' draft integrated national energy and climate plans and long-term strategies"; member states are required to include a summary of the comments or preliminary comments from the public when submitting their plans to the European Commission, as well as long-term strategies. In addition, Article 10, paragraph 2 of the Governance Regulation requires member states to ensure that the public is well informed and that appropriate deadlines are set for the information and participation of the public and the opportunity to submit their views.

The nature of public participation in emergency and crisis management-related EU legislation is inconsistent; in particular, there are differences with regard to the timing and the group of persons to be involved.[86] For example, a distinction is made between the concerned public, which usually has to be informed in a more specific way and has the opportunity to express opinions and make comments — and the general public, which simply has to be informed.[87] What the legal acts have in common is the obligation to consider the results of the consultations and to take them into account when drafting decisions for policies.[88]

The form in which public participation takes place is regulated differently in the various legal areas. Quite often, this involves the right to submit an opinion and the right to be heard in the form of a discussion of the factual and legal situation in order to answer questions and address concerns. The EU conducts dialogues with local authorities, civil society organisations, business, investors, and other stakeholders in the form of so-called citizens' assemblies in all member states to discuss EU challenges, including issues of safety, security and risk management. Although citizens' dialogues are not enshrined in primary law (i.e. treaties or Charter of Fundamental Rights), they are taken up in secondary law: Article 11 of the Governance Regulation, for example, obliges the member states to establish a dialogue on major risk issues such as climate and energy.[89] This dialogue

86 For example, Directive 2003/35/EC (OJ 2003 L 156/17) provides for public participation in certain plans and programs relating to the environmental risk and health threats. EIA Directive (Directive 2011/92/EU, OJ 2012 L 26/1) mandates public involvement for public and private projects with likely and significant effects on safety and in the TEN-E Regulation (Regulation 347/2013, OJ 2013 L 115/39) demands public participation in the context of the development of priority corridors when dealing with energy planning and the risk of climate change.

87 Cf. Art. 1(2)(e) EIA Directive: "public concerned" means the public affected or likely to be affected by environmental decision-making pursuant to Art. 2(2) or the public with an interest therein. For the purposes of this definition, non-governmental organisations, working for the protection of the environment and meeting all the requirements applicable under national law have an interest."199 Cf. Art. 1(2)(d) EIA Directive states: "'the public' means one or more natural or legal persons and, in accordance with national legislation or national practice, their associations, organisations or groups.

88 See, for example, Article 8 of the EIA Directive: the results of consultations and the information obtained in accordance with Articles 5, 6 and 7 must be taken into account in the authorisation procedure.

89 Article 11 of the Governance Regulation: "Each member state shall establish, in accordance with its national legislation, a multi-level dialogue on climate and energy issues, in which local authorities,

is intended to enable local authorities, civil society organisations, business, investors, other significant stakeholders, and the general public to actively participate and discuss various scenarios, including long-term ones, envisaged in dealing with global risks such as climate change or other challenges. Article 9(1) of the EU Climate Change Act also requires the Commission to enable and empower all sectors of society to take action to make the transition to a carbon-neutral and climate-resilient society fair and equitable. It promotes an inclusive, accessible process at all levels, including national, regional and local levels, as well as with social partners, academia, business, citizenship and civil society, to share best practices and identify actions that contribute to the objectives of this Regulation. The Commission may also refer to the public consultations and multi-level dialogues established by the member states in accordance with Articles 10 and 11 of the Governance Regulation.

The role of science, civil society, economic private actors and policymakers in crisis governance

Since the EU legislation is fairly non-specific and also inconsistent about public and stakeholder participation in risk and crisis management, it is essential to specify the roles of different actors in society. What are the legitimate roles and functions of stakeholders and citizens in risk and crisis management and planning?

Decisions and policies about crisis management need to meet four generic criteria (Parsons & Shils, 1951; Rosa et al, 2014; Renn, 2014:

- **Effectiveness** refers to the need of societies to have a certain degree of confidence that human activities and actions will actually result in the consequences that the actors intended when performing them.
- **Efficiency** describes the degree to which (frequently scarce) resources are used to reach the intended goal. The more resources are invested to reach a given objective, the less efficient the activity under question remains.
- **Resilience** describes the capacity to sustain or rapidly recover the functionality of a system or a service even under severe stress or unfamiliar conditions (see Chapter 2.4).
- **Social cohesion** covers the need for social integration, justice and collective identity, despite plural values and lifestyles.

All four needs or functions of society build the foundation for legitimacy. 'Legitimacy' is a composite term that denotes, first, the normative right of a decision-making body to impose a decision even on those who were not part of the decision-making process

civil society organisations, business, investors, other relevant stakeholders and the general public can actively participate and consider the various scenarios, including long-term scenarios, that may be envisaged in the energy and climate protection policy."

(issuing collectively binding decisions), and second, the factual acceptance of this right by those who might be affected by the decision (Zelditch, 2018). As a result, it includes an objective normative element, such as legality or due process, and a subjective judgement, such as the perception of acceptability.

Within the macro-organisation of modern societies, these four functions are predominantly handled by different societal systems: economy, science (expertise), politics (including legal systems), and the social sphere. In the recent literature on governance, the political system is often associated with the rationale of hierarchical and bureaucratic reasoning; the economic system with monetary incentives and individual rewards; and the social sphere with the unregulated interactions of groups within the framework of a civil society (Renn, 2008). Another way to phrase these differences is by distinguishing among competition (market system), hierarchy (political system), and cooperation (socio-cultural system).

In the field of crisis management decision-making, it is appropriate to operate with four separate subsystems, since independent scientific expertise is crucially important to risk-related decisions and cannot be subsumed under the other three systems. Each of the four systems can be characterised by several governance processes and structures adapted to the system properties and functions in question. The four systems and their most important structural characteristics are shown in Figure 14. What findings can be inferred from a comparison of these four systems?

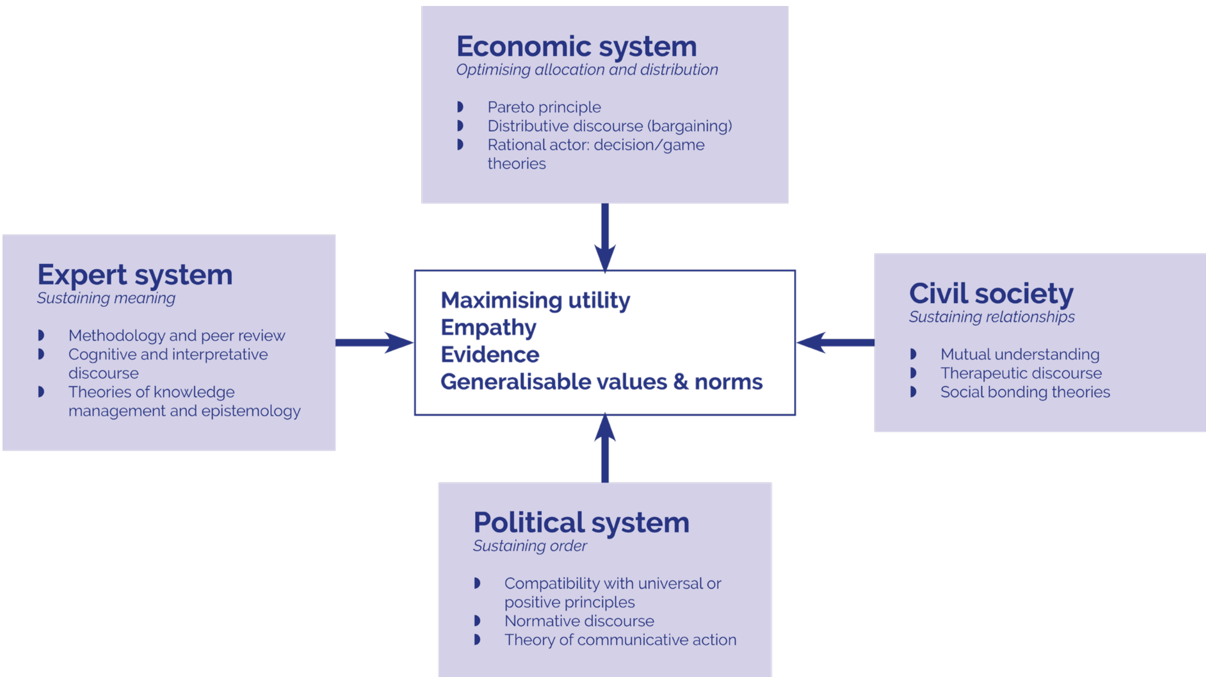

Figure 14. The functional contributions of the four major players to policymaking
Author: Ortwin Renn

In the market system, decisions are based on cost-benefit analysis, performed on the basis of individual preferences, property rights, and individual willingness to pay. However, conventional cost-benefit analyses make ceteris-paribus assumptions, by which 'all other aspects' of the system under considerations remain stable. COVID-19 has starkly illustrated the surge in prices of protective equipment, and other essential supplies, highlighting that even within the market logic, cost-benefit analysis is not adequate to investigate crises. Further, we have stressed multiple times that crises in increasingly complex systems will create cascading impacts across different markets and sectors, further violating the assumptions underlying such an analysis. Similarly, General Equilibria Models or Input-Output Analyses assume that the demand for specific services or good remains unchanged. And again, the COVID-19 crisis provides us with ample evidence that — of course — the demand for products, goods and services changes dramatically under crisis conditions. As such, alternative methods are needed to assess the impact of crises that take into account the dynamics and drastic behavioural shifts that are characteristic of disasters.

The conflict-resolution mechanisms relate to civil law (regulating contractual commitments), Pareto optimality (requiring that each transaction should make at least one party better off without harming third parties), and the application of the Kaldor–Hicks criterion (if a third party is harmed by a transaction, this party should receive financial or in-kind compensation to such an extent that the utility gained through the compensation is at least equivalent to the disutility experienced or suffered by the transaction). The third party should hence be at least unchanged between the situation before and after the transaction. In economic theory, the transaction is justified if the sum of the compensation is lower than the surplus that the parties could gain as a result of the planned transaction. However, the compensation does not need to be paid to the third party. Additional instruments for dealing with conflicts are (shadow) price-setting, the transfer of rights of ownership for public or non-rival goods, and financial compensation (damages and insurance) to individuals whose utilities have been reduced by the activities of others. The main goal here is to be efficient.

In politics, decisions are made on the basis of institutionalised procedures of decision-making and norm-control (within the framework of a given political culture and system of government). The conflict resolution mechanism in this sector rests on due process and procedural rules that ideally reflect a consensus of the entire population. In particular, decisions should reflect the common good and the sustainability of vital functions to society. This is why resilience lies at the heart of public activities. In democratic societies, the division between legislative, executive and judicial branches, defined voting procedures and a structured process of checks and balances lie at the heart of institutional arrangements for collective decision-making. Votes in a parliament are as much a part of this governance model as is the challenging of decisions before a court. The target goal here is to seek resilience as a major prerequisite of legitimacy.

Science has at its disposal methodological rules for generating, challenging and testing knowledge claims, with the help of which one can assess decision options according to their likely consequences and side-effects (SAPEA, 2019). If knowledge claims are contested and conflicts arise about the validity of the various claims, scientific communities make use of a wide variety of knowledge-based decision methods, such as methodological review or re-testing, meta-analysis, consensus conferences, Delphi, or — most relevant in this arena — peer review to resolve the conflicts and test the explanatory or predictive power of the truth claims. These insights help policymakers understand phenomena and be effective in designing policies.

Finally, in the social system, there is a communicative exchange of interests, preferences, and arguments assisting all actors in arriving at a unanimous solution. Conflicts within the social system are normally resolved by finding favourable arrangements for all parties involved, using empathy as a guide to explore mutually acceptable solutions, referring to mutually shared beliefs, convictions, or values or relying on social status to justify one's authority. These mechanisms create social and cultural cohesion.

This classification of four major systems of governance is particularly important for crisis management. The need to be prepared for crisis involves the requirements of each of the four basic systems: the measures need to be:

- effective based on best available evidence
- efficient ("economic") in order to be aware of existing scarcities of resources and time
- resilient so that enough capacity is created to cope with multiple stress situations
- sensitive to social requirements of fairness, proportionality and cultural identity

These functional requirements can best be met when actors in society cooperate, and are particularly competent and responsible for the implementation of each of the four criteria. Beyond the democratic norm of inclusiveness, it is also a functional requirement to convene representatives of each of the four actor groups to establish and implement effective, efficient, resilient and socially compatible crisis preparedness programmes and plans.

Volunteering as a special form of participation in crisis situations

The scientific literature in the field of crisis management has demonstrated that grassroots initiatives appear at the same time as the crisis, as a means of response. During an earthquake or a flood, those people present are often the first to help the victims, and after the crisis, local people are often the ones who organise the cleaning up and rebuilding of the affected area. Genoa experienced two rapid and violent floods in 1976 and 2011; on both occasions, young people volunteered to clean up the streets and help shop owners and inhabitants in the days that followed the event. During the terrorist attack in Paris in 2015, Parisians opened their doors to those who could not go home and used the hashtag #parisportesouvertes (#parisopendoors).

There has been an increase in these initiatives following the arrival of information and communication technologies, and more specifically social media. Digital tools and platforms have been used to provide organisational support online as a complement to actions that usually arise spontaneously in the field.

We usually think of social media and other digital tools as a means of communication used by institutions (ministries, municipalities, fire and emergency services etc) to communicate with citizens top-down and improve the situational analysis of the event through the information conveyed bottom-up from citizens. The academic literature in the field of crisis informatics has demonstrated the changes brought about by social media: how citizens have been using them to communicate in the course of an event, to provide information or to organise help (e.g. Palen et al, 2020). We commonly make the distinction between 'real volunteers', who act onsite to respond to crisis needs, and 'virtual volunteers', who provide help and support by organising action and information on social media (Reuter et al, 2013). This distinction helps to capture how social media has become a site for expressing and organising solidarity (Batard et al, 2018; Bubendorff et al, 2019). Whether these citizen initiatives take place onsite or online, they are mostly spontaneous: spontaneous volunteers are people who act in response to or in anticipation of a disaster, who are not affiliated with a crisis management organisation, and who may or may not have the required skills (Drabek & McEntire, 2003). Thus, the notion of affiliation with a crisis management authority helps to characterise citizen initiatives (Batard et al, 2019; Stallings & Quarantelli, 1985; Zettl et al, 2017). In Europe, some online volunteers have signed agreements with public institutions and their actions are coordinated. This is the case with Virtual Operational Support Teams in Europe, for instance, but other user communities, such as the Waze community, can also be mentioned (Rizza, 2022).

Nevertheless, integrating citizen-led initiatives and facilitating their participation in the crisis management processes requires time, resources and reorganisation of practices, and it raises challenges. First of all, crisis management organisations tend to communicate with citizens from a top-down perspective, whether through traditional or social media. It has been demonstrated that such top-down communication exhibits a lack of empathy towards citizens' questions (e.g. Borraz, 2019, Bubendorff et al, 2019). With the opportunities offered by digital tools and platform, everything happens as if citizen initiatives were horizontally 'colliding' with the institutions in their professional practice (Rizza, 2020). In other words, participation implies recognising citizens as major actors in the crisis management operations: participation requires a change of our crisis management culture, which often considers that citizens have to be protected (Rizza, 2022). Despite this challenge, participation in crisis management and response constitutes one key element in (re)building trust between public institutions and citizens at an uncertain and tense time.

Participation and digitalisation

Participatory resilience and digitalisation

Traditional disaster response is organised in a hierarchical, quasi-military way. Information about the situation at hand is collected and aggregated, and decisions are taken at the top, typically in a 'war room'. After this, commands are issued and executed in a top-down way as effectively as possible.

As powerful as this approach may be, it has its limits. Disaster response capacity depends, among other things, on the information processing capacity of the leadership, and on the execution capacity at the bottom. Both are limited. Furthermore, there will typically be delays between information gathering and disaster response — but a quick response is one of the most important elements to stop destructive cascading effects during disasters (Buzna et al, 2007).

In recent years, with the widespread availability of smartphones and other technologies, a new and more effective model of disaster response has emerged: participatory resilience (Pfefferbaum et al, 2015; Helbing and Seele, 2019). Here, people help themselves and support each other. Local, community-based response reduces the pressure on the government-based disaster response and increases the overall response capacity. This is particularly critical during the first 72 hours after a disaster strikes, which is the time it often takes until government response is fully operational. Without help, however, many people may die during this period of time.

Therefore, the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA), offers useful smartphone apps for disaster preparedness and response.[90] This includes a service providing help, for example, based on tweets that people send, which are often geolocated. This allows one to generate an annotated map. But it also enables the organisation and coordination of help in the respective neighbourhoods.

It is easy to imagine extensions to this (Helbing, 2021). For example, at a hackathon on earthquake resilience in San Francisco, Amigocloud[91] prototyped a service which allowed people to annotate pictures of damaged infrastructures, which would be uploaded to a public map such as OpenStreetMap whenever connectivity was available. In this way,

90 United Nations Office for the Coordination of Humanitarian Affairs (OCHA). https://www.unocha.org (accessed on 8 November 2021); United Nations Disaster Reporting App & what3words (Aug. 26, 2015) https://what3words.com/news/general/un-asign (accessed on 8 November 2021).

91 Amigo Cloud Inc., Location Intelligence Made Simple, https://amigocloud.com (accessed on 8 November 2021).

everyone, including first aid units, would quickly get an overview of the situation: what roads are blocked, what bridges collapsed, what houses damaged? Which areas require help, and how to reach them? Such functionality is now common in various emergency warning and response apps. ChargeBeacon[92] proposed an autonomous infrastructure to recharge the batteries of smartphones using solar power, so that people would be able to keep their tools operational. Helping Hands proposed a local social media platform which would allow people to offer and ask for help in their neighbourhood, and thereby match supply and demand. In such a way, the availability of important goods and services could be ensured. This could be the basis of a local sharing economy during emergencies and even beyond. Furthermore, decentralised, blockchain-based functionality might be added to offer payment and incentive systems while the internet is down. To maintain communication when regular communication infrastructures fail (as often happens during disasters), peer-to-peer communication software has been developed which allows smartphones to establish an ad-hoc communication network (Lin, Hsueh and Pa, 2015). Recently, a particular ad-hoc communication protocol has been proposed to ensure that everyone could stay connected for a period of about 3 days, even if recharging batteries is not possible. The underlying fairness-based approach serves individuals and communities alike (Banerjee, Warnier, Brazier et al, 2021). In addition, smartphone sensors can be used to run measurement systems. For example, applying the principle of crowdsensing, it is possible to run a collective earthquake sensing and warning app (Faulkner et al, 2011). Using the Internet of Things in a distributed way could certainly offer a lot of further functionality. Participatory resilience does not stop there. Fab Labs and Makerspaces allow citizens to produce their own physical products and tools, as has been demonstrated during the COVID-19 crisis (Dumez et al, 2022; Gershenfeld, 2012). To be available in emergency situations, they should be based on autonomous energy generation.

The above underlines that the ability to cope with disasters and crises can be increased considerably by participatory resilience, which is based on empowering citizens to help themselves and support each other. This resilience builds on a distributed and diverse approach as well as digital assistance (Helbing, 2013), which supports synergy effects, trust and solidarity in the community networks of civil society. A recent publication therefore suggests creating "tools and forums that promote engagement and participatory resilience. These should empower communities to survive and thrive" (Mahajan et al, 2022). Tools like this should be developed well ahead of crises and deployed through smartphones or other commonly-used devices. For this, different ways of implementation are conceivable (as disasters are rare, commercial products might be insufficient):

- The military could develop and deploy such tools.

92 Hackathorn Winners 2nd Place (Sep. 16, 2014) https://www.youtube.com/watch?v=LVGwHAtLwVQ (accessed on 8 November 2021).

- Organisations responsible for civil security could do it.
- Citizen initiatives could cocreate such tools, in a similar way as Wikipedia and OpenStreetMap have been built.
- The gaming industry could develop multiplayer games containing all required functionality.
- A combination of the previously mentioned approaches might be best.

Wikipedia

The crisis management literature shows that information shared on social media during a crisis is relevant both to emergency agencies, when it establishes a more accurate situational awareness, and to citizens, when it enables a collective and coherent approach to the event (e.g. Stieglitz et al, 2018; Palen et al, 2020). However, social media is also considered to be a place where "noise" and fake news can be disseminated (e.g. Alexander, 2014; Starbird, 2017).

Wikipedia and Twitter play a major role in the construction and dissemination of information during an event. Despite their own paces and designs, Wikipedia and Twitter are used by citizens with similar concerns for seriousness and reliability, when reporting or verifying information about a crisis. Consequently, social media has changed the landscape of means of communication for official institutions, and there is an acknowledgement of the need to integrate them in their practices (Bubendoff, Rizza, & Prieur, 2021).

Seeing Wikipedia only as a collaborative platform underestimates its role in the resilience process during a crisis, when it also fulfils a function of information gathering and dissemination. Wikipedia offers freely reusable, objective and verifiable content that every citizen can edit and improve. This is a difficult task when it comes to documenting in real time a crisis characterised by uncertainty, such as the one linked to the current COVID-19 epidemic. Wikipedia articles about an event are created very quickly in order to present a synthesis of the available information. Studying the construction of this synthesis allows understanding of how information circulates and is aggregated around an event in progress: the dynamics of page creation, the debates between contributors on what constitutes a reliable source or not, and the strategies for building knowledge trees to best present information (Bubendorff & Rizza, 2020; Bubendorff et al, 2021). Civil security crises usually unfold rapidly and over a short period: whether it is anticipated or unexpected, we observe a rapid peak in the crisis with a 'return to normal' in the hours or days that follow. The COVID-19 health crisis presents a different temporality: on the eve of the first containment, it was characterised by a peak rise, which then stagnated in a plateau without any real forecast of a return to normality. Because of this plateauing, we find on Wikipedia a mixture of mechanisms, some specific to crises, others closer to the issues raised by topics that are more common.

On crises, citizens contribute to find meaning and to fill an information vacuum. Every crisis comes with its share of uncertainties (Starbird, 2020; Starbird et al, 2020) and these uncertainties translate into anxiety among citizens. In order to cope with this, they will try to 'solve' or answer these questions. They will try to understand what is happening and what should be done, or even what they should or could do. They meet, communicate via their smartphones or organise themselves via social media. This is exactly what we found for Wikipedia during this health crisis (Bubendorff & Rizza, 2021a, 2021b). In the absence of effective crisis communication, citizens are plunged into uncertainty, which they will try to resolve through the co-production of informative encyclopedic content. Community work — the debate on the sources and quality of information — allows them to find some certainty in the mass of (sometimes contradictory) information circulating, and, finally, to fill an informational vacuum that would otherwise leave room for rumours or false information. This is what we are witnessing today, and it is no coincidence that the COVID-19 pandemic has been associated with the idea of 'infodemia'.

Wikipedia during crises

Wikipedia is a collaborative online encyclopaedia powered by user contributions. It is a novel experiment in that it opens up the writing of content to all internet users. Although it is intended as a general encylopaedia, since 2003 Wikipedia has actually been used primarily as a means to obtain information about a current or recent event (Keegan et al, 2013).

Wikipedia contributors also exchange information with one another, as can be seen in the 'Discussion' tab on each page. These pages house various debates among contributors about the subject of the article, from very pragmatic questions about the organisation of the page to the details of the way the subject is treated. This interaction space testifies to the activity of the contributors and the eminently social nature of the exchanges. Wikipedia is not just an online encyclopaedia, but a place where knowledge is created and organised. The site generates a number of exchanges, debates and interactions between users.

The literature has largely focused on this interactive aspect (Hocquet, 2015), but Wikipedia's role in the dissemination of information in times of crisis has been little studied. During a major event, Wikipedia plays the role of a digital social network, and presents certain characteristics (Bubendorff et al, 2019):

- The speed with which new information is created shows an extreme reactivity to current events.

- Articles on major events give rise to a large number of collaborations very quickly after the creation of the article. By comparison, other articles take at least a year to reach the same level of participation.
- The most important contributors on pages related to current events are regular users of Wikipedia, registered as users: they frequently contribute to specific topics and also have a mediation role on the site. They play this role even more in times of crisis, where modifications to an event page are made at a particularly high rate in the first few hours following the announcement of the event. Users seem to specialise according to the type of crisis.
- Articles about crises have a higher proportion of contributors who are not used to writing articles, compared to other articles.
- Particular attention is paid to the sources used. In the case of unpredictable crises such as terrorist attacks, traditional media remain the main source of information, particularly the major national media. When it comes to meteorological events, pages can be created in anticipation with a wide variety of sources (climatic sciences, specialised press, etc.). Moreover, the state and its authorities become the guarantors of the truth in a situation that cannot be confused with a 'political' crisis.

In the case of crises, Wikipedia articles are supplemented as new information becomes available. 'Recent event' or 'current event' banners are often attached to articles, indicating to users that the article is frequently changed and does not yet constitute encyclopaedic knowledge.

The specifics of articles related to the COVID-19 crisis

An initial observation of the handling of the pandemic reveals that it has the same immediate characteristics as the handling of a crisis: there are many contributors, and they take up the issue very quickly. In France, for example, the first article on the pandemic was created on 19 January 2020. Now called *COVID-19 pandemic*, it has more than a thousand contributors (when the average number of contributors per article is around seven; Auray et al, 2009). Nevertheless, the pandemic is characterised by slow kinetics that strongly influence the way it is treated. These kinetics allow for a particularly detailed observation of the construction of meaning around this uncertain event.

An analysis of the French pages relating to the pandemic shows that contributors' normal ways of doing things were put to the test (Bubendorff et al, 2019; Keegan, 2015). The process of developing the pandemic pages had the same characteristics as those of the pages for rapid-onset civil security crises, but the scale of the pandemic (both its long duration and the profusion of events and associated debates) made it more difficult for editors to summarise information, and led to an unprecedented deployment of tools to help with regulating this:

- Warning banners are embedded in the headers of several articles dealing with the pandemic.
- Articles can be temporarily locked to limit the number of modifications.
- Some contributors increased their moderation activities to stabilise the content.

Additionally, an article devoted solely to misinformation during an event was published for the first time. Initially published on the English Wikipedia and then translated into French, it lists rumours, disinformation campaigns and other forms of false information, categorises them by origin or theme, and includes evidence of debunking by media or analysts.

Until very recently, quality of sources on Wikipedia was a matter of good faith on the part of each contributor (described in the *Cite your sources* help page). The creation of the article *Observatory of sources* marks one of the most important upheavals caused by the pandemic, formalising quality criteria that are more precise and more explicit (Bubendorff & Rizza, 2021a). The page discusses the reliability of various media, academic journals and television programmes in order to propose an inventory of sources that can be mobilised on Wikipedia.

Wikipedia as an unaffiliated expert citizen community to fight disinformation

Wikipedia played a significant role in the fight against disinformation since the beginning of the COVID-19 crisis. As a non-affiliated expert citizen community, it can play a significant role in communicating to citizens about major risks, the documentation related to those risks, and, in the case of a major incident, how to make sense of the event in progress. Nevertheless, in a disinformation war like the one that surrounds the conflict in Ukraine, Wikipedia is not spared and some pages in specific languages are unfortunately challenged by misuse.

Twitter

During a major event, the pace of Twitter use is fast. First, information about a crisis appears quickly on the platform and related tweets start with the first suggestion of a crisis. For instance, in the case of the November 2015 Paris attacks, messages sent by witnesses concerned unusual or suspect noises (gunshots attributed to firecrackers). In the 2018 December terrorist attack in Strasbourg, the first tweets mentioned unusual law enforcement activities in the neighbourhood. The platform was quickly filled with messages regarding the event, covering a broad range of activities: from gathering information (e.g. during hostage-taking in Trèbes in March 2018, Twitter users asked if some roads were indeed closed to traffic), to citizen self-organisation to escape life-threatening situations (e.g. during the 13 November 2015 Paris attacks, the hashtag #porteouverte (open door) was used by citizens to offer shelter to anyone in need). Furthermore, information spread as soon as it appeared on Twitter. The speed of the dissemination of the most retweeted messages is independent of their content, the time of their publication, and the number of followers of the accounts (Bubendorff et al, 2021).

Patterns of verification and uses of traditional media

Although the rhythms of information dissemination through social media vary, users from both Twitter and Wikipedia mobilise the same type of news and sources to make sense of the ongoing event. Their specific attention to sources and their appetite for 'official news' (from the authorities), combined with the primacy of traditional media in the information they relay, imply considerable reliability in the way they process major events (Bubendorff et al, 2021).

In the digital age, it becomes possible to coordinate many actors in a bottom-up way through digital platforms, particularly those that locally provide context-relevant real-time feedback. Benefits can be achieved in many areas — for a lot more people than traditional social benefit systems can do it. Public institutions need to adapt their digital culture and practices, more specifically in their ways of communicating and engaging with citizens through social media. A combination of various approaches often delivers solutions that work better for more people, towards collective intelligence. This offers the perspective to upgrade democracies in digital ways towards digital democracies. This benefits from mass innovations and developments such as open data, open source, open access, creative commons, open innovation, citizen science, hackathons, gov labs, fab labs and maker spaces, crowd sensing, crowd sourcing, crowd funding, open-source urbanism, information ecosystems, combinatorial innovation, etc. Digital platforms allow connective action. They allow people to engage more effectively and to successfully organise initiatives and projects with others towards the development of improved solutions and the local societal transformation towards more sustainability, resilience, and health. This uses apps and platforms of all kinds, such as digital recruiting platforms, neighbourhood and sharing platforms, social computing.

Stakeholder and citizen participation: keys for inclusive governance in crisis management

In addition to the need for effective crisis communication at all stages, inclusive governance requires input on all governance levels from a diversity of social groups and stakeholders and includes the obligation to ensure the early and meaningful involvement of all stakeholders and, in particular, civil society. Inclusive governance is based on the assumption that affected and interested parties have something to contribute to the governance process and that mutual communication and exchange of ideas, assessments and evaluations improve the final decisions, rather than impede the decision-making process or compromise the quality of scientific input and the legitimacy of legal requirements (IRGC, 2017). However, the recent example of COVID-19 also highlights the risk of decision-making and crisis management being paralysed by adversarial or single-issue groups.

As the term 'governance' implies, analysing and managing risks cannot be confined to private companies and regulatory agencies. Rather, it involves a wide array of actors: political decision-makers, scientists, economic players, and civil society. There has been much concern in the literature that opening the crisis management authorities to stakeholder input would lead to a dismissal of factual knowledge and to inefficient spending of public money (Sunstein, 2002). Given the experience with stakeholder involvement so far, these concerns are not warranted. There are only a few voices that wish to replace scientific input by gut feelings. Scientific expertise is an essential element of stakeholder involvement and a crucial pillar of all formats for stakeholder involvement. The role of scientific analysis in designing and evaluating crisis management should not be weakened but rather strengthened when opening the discussion to stakeholder input.

Profound scientific knowledge is required especially with regard to dealing with complexity. This knowledge should be assessed and collected by scientists and crisis management professionals who are recognised as competent authorities in the respective field. The systematic search for the 'state of the art' in scientific analysis and oversight leads to a knowledge base that provides the data for further deliberation. At the same time, however, the style of deliberation should also transform the scientific discourse and lead the discussion towards classifying knowledge claims, characterising uncertainties, exploring the range of alternative explanations, and acknowledging the limits of systematic knowledge in favour of long-standing experiences of practitioners. This can be done in any European country, independent of political system, or governmental structure. Stakeholder involvement and public participation are, however, particularly suited and needed for the EU as a whole.

One suggestion for combining both aspects of risk and crisis management is the model of analytic-deliberative participation (National Research Council, 2008; SAPEA 2019). This idea is one of the most promising suggestions for developing an integrative approach to inclusive risk and crisis governance based on the inclusion of experts, stakeholders and the general public (National Research Council, 1996; Renn & Schweizer, 2020; Webler et al, 2001).

A combination of scientific and deliberative methods may not always lead to the desired results, but the experiences so far justify a fairly optimistic outlook (National Research Council, 2008; OECD, 2020b). The main lesson from these experiences has been that scientific expertise, rational decision-making, and public values can be reconciled, if a serious attempt is made to integrate them. The transformation of a crisis management authority into a well-structured and professionally moderated analytic-deliberative discourse seems to be an essential and ultimately inevitable step towards improving existing management practices in the EU and facilitating the transformation towards an effective, efficient, resilient and socially coherent practice of dealing with eminent crises.

Last but not least, it should be stressed that the digital revolution has created entirely new opportunities to empower citizens and civil society to contribute to resilience beyond what has already been discussed in section 6.5, p.153. This includes powerful approaches such as:

- open source, open data, open access, open innovation, etc.
- hackathons
- maker spaces
- crowd sourcing, crowd sensing, crowd funding etc.
- citizen science
- open source urbanism
- city challenges, cups, Olympics

These approaches can create a networked ecosystem of public goods and public services. They also have catalytic effects and can fuel combinatorial innovation. Furthermore, they are fundamental for a digital democracy built on hybrid and collective intelligence, supporting connective action, and for a socioecological finance system combining Internet-of-Things-based measurements with multiple feedback and incentive mechanisms, supporting a better management of complex dynamical systems and enabling a multi-goal co-evolution towards a sustainable system.

A change of digital culture and practices in public institutions in charge of crisis management is required to ensure collaboration and trust between citizens and public stakeholders. Details can be found in the books entitled *Next Civilization* (Helbing, 2021) and *Finance 4.0* (Dapp, Helbing and Klauser, 2021), and the report *Mission sur la transparence, l'information et la participation de tous à la gestion des risques majeurs, technologiques ou naturels* (Courant et al, 2021).

Conclusions

The accelerated and deepened implementation of crisis and disaster preparedness can lead to conflicts, especially at the local level. Participation processes can prevent or help resolve these conflicts to a certain extent. A distinction must be made between formal and informal participation procedures. Formal, i.e. legally prescribed participation procedures, e.g. in the course of national or European legislation on crisis management and preparedness are usually limited to hearing the (affected) public and thus primarily serve to provide the authorities with information and to provide legal protection. They have only limited potential to resolve conflicts and to include local knowledge and concerns into emergency and contingency planning. Nonetheless, formal public participation, at least when it begins at an early stage, certainly promotes the inclusion of public knowledge into the planning process.

Informal participation procedures are not required by law and are not legally binding; however, they do trigger expectations that the results will be taken into account by politically elected officials. In principle, an extension of representative democracy through accompanying informal participation measures represents an effective means of placing far-reaching decisions, such as implementing resilient solutions with respect to infrastructure, supply chains and diversification of services and goods, on a broader footing, generating new proposals for co-creating crisis management plans, or increasing the consent of those affected to comprehensive crisis preparedness.

It is important to select the appropriate participation procedure depending on the type of crisis and the vertical governance level. At the national level, for example, and for issues that are often of overriding importance, citizens' assemblies with randomly selected citizens can be used to formulate recommendations for a specific policy area for a limited period of time with scientific support (Dryzek et al, 2019). Experiences with citizens' assemblies in France (called 'mini-publics') and Denmark, and recently with the citizens' council on climate in Germany, have shown that participating citizens are able to articulate consensual recommendations and to accept personal cuts (taking into account that the participants often have a strong orientation towards the common good in their role) (Breckon et al, 2019; Farell et al, 2019; OECD 2020). At the regional and local level, the focus is usually on more concrete issues such as expanding individual infrastructures to make them more resilient.

A particular promising form of participation is offered by using the multiple possibilities of digital consultation and IT-based deliberative forums. There are many new tools available that help to convene stakeholders and citizens in digital rooms and provide opportunities for intense deliberations. It is important to combine these new tools for participation with access to resources, as can be done through participatory budgeting or more advanced forms such as investment premiums which facilitate 'crowdfunding for all'. Digital forums based on deliberative facilitation tools promote more equal opportunities and social inclusion. They have the potential to revive democracies by upgrading the idea of empowerment in digital ways. The so-called metaverse may offer new opportunities of engagement as well, when combined with the Web 3.0 potentially in a way that is also better compatible with self-determination. Finally, but importantly, better use can be made of the complementarity of traditional and social media and social media to ensure that messages are disseminated through all channels and received by the entire population, and to seize the opportunity offered by social media to interact and engage with citizens (Courant et al, 2021).

In addition to acceptance and consent through numerous advice mechanisms (as outlined in 5, p.111) and the opportunity for stakeholders as well as citizens to participate, the policy of building back better is increasingly dependent on active sponsorship, i.e. broad and sustained support for transformative change by societal actors. Policymakers can foster this active ownership by targeting existing stakeholder preferences with their inclusion in pre-crisis consultation processes. So far, it is far from systematically tapping the existing potential.

7. Information, data & intelligence

7.1. Summary and key messages

In line with the scoping paper, this chapter focuses on the use of strategic foresight for prevention and preparedness, on decision support tools for crisis preparedness and response, on training and emergency exercises to turn the acquired information and data into adequate actions, and on the related issue of harmonised data standards for appropriate information exchange.

Strategic foresight is the practice of exploring expected and alternative futures to inform and guide strategic decision-making. In practice, it is especially challenging to generate a complete set of representative scenarios that allows foresight to be turned into concrete actions. In this respect, strategic foresight has limitations for dealing with the increasing complexity of our world. To be effective for strategic decision-making, it should be complemented by tools that can increase the robustness of decisions and system resilience. For example, horizon-scanning can aid in identifying, collecting and interpreting indicators of shifts in existing trends of behaviours and process, or the emergence of new ones. It is particularly well-suited for identifying systemic risks and multiple crisis situations. A potential role for the EU would be to support local and regional capacities to use scenarios for prevention and preparedness, and to use strategic foresight for improving preparedness across different regions and hierarchical levels.

This chapter also reviews some prominent approaches by which to support decisions during the crisis preparedness phase. These include safety and security risk assessments, expert judgement and statistical early-warning signals. One example of decision support is supply and logistic preparedness optimisation, which involves planning and decisions on resource allocation. On the other hand, for decisions where there is a lack of data, we often rely on judgements from experts, whose skill can be learned and incentivised. Where data is available, statistical early-warning signals can be used instead, to indicate that a system is approaching a critical transition. Automated big data interpretation can inform and warn about changes in criticality indicators, providing an informed picture of an evolving crisis. A crucial question is when to act and how to build sufficient political and community-driven support. In this respect, collaborative resilience is vital, i.e. the ability of a community to prepare for, respond to and recover from a crisis. Citizen initiatives in response to crises are often important; volunteers are often the first to act onsite and require intensive communication. Social media can be very useful when they convey 'true' information during an event. It is useful to distinguish misinformation from disinformation or propaganda, and the EU has an Action plan against Disinformation. On the other hand, freedom of expression is an important value, and there is evidence that shortfalls in digital media literacy are an important factor that may lead people to believe misinformation. Transparent and good risk communication is important to increasing trust in official information. The promotion of the ethics of resilience through information, communication, education and training is important. Responsibility for one's own behaviour, altruism, solidarity, care for the other, care for the environment, a sense of sacrifice, and so on are the values that should be taught as moral principles. For this, information must be authoritative and educational.

Sensemaking and situational awareness can provide an accurate overview of a crisis situation, but what is missing in existing EU platforms are elements that integrate the many feedback loops. There is a trade-off to make in the balance between representing the complexity, dynamics, and uncertainty inherent to a crisis, with providing concrete, timely and actionable advice. Instead of trying to compress information in increasingly complicated dashboards and graphs, a way forward is a focus on information quality, which comprises timeliness, accuracy, relevance, completeness, and consistency. Training exercises are essential for improving crisis preparedness. Despite the broad range of training tools, there remains a lack of comparable standards, curricula and evaluation criteria for training. Responsible policymakers and the general population have far less training than professionals such as firefighters etc. New computational methods promise to develop and compile scenarios that are tailored to the required training goals, and the recent interest in 'digital twins' and Virtual Reality and Augmented Reality-based training can complement training in the physical world. Data management and platforms for trustworthy data sharing are key to crisis management. The European data strategy aims at creating a single market for data and the Data Governance Act should establish a framework to facilitate the sharing of data. The Data Act is a regulation on harmonised rules for fair access and use of data. However, data-driven crisis management requires additional measures, like trustworthy digital-sharing platforms, reliable digital communication infrastructures, and digital technologies like trusted sensors and actors. There is a considerable need for action at the European level, and the European Commission proposes to establish a Joint Cyber Unit by 2023. Instruments are to be developed that enable a coordinated response to and recovery from large-scale incidents and crises. In transboundary crises particularly, effective information sharing across member states is important, and a potential role for the EU could be in supporting uniform data preparedness approaches for the most important crises that its member states may face.

The key messages for this chapter can be summarised as follows:

- Strategic foresight exercises are useful for identifying trends and potential crises. In a world of scarce resources, it is essential to connect such activities with decision-support activities, as a means to improve preparedness and enhance resource allocation processes.
- Existing methodologies like scenario analyses and risk matrices have a role as relatively simple tools that can be implemented, yet there is much to be gained when framing the problems in quantitative terms. This, however, requires sophisticated modelling skills.
- When crises emerge, lighter decision-support protocols would have a role; a compromise between accuracy and speed must be sought.
- Structured expert judgement methodologies and technologies provide tools for the incorporation of rigorous domain expertise. Adversarial threats and risks demand specific tools that take into account the intentionality of adversaries.
- There is a plethora of training tools and methods available for different team sizes and scopes. Yet training is often only conducted by emergency services and does not involve key decision-makers and citizens. It is important to allow knowledge on strategic foresight and crisis management culture to reach policymakers, crisis managers and the public.
- There is a lack of European standards and evaluation on the impact of training at individual level, and most importantly at organisational and inter-organisational level.
- Proper risk communication strategies are essential in crisis management.
- There is a clear need for harmonised data standards, by which to facilitate policy evaluation and crisis management. EU data strategies should be extended to meet the special quality requirements for data-driven, cross-border crisis management. Special data spaces in which to share crisis data between relevant stakeholders should be established and protected against misuse. These cross-border EU crisis management platforms should be promoted with very high priority, as they would enable horizon-scanning of weak signals and real-time monitoring of crisis development, at European level. Uniform standards for shared data and AI algorithms used in crisis management systems must be specified, for their effective use at European level.
- Government agencies responsible for crisis management should be given access to data from the private sector proactively and continuously, e.g. not only ad-hoc in-emergency situations.
- Data access, data transfer and sharing must be designed in a manner that preserves data privacy.

7.2. Introduction

Information, data and intelligence have long been recognised as vital to managing crises and disasters (IFRC, 2005). The rapid progress in electronic sensors for data collection and technologies for information processing (including artificial intelligence) and telecommunication, has led to unprecedented opportunities to gather, share and analyse information for intelligent forecasting and decision support. We can now use sensors to track fleets of vehicles delivering assistance on the other side of the globe (Delmonteil & Rancourt, 2017), employ satellite imagery or drones for the early detection and damage assessment of floods (AghaKouchak et al, 2015), tap into social media to understand the needs of the population affected by calamities (Palen & Andersen, 2016), and use mobile phone data to analyse behavioural shifts during a pandemic (Chang et al, 2021). But despite the unprecedented potential offered by technology and data, we have not yet been able to translate this increased and improved information into a reduction in disaster losses (White et al, 2001).

Based on the scoping paper, we review three areas that relate to the questions on how we can improve the collection and analysis of data, its use, and the sharing of data and information for risk and crisis management. As indicated in section 2.3, p.42, and 4, risk management involves the identification, assessment, monitoring and control of risk, which are tasks vital to crisis prevention and preparedness. At the same time, data and intelligence for interpretation and use are also crucial for crisis management, response and recovery. Yet the uncertainties and timeframes considered in risk management and crisis management are typically very different. Prevention and preparedness conventionally focus on long-term forecasting techniques and related training; the time horizon is longer than that in crisis response and recovery, and the uncertainties are related to the uncertain behaviour of the system in the future. Conversely, in crisis response, the urgency of the actions to decide on is the main driver of uncertainty, because it makes it difficult to accurately interpret and correctly understand the dynamically-evolving situation. During the crisis phase, information and data sharing are key to preparedness, to ensure that cross-situational awareness and corresponding organisational sensemaking are achieved rapidly and effectively.

To cover both risk management and crisis management, we focus on the use of strategic foresight in prevention and preparedness (section 7.3, p.176), on decision support in crisis preparedness and response (section 7.4, p.181), on training and emergency exercises by which to build the capability of turning information and data into adequate action (section 7.5, p.198), and on harmonised data standards for appropriate information exchange (section 7.6, p.201).

7.3. The use of strategic foresight for prevention and preparedness

Strategic foresight refers to the research-driven practice of exploring expected and alternative futures by which to inform and guide strategic decision-making. Whereas prevention focuses on avoiding crises, by removing potential triggers and vulnerabilities and reducing exposure, preparedness aims at planning actions in response to crises that may occur. Both areas require strategic foresight as a means to identify risks and triggers, deploy the necessary protection mechanisms and ensure that adequate resources, capabilities and capacities are in place. During his mandate since 2018, Vice-President Šefčovič (Commissioner for Inter-institutional Relations and Foresight) has led efforts to embed such practices of strategic foresight within EU policymaking, with the support of several bodies including the Secretariat General, the Joint Research Centre, the Strategic Foresight Network, the European Strategy and Policy Analysis System, the EU-wide Foresight Network, and the recent Competence Centre on Foresight.

Strategic foresight is designed to anticipate and detect critical aspects of the dynamics of change that an organisation faces. Over the past four decades, there has been an increasing wealth of future-oriented literature focusing on strategic foresight and scenario analysis (e.g. Hines & Bishop, 2006). Typically, the process for developing strategic foresight has six stages, ranging from scoping and collecting input via analysis and interpretation, to a review of decision options and implementation of actions (Cook et al, 2014). To support the development of strategic foresight, there are numerous methodologies and tools that are used at the different stages (see Figure 15 below), including back-casting, cost-benefit analysis, Delphi (e.g. Linstone & Turoff, 1975), relevance trees, scenario analysis, horizon-scanning, brainstorming, 'Strengths, Weaknesses, Opportunities and Threats' analyses, surveys, interviews, megatrends analysis, scenario planning and expert panels. Although it is impossible to summarise them all here, care must be taken when choosing the methodology, based on the specific objectives and the complexity of the problem considered. Today, the identification of key risks, their drivers and triggers, are manifold (see e.g. the annual Global Risks reports of the World Economic Forum,[93] the AXA Future Risks Reports,[94] the 2021 Commission Strategic Report,[95] or various national security strategies).

93 https://www.weforum.org/reports/global-risks-report-2022/

94 https://www.axa.com/en/magazine/2021-future-risks-report

95 https://ec.europa.eu/info/strategy/strategic-planning/strategic-foresight/2021-strategic-foresight-report_en

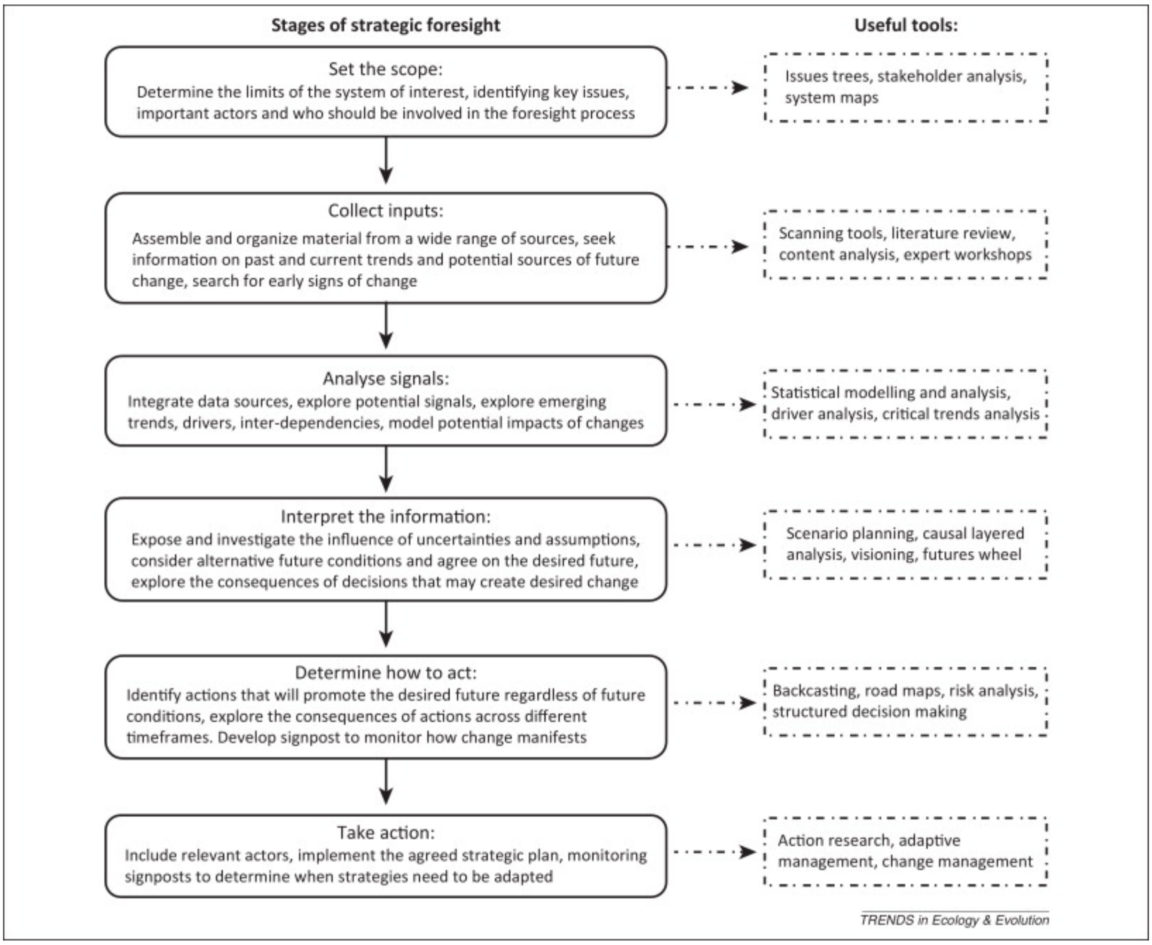

Figure 15. The six stages of the strategic foresight process and associated tools
Source: Cook et al, 2014

Importantly, a crux of strategic foresight in general, and the identification of key trends, risks and drivers in particular, is the tendency to remain at a vague and strategic level, insufficient for prevention, contingency planning and preparedness. For instance, Nemeth et al (2018) present a case where the Hungarian Ministry of Defence had correctly anticipated the European migrant crisis and a more confrontative stance from Russia. Yet even though both were correct, there was a missing link between long-term foresight and analysis or interpretation. Because the findings were never made concrete and monitored, even though the "Hungarian analysts came to the right conclusions, they did not internalise some of the results of their foresight study and did not foresee the timing of the events they anticipated accurately" (Nemeth et al, 2018). Therefore, it is important to connect strategic foresight with concrete steps for interpretation, implementation, and monitoring, embedding them within decision support to effectively arrive at deploying appropriate actions on the field. Given also that the European Strategy and Policy Analysis System annual foresight reports are on a very high strategic and relatively abstract level,[96] there is a risk of not translating them into concrete action for implementation and monitoring. Furthermore, the annual rhythm of the foresight report may not be sufficient to follow very dynamic events such as the war in Ukraine.

Since crises remain — fortunately — low-probability events, turning insights from scenarios and strategic foresight into concrete action is especially challenging. Wright & Goodwin (2009) and Montibeller & von Winterfeldt (2015) show that there are several biases at play, including inappropriate framing, cognitive and motivational bias, and inappropriate attributions of causality. Even though there are inevitable limits to the predictability of rare events (Goodwin & Wright, 2010), several strategies can still be used for strategic foresight, such as:

- challenging mental frames and broadening the scope of scenarios
- understanding motivational biases and power relations that might bias the scenarios that are considered
- augmenting scenario planning through compiling a portfolio assessment of crises that will demand very different response to ensure preparedness for them all
- assessing flexibility and response diversity (see 'The need for response diversity', p.54)

Although as such, strategic foresight can be valuable in itself, it has also limitations given the increasing complexity of our hyper-connected, hyper-dense and dynamic world, where uncertainty, instability and turbulence have become the norm rather than the exception. Therefore, strategic foresight must be complemented by tools that increase robustness and resilience, e.g. redundancies and buffers, injecting properties of adaptivity and flexibility into systems and processes (see section 2.4, p.47, for an overview of resilience principles). On the other hand, the structured embedding of strategic foresight activities within rigorous frameworks of risk analysis (see 4, p.87) and expert judgement elicitation facilitate decision-making for prevention and preparedness.

While the remarks above are generally valid for most foresight methods, in the following we provide a brief overview of two of the most popular approaches: horizon scanning and scenario thinking:

- **Horizon scanning** is primarily concerned with identifying, collecting, and interpreting weak signals that may indicate shifts in existing trends or the emergence of new trends. For two important reasons, horizon scanning is particularly well suited for identifying systemic risks and multiple crisis situations. First, horizon scanning supports the identification of systemic risks through information on emerging trends in political, economic, social, technological, environmental and legal areas. As such,

96 The 2021 report is available via https://ec.europa.eu/info/strategy/strategic-planning/strategic-foresight/2021-strategic-foresight-report_en

it often involves multidisciplinary perspectives. Secondly, it can take a long-term perspective, which increases the chances of identifying emerging or creeping risks (IRGC, 2018).

- **Scenario analysis and planning**, in its most basic forms, is largely informed by Schwartz (1991) and Heuer and Pherson (2015). The work of Kahn & Wiener (1967) and Bradfield et al (2005) should also be mentioned. The aim of scenario thinking is to help decision-makers manage (future) uncertainties (Ringland, 1998). Importantly, a scenario is not a forecast, but a possible future whose implications can explore by decision-makers in order to test for the appropriateness and robustness of current or planned policies (Comes et al, 2011). However, there are numerous alternative approaches outlined for foresight in various domain applications, including back-casting (Dreborg, 1996), cost-benefit analysis (Layard & Glaister, 1994), Delphi (Linstone & Turoff, 1975); see Technology Futures Analysis Methods Working Group (2004) for a compendium.

To showcase this richness of possibilities, we compare two of the most frequently used scenario approaches.

Scenario analysis in support of crisis management: pluralistic vs. probabilistic scenario analysis

Innovation in digital technology and computing power can enable real-time-informed scenario analysis by which to support decisions and operations for managing a developing crisis. A major challenge in scenario analysis is comprehensiveness, which relates to the extent of the residual uncertainty about the development of a crisis and associated risk (Tosoni et al, 2018). Specifically, when the approach taken is pluralistic, scenarios are formulated based on expert judgement and are analysed without quantifying the residual uncertainty. The analysis is considered comprehensive if the scenarios can be assumed to represent all relevant future crisis developments. Alternatively, probabilistic approaches to crisis scenario analysis quantify the residual uncertainty about the risk indicators, by sampling scenarios from a probability space, whereby comprehensiveness can arguably be attained by ensuring that the sample size is sufficiently large.

As a rule, scenario approaches should be chosen that do not ignore scientific uncertainties and also allow for the possibility of a regime change (at least potentially). There are scenarios that extrapolate past trends into the future, without any reflection, and only allow for minor adjustments in policy parameters. These approaches may continue to be justified for short-term analysis frameworks. However, these approaches are of limited use when dealing with risks in coupled systems, where the course of events is often unpredictable, due to complex system dynamics (IRGC 2018, p.57).

The practical approach that needs to be undertaken for proper scenario analysis is to consider the level of comprehensiveness, if the residual uncertainty is sufficiently small to allow conclusive decision-making in response to analysis (Aven & Zio, 2011). This implies:

- the characterisation and propagation of epistemic uncertainty as a means of quantifying the residual uncertainty
- the selection of computer simulations should be performed to reduce residual uncertainty and pursue comprehensiveness efficiently

For this, Bayesian networks and Adaptive Bayesian Sampling algorithms can be used, together with sensitivity analysis that identifies those expert judgements for which the attainment of a greater degree of consensus would lead to more conclusive results (Woo, 2011).

The creation of scenarios with cascading, interdependent events that are widely distributed in space and time and that have significant transboundary impacts, requires knowledge of the local potential triggering conditions, simultaneously at different locations. Consideration must be given to whether the model used for forecasting or scenario-building is appropriately scaled to provide meaningful indications of local or regional risks where triggering events could occur (Vervoort et al, 2015). Where local conditions can trigger a cascade of risk, models should be designed with sufficient granularity. Meanwhile, more risk models include socioeconomic parameters. Efforts should also be made to consider economic endogenous effects, beyond exogenous ones (Hochrainer-Stigler et al, 2020). It is important to consider multiple potential causes, or at least meaningful correlating factors that may have an economic impact.

Classic risk assessment is based on the calculation of expected negative consequences that are triggered by a concrete event, activity or technological failures, and modified by the vulnerability of the targeted system. The same logic applies to crisis management: once the negative consequences are released, what can crisis management agencies do to mitigate these consequences, minimise harm and restore functionality? The new systemic approach to risk and crisis management starts with the assumption that multiple risks are released simultaneously and overlap, such as witnessed today with the combination of pandemic, war, food crisis and political upheaval. The occurrence of polycrises demands new assessment and management strategies. The assessment needs to focus on scenario methods that explicitly address amplification, contagion and cascading effects associated with the interference of multiple crisis. In the same line of argument, crisis management needs to identify critical nodes in the web of interrelated impacts that show particular sensitivity and vulnerability to multiple stressors. Crisis management also needs to focus on secondary and tertiary impacts early on, even if those occur in the aftermath of the primary losses. This requires the construction of robust contingency plans, cross-sectoral cooperation and interdisciplinary expertise.

Integrating strategic foresight in prevention and preparedness

Strategic foresight and scenario planning are by now well-established methods by which to explore an uncertain and complex future. They are especially useful to explore the implications of low-likelihood and high impact events, and engage in preparedness and capacity building to respond to these events. Yet the one-day expert workshop held on 25 March 2022 (SAPEA 2022, forthcoming; see also Annex 2, p.295) confirmed that the practices of risk management and crisis preparedness still rely on conventional risk assessment and evaluation methods (see also the following section) that are based on linear planning, rather than embracing dynamics and complexity. Because the local and regional levels of crisis management often do not have the capacity to engage in scenario planning and strategic foresight, a potential role for the EU is to engage in scenario exercises, train decision-makers in using scenarios for prevention and preparedness, and use strategic foresight to improve preparedness across different regions and hierarchical levels.

7.4. Decision support for crisis management

The final aim of foresight is to inform decision-making. We describe here how to support such decisions. Decision support in crises falls into two distinct phases. First, during the preparedness stage, when there is ample time to collect data, develop models, involve different stakeholders in the model-building process, and deliberate and discuss the results. Here, the main challenge is in accurately representing or exploring the possible events and their impact. Questions refer to how likely those scenarios are, or how to best protect in such an environment. In contrast, the exceptional circumstances of crises put enormous pressure on decision-making. Crises are characterised by decision density, by which — especially in the early phases — an exceptional number of far-reaching decisions need to be made rapidly, despite tremendous uncertainty (Baharmand et al, 2019a). Further, the initial phase is often heavily resource-constrained (Comes, Van de Walle, et al, 2020). These characteristics pose a double challenge (Paulus et al, 2022):

- Data may be unavailable, uncertain, conflicting or biased, given limited access or data collection regimes — with limited options to collect additional data because of the time constraints.
- The cognitive processes of analysts or decision-makers may be under strain, given the urgency and high stakes of the situation, leading to biased or wrong decisions.

We argue that, especially for decision support during crises, these informational and cognitive factors need to be taken into account.

Decision support for crisis preparedness

Here, we review some of the most prominent approaches for decision support in the crisis preparedness phase.

Safety and security risk assessments

Most countries in the EU undertake national security risk assessments (Vlek, 2013). There are also global exercises undertaken by various organisations, like the annual World Economic Forum global risk maps (e.g. WEF, 2022). Their purpose is to identify the greatest threats to an organisation, country, etc., and identify where to allocate safety and security resources. Similarly, the JRC has developed the INFORM Risk Index that serves to prioritise countries in terms of their risk levels.[97]

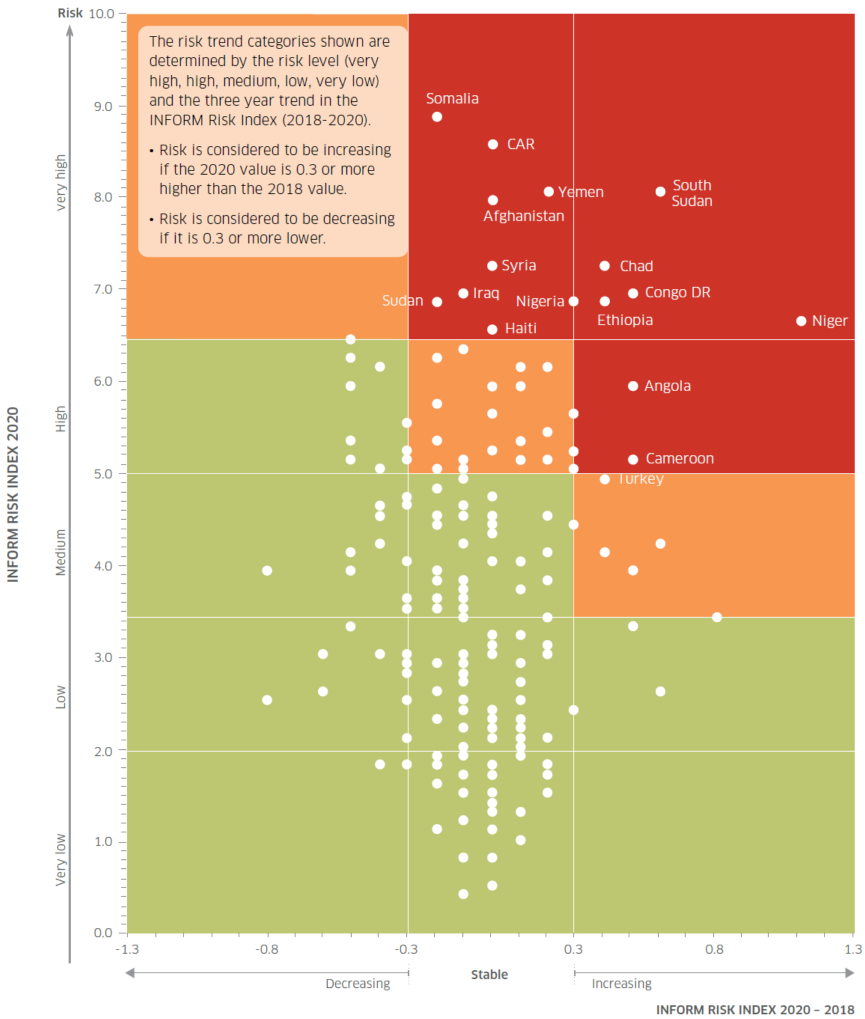

Figure 16. INFORM Risk Index 2018-2020[98]

97 https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk

98 https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Results-and-data/moduleId/1782/id/433/controller/Admin/action/Results

However, these exercises tend to be based on risk matrices frequently used in many domains, including aviation and government (HM Government, 2020; NASA Standard GSEC-STD-0002; ISO 17166). They are based on two dimensions: the probability of the hazard occurring, and the (expected) impact of the hazard when it does occur. Yet the approach has well-known shortcomings (Cox, 2008; Thomas et al, 2014). The ordinal ratings for likelihood, severity and risk used in risk matrices are prone to ambiguity and subjective interpretation; they also systematically assign the same rating to threats that are significantly different qualitatively. In turn, and more importantly in a world of scarce resources, this can potentially lead to a sub-optimal allocation of resources.

There are potentially important benefits and savings to be realised when performing safety and security assessments with more stringent methods from risk analysis (Bedford and Cooke, 2001; Aven, 2016) as, for example, showcased in the development of the Spanish national aviation safety plan (Elvira et al, 2021). Yet such methods entail much harder and sophisticated modelling work, possibly not available in the organisation. As final comments, when undertaking transnational risk assessments (or coordinating national risk assessments), the potentially conflicting multiple objectives of various countries should be considered. Similarly, we will typically need to face multiple objectives, and their aggregation necessarily involves values that reflect specific political positions (Daniell et al, 2016).

Supply and logistic preparedness optimisation: formal methods

Decision support for resource allocation is an important application domain for operations research and management science (Banomyong et al, 2019), with a focus on facility location and prepositioning (Caunhye et al, 2012). Most of the existing approaches are based on simulation models or simulation-optimisation frameworks. However, these do not explore the full range of decisions or uncertainties to guarantee that the optimal ones are selected. In the face of tremendous uncertainty, several authors have favoured robust approaches, which perform relatively well under a broad range of possible futures (e.g. Zokaee et al, 2016). Other authors have stressed the need to focus on flexibility (Baharmand et al, 2019b), responsiveness (Jahre & Fabbe Costes, 2015) or agility (Charles et al, 2010), especially in the domain of disasters.

For effective crisis preparedness, it is important to adopt optimisation modelling frameworks by which to support policymakers in their planning and decisions on resource allocation for the mitigation of crisis effects. Since crisis progression is inevitably a non-linear phenomenon, the model must capture key crisis characteristics, the underlying non-linear dynamics; and the distinct vulnerability and risk levels of the different areas of exposure, segments of population and sectors of society. Agility and flexibility are objective functions of complex optimisation problems, wherein the balance (given the uncertainties expected during the crisis) requires decisions that enable action-taking within a precautionary principle paradigm, or waiting for more information for more confident sensemaking. The spatio-temporal aspect of decision-making needs to be considered for population mobility between regions. Finally, the proposed modelling framework should take account of equity considerations towards exposed and vulnerable communities within the decision-making process (Berke et al, 1993).

Structured expert judgement

As mentioned, crises remain — fortunately — low-probability events. Therefore, in many domains there is a lack of data on which to build probabilistic forecasts and we end up getting judgements from experts to make the required forecasts. In general, expertise in a particular domain does not necessarily imply that the expert is also good at making assessments of uncertainty in that area. However, this is a skill that can be learned and incentivised. A structured approach to expert judgement is one that seeks to minimise any biases and sources of ambiguity in the process of collecting expert data, and which ensures that the process is as transparent as possible. Strong protocols and processes are available, e.g. from EFSA (2014) or the COST project on expert judgement.[99] Broadly speaking, selecting the right experts, training, incentive alignment, teaming via information sharing and the aggregation of probabilistic judgements are key steps to good quality, structured expert judgement assessment (Tetlock et al, 2014).

An important observation is that many person-caused crises (e.g. associated with wars, terrorism or cybersecurity) will require the forecasting of actions by adversaries, that is, intelligent and adaptive persons making decisions with a purpose. This requires quite different approaches than those conceived for non-person caused crises (e.g. associated with natural catastrophes), which will not be typically adaptive. Relevant methods in adversarial crises come from adversarial risk analysis (Banks et al, 2016) and typically go through gathering as much information as possible from the adversaries, and simulating from the problems they face, to forecast their actions.

Statistical early-warning signals

Statistical early-warning signals can be used in various forms to indicate that a system is approaching a critical transition. This is done in the time domain, with temporal statistical early-warning signals (e.g. critical slowdown), in spatial correlations or spatial cluster formation, or through the analysis of power-spectrum density (a statistical measure of the amplitude and number of fluctuations in a frequency interval of a signal) resulting from increased volatility or fluctuations at low frequencies (IRGC, 2018). If there is a lot of background noise in addition to the signal, it can be difficult to detect a critical slowdown or changes in the amplitude, indicating that the system is approaching a tipping

99 https://www.expertsinuncertainty.net

point. The power spectrum density measurement shows a shift of the high amplitude fluctuations toward lower frequencies.

This form of analysis is not only suitable for physical processes but also is increasingly used to describe and predict the behaviour of socio-technical systems and processes. The difficulty in this case is to define the socially-observable data for the analysis. In media analyses, e.g. of Twitter, this method is used, whereby the number of tweets per unit of time following an original tweet is used as the data basis. Such analyses can be extended by aiming to understand networks of users (humans or bots) that spread specific types of information or misinformation (Starbird et al, 2019), as well as for sentiment and discourse analysis as an indicator for potential social unrest and polarisation. A deeper analysis on misinformation can be found under 'Citizen-generated content and social media: opportunities and perils', p.188.

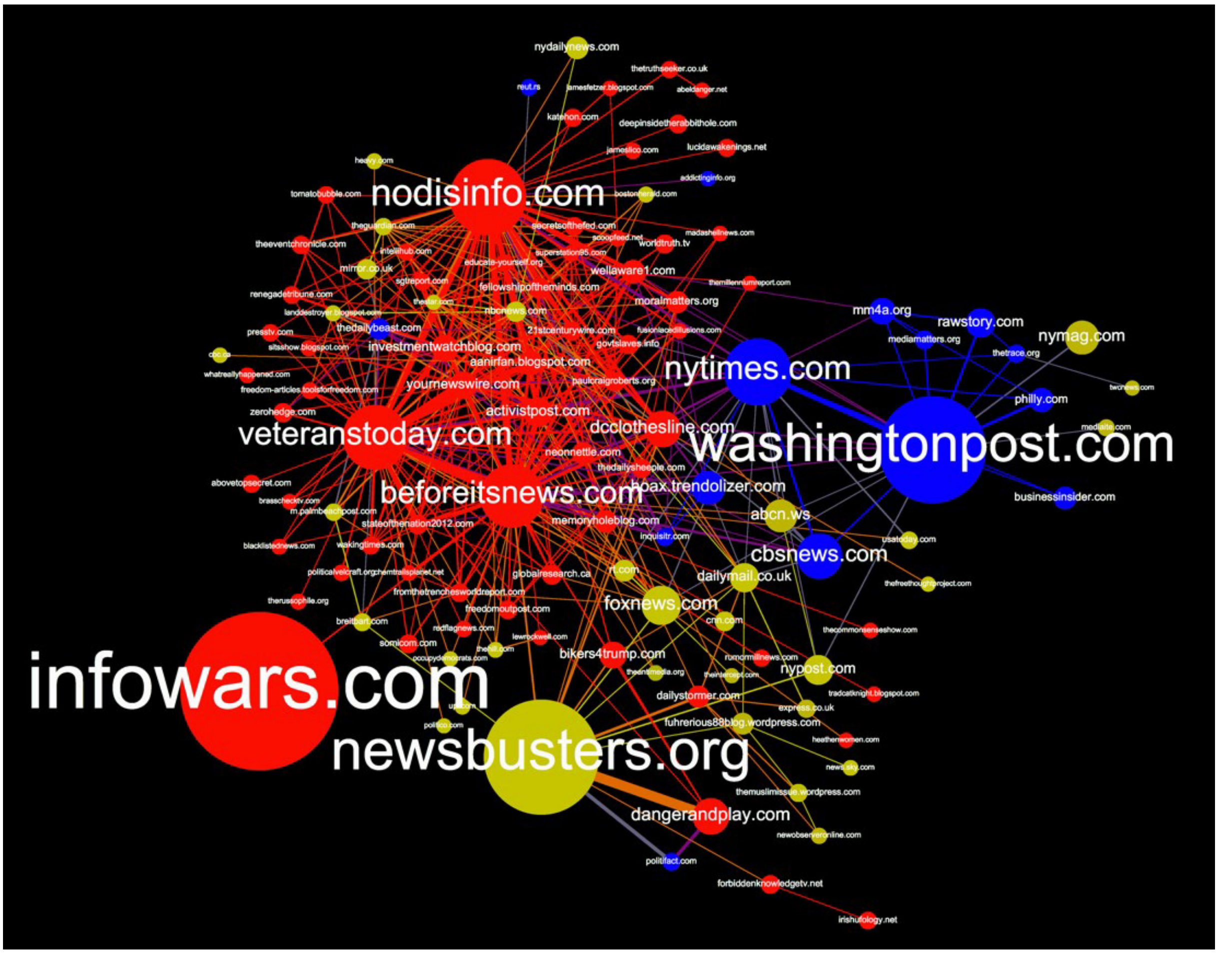

Figure 17. Example of an analysis of the online information network and its polarisation
Source: https://medium.com/hci-design-at-uw/information-wars-a-window-into-the-alternative-media-ecosystem-a1347f32fd8f

However, such analyses are not common yet for the many EU tools that focus largely on natural disasters and the analysis and prediction of the physical system and direct damage. For instance, the Global Disaster Alert and Coordination System[100] contains information about floods, earthquakes, volcano outbreaks, droughts, and forest fires, and its social media analyses focus on counting the number of tweets about an event.

Modern big data contexts also require dealing with scalable (in time and space) early-warning systems, based on large numbers of spatial-temporal indicators, ranging from socio-demographics, economics to infrastructure and a characterisation of the event. With the advancements in data analytics, automated big data interpretation can be implemented to inform and warn decision-makers about critical changes in indicators based on predictive intervals. This provides them with a better picture of the situation for adequate sensemaking, and suggests actions to plan with appropriate decision-support tools. Related ideas can be found in Naveiro et al (2019).

The classic vulnerability visualisation approach (Dewar et al, 1993) can be used to illustrate and validate basic assumptions that may be applied to select strategies to deal with systemic risk. The basic idea is to plan for future crisis operations by listing the assumptions on which current planning is based, then analysing which assumptions are most likely to fail in the given timeframe. This approach requires testing and constant monitoring of vulnerability, as well as contingency planning, should a crisis be unavoidable. Again, greater data availability facilitates the adoption of machine learning and other decision support tools to enrich the picture, as illustrated in Eini et al (2020) in the flood risk domain.

Risk communication: relevance for policymaking

It can be noted that risk communication, together with sharing assumptions and conclusions from simulations and scenarios, should take place early and among all relevant actors. This will ensure timely response and allow sufficient time to take appropriate countermeasures. Not only should assumptions be clearly communicated, but provisional (though yet unproven) assumptions should also be expressed. This requires the creation of a protected space where people can exchange ideas without fear of negative repercussions for their careers, should their assumptions prove to be inaccurate. Policymakers should be made aware of the explicit and implicit assumptions, so as to understand the limitations of the research and context conditions under which the assessments are proven to be valid.

A crux in the preparedness phase is the question on when to act and how to build sufficient political and community-driven support, so as to introduce preparedness actions. This is especially important if developments are non-linear, as demonstrated by the various waves of COVID-19: a delay of only a few days led to an exponential explosion of case numbers — but at the time when an intervention would have been

100 https://gdacs.org/default.aspx

most efficient, there clearly was not yet sufficient support. Figure 18 illustrates this phenomenon by using the example of epidemics outbreaks. A focus on environmental conditions (e.g. infection numbers) provides early information that the system starts to deteriorate, and that the performance of the health system will be affected. The impact on the health system (at the bottom of the figure) is delayed, yet also exponential. Waiting until the health system performance exceeds a certain threshold will delay the response. The figure also illustrates that different decision options (A and C or D in the example) have different lead times. As such, to be successful, they may need to be implemented before the signal on system performance is very clear. Waiting for a strong impact in performance reduces the number of feasible policy options, and thereby also the flexibility. Note that, while we have experienced this phenomenon in the context of COVID-19, it is discussed in the literature in the context of the looming climate crises (Haasnoot et al, 2018), showing the universal importance of early action and leading indicators (i.e., those that suggest future developments versus lagging indicators that highlight past performance) in a situation of great uncertainty.

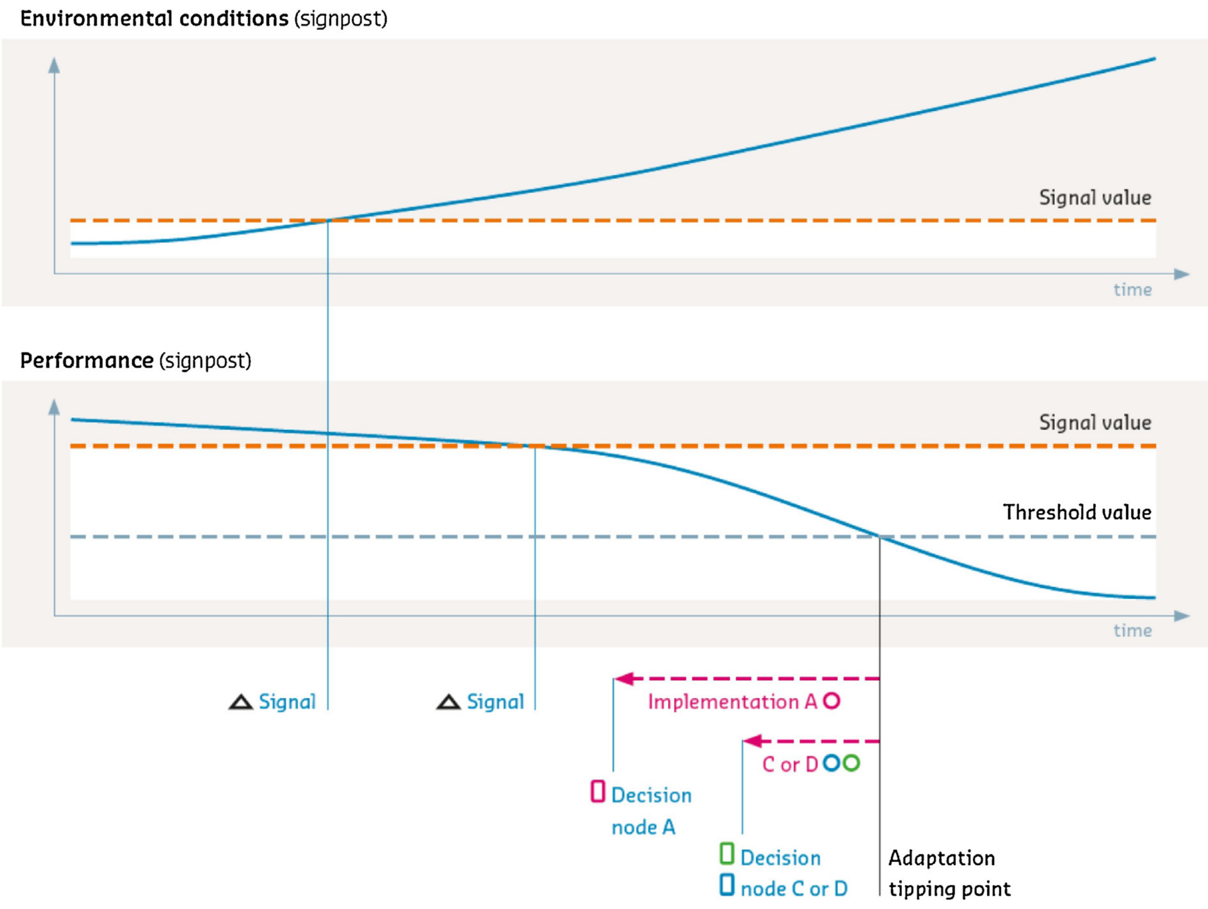

Figure 18. The challenges of early action — signposts in environment and performance Source: Haasnoot, M., van't Klooster, S., & Van Alphen, J. (2018).

Citizen-generated content and social media: opportunities and perils

The literature emphasises the need for collaboration and reliable models between heterogeneous actors (such as the police, fire brigade, public administration and citizens) in order to improve collaborative resilience (Goldstein, 2012; National Research Council, 2011). In addition, the presence and simultaneous manifestation of citizen initiatives in response to crises must be highlighted. These volunteers are often the first to act onsite and require intensive communication (Reuter et al, 2013). The arrival of social media in everyday life has enriched these initiatives by allowing them to manifest and organise themselves online as well.

The use and challenges of social media in crisis management have been discussed over the past twenty years in the specific field of 'crisis informatics', which studies how networked digital technologies, and in particular social media interact with crisis management, within both the social and computer sciences (Palen et al, 2020). It is a field that studies the issues and uses of digital tools by the actors involved (public institutions, emergency and crisis professionals and citizens), in anticipation or during major events, whether natural (e.g. earthquakes, forest fires), technological (e.g. chemical explosions, plane crashes), or urban (e.g. terrorist attacks, riots). However, many actors, especially institutions, are wary of these media, now commonly used by citizens. Indeed, social media are seen also as a space where false information and rumours circulate, but as many studies point out, they can also be very useful when they convey "true" information during an event, which informs the institutions in charge of managing it. For instance, in some EU countries, virtual operational support teams assist institutions in charge of crisis management, in the search for operational information.

Combatting misinformation

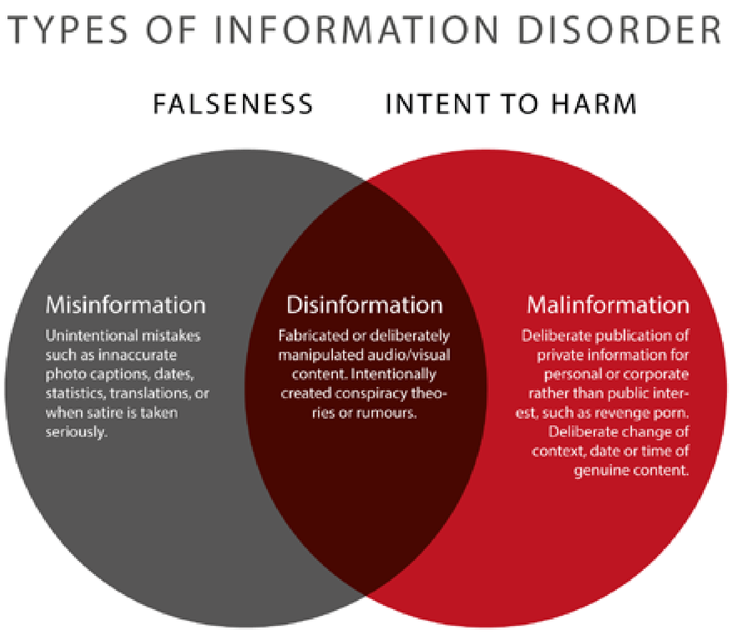

Figure 19. Types of information disorder
Source: ALLEA Discussion Paper[101]

The uncertainty of crises, along with limited access to the regions affected, are a breeding ground for rumours and misinformation. However, with the rise of social media platforms, these rumours have unprecedented reach and are widely diffused across the globe. To discuss the issue of false and misleading information, it is useful to distinguish misinformation from disinformation or propaganda. Disinformation is deliberately false, with the intention to deceive (ALLEA, 2021). There are many attempts to 'secure' the information space. The EU's Action Plan against Disinformation[102] (2018) includes four pillars:

- improving the capabilities to detect, analyse and expose disinformation
- strengthening coordinated responses
- mobilising the private sector
- raising awareness and improving societal resilience

A Code of Practice was signed in late 2018, covering Facebook, Google, Mozilla and Twitter, and websites such as EU Vs Disinfo[103] analyse misinformation and rumours, and try to prevent their spread. At the same time, research has cautioned against making the information space another 'battlefield' and against the outsourcing of content deletion or labelling. Rather, research has

101 https://allea.org/wp-content/uploads/2021/04/Fact-or-Fake-Discussion-Paper.pdf
102 https://www.eeas.europa.eu/sites/default/files/action_plan_against_disinformation.pdf
103 https://euvsdisinfo.eu/

found that attempts to protect and 'close' the online space led to moves to other communication channels (such as Telegram) with closed information echo chambers, and thereby counteract the ambition of allowing citizens to make their own (democratic) judgement (Ördén, 2019).

As an example, consider the Russian propaganda in the context of the Crimea annexation, since there is not yet sufficient evidence published on the 2022 Ukraine invasion. Importantly, research has shown that Russian disinformation is overwhelmingly countered by correcting information (Golovchenko, 2020; Figure 18, p.187). We seem to be largely 'immune' to disinformation that does not confirm our prior beliefs, as it creates cognitive dissonance. However, there is evidence that disinformation helps mobilise and coordinate groups that are already following demagogic leaders in their visions (Petersen, 2020). In contexts where the prior beliefs are less 'immunised', propaganda may have a bigger impact: for instance, research has shown that there has been increased activity by Russian news media such as RT and bot networks, discrediting the AstraZeneca vaccine (Jemielniak & Krempovych, 2021). As such, especially contested and polarised areas may lend themselves to propaganda and be more vulnerable to geopolitical information warfare.

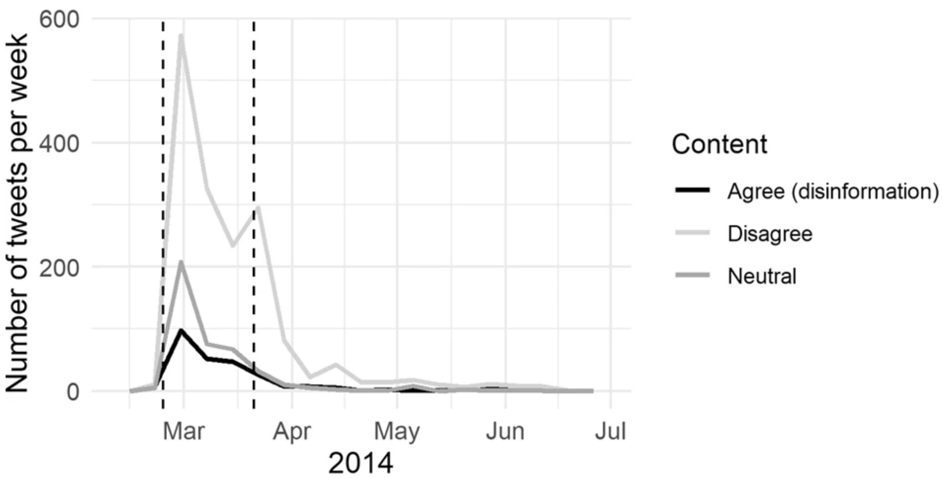

Figure 20. The framing of Russian military presence in Crimea
Source: Golovchenko, 2020

Because freedom of expression is an important value, and seeing and reading the media landscape unfiltered and uncensored may help EU citizens understand the thinking and sentiment in other areas of the world, solutions other than a mere ban on propaganda have been suggested, such as pre-bunking (effectively applied before the Russian invasion), debunking and fact-checking. A meta-analysis on 30 fact-checking studies found significant positive effects of the fact-checks, even though fact-checks that confirm prior beliefs (or political orientation) receive more support (Walter et al, 2020). However, results for COVID-19 show that exposure to fact checking information needs to be consistent. While exposure to fact-checking information that debunked misleading claims was able to reduce misperceptions, this effect was not persistent (Carey et al, 2022). For both the COVID-19 response and the war in Ukraine, there are several fact-checking platforms that aim to rapidly debunk misleading or wrong information (see Figure 21). To monitor the Russian Federation's disinformation campaigns in Europe, the platform EU vs DisInfo[104] has been established, which provides data analysis and monitoring in 15 different languages. The platform provides both a searchable database, as well as reports and analyses about underlying disinformation and propaganda strategies. To be effective, this information needs to be diffused across the different (social media) channels to reach all communities, continuously.

Further, there is evidence indicating that shortfalls in digital media literacy are an important factor for people to believe misinformation, even independently of prior beliefs or political orientation (Guess et al, 2020). Finally, transparency and good risk communication has been shown to increase trust in official information (Petersen et al, 2021). This is in line with the ALLEA report on misinformation (2021), which advocates for transparency, integrity and improved communication, as tools to combat rumours and misinformation. In-depth considerations on the role that collaborative platforms such as Wikipedia can play to tackle misinformation, can be found in 'Wikipedia during crises', p.164 of this report.

104 https://euvsdisinfo.eu/

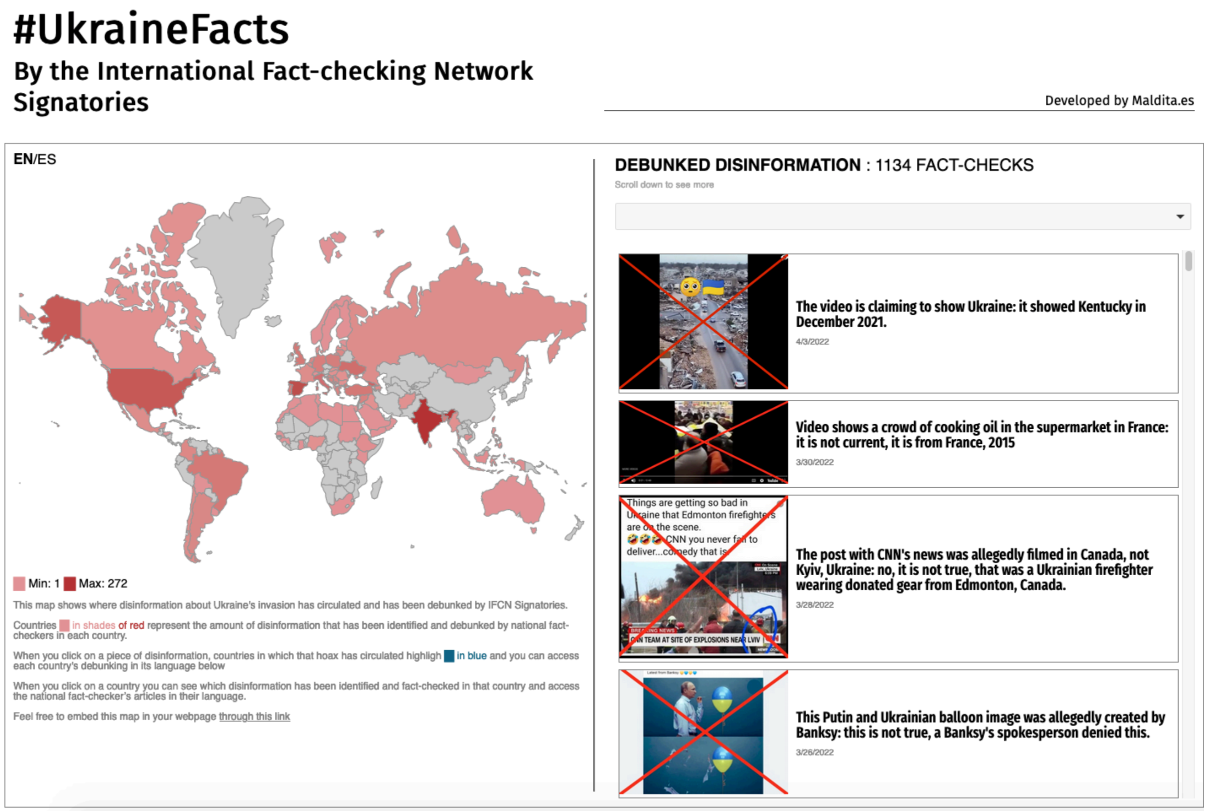

Figure 21. Example of a fact-checking website for Ukraine crisis
Source: https://ukrainefacts.org, screenshot taken on 6 April 2022

In sum, social media are a key element in the modernisation and co-construction of a risk culture in the preparedness phase. They constitute both a virtual public space where information exchanges and debates take place and, in addition to traditional media, a channel for disseminating information in a more 'horizontal' format, as they support exchanges among citizens (Courant et al, 2021).

Decision support during crises

We have referred earlier to the special constraints of decision-making in crises: high time pressure and urgency, uncertainty, decision density and resource constraints — even though the decisions that are made during crises can have far-reaching implications. While decision support methods (see above) are useful in improving preparedness, better preparedness improves response, for instance via contingency plans. However, the urgency of a crisis typically requires light decision support approaches, as illustrated in Couce-Vieira et al (2018; 2019) for crises in the cybersecurity domain.

We distinguish here between two general approaches to decision support:

- approaches to improve situational awareness (Endsley, 1988) or sensemaking support systems, by providing analyses of the situation (Klein, Wiggins, et al, 2010)

- normative approaches that suggest specific decision alternatives and policy options that should or could be implemented

Generally, sensemaking describes the act of interpreting the stream of information and data that we are exposed to. In his seminal work, Weick (1993) stresses the importance of sensemaking as a social and continuous process, by which we constantly check with our peers for their (re)action and interpretation of the situation. Further, mechanisms to increase resilience include improvisation and flexibility of roles by which to adjust to the situation on the ground. In contrast, decision-making is a normative action that refers to choosing an alternative over several other options. While sensemaking is a broad activity, decision-making is usually targeted and directed at achieving specific objectives, which can be explicit or implicit (see Figure 22).

An important conundrum here — especially in an era of automation — are questions of accountability, responsibility and moral trade-offs. Conventional decision support describes the aims of decision-makers in an analytical objective function. These functions still largely disregard important moral implications such as distributive justice and fairness, social norms and taboos. Keeney (1984) and Caballero et al (2021) bring in perspectives on ethics and broader values in risk analysis and decision support.

The interplay of decision-making and sensemaking, or problem formulation and solution, has been described as a 'virtuous circle' (Comes & van de Walle, 2016; Gralla et al, 2016). Sensemaking allows decision-makers to establish a mental model of the situation and the key aspects that need (urgent) attention. Then, the decision-making process formulates concrete goals and plans, which change the situation and direct information flows, in turn, informing situational awareness (see Figure 22). As such, we advocate for an integration of approaches and tools for sensemaking and decision-making. Below, we provide a brief overview on the most used tools in both these domains, and their areas of application. We note that both sensemaking and decision-making can benefit from advancements in artificial intelligence for analysing data, texts and images, and extracting relevant information to define the situation and evaluate potential solutions.

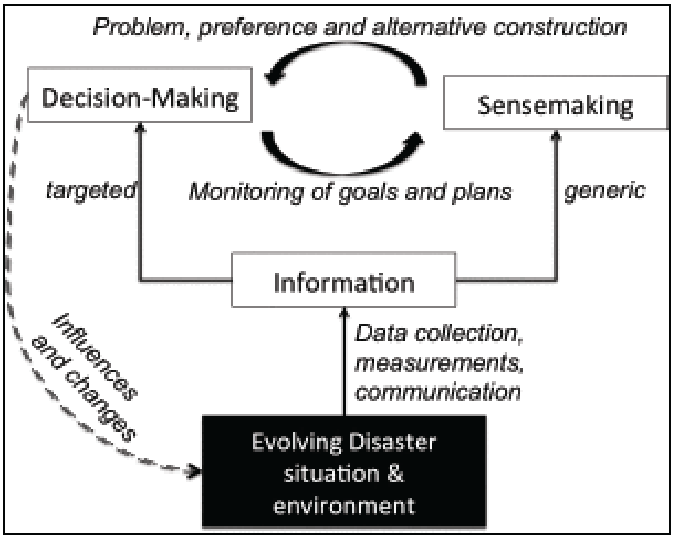

Figure 22. The virtuous circle of sensemaking and decision-making
Source: Comes, 2016

Currently, there is a wide range of approaches on sensemaking and situational awareness models that focus on analysing or predicting the damages or impacts related to specific events, such as floods (Apel et al, 2022), earthquakes (Dell Acqua & Gamba, 2012), wildfires (Verde & Zêzere, 2010) and storms (Cheng et al, 2021). The EU also has several tools targeted at rapidly understanding the situation on the ground, and estimating the most important damages to physical infrastructure, such as the Global Disaster Alert & Coordination System (GDACS), a cooperation between the UN and the European Commission, or the Copernicus Rapid Mapping Service for Emergency Management.[105] While GDACS focuses on early-warning and damage prediction based on models and forecasts, Copernicus provides (rapid) analysis of damages to the affected areas, as well as baseline information based on satellite imagery. Importantly, the Copernicus mapping products are now available within a very short period (two hours for First Estimation Products), making them suitable also for the very early phase of a sudden onset disaster response.

105 https://emergency.copernicus.eu/mapping/node/358

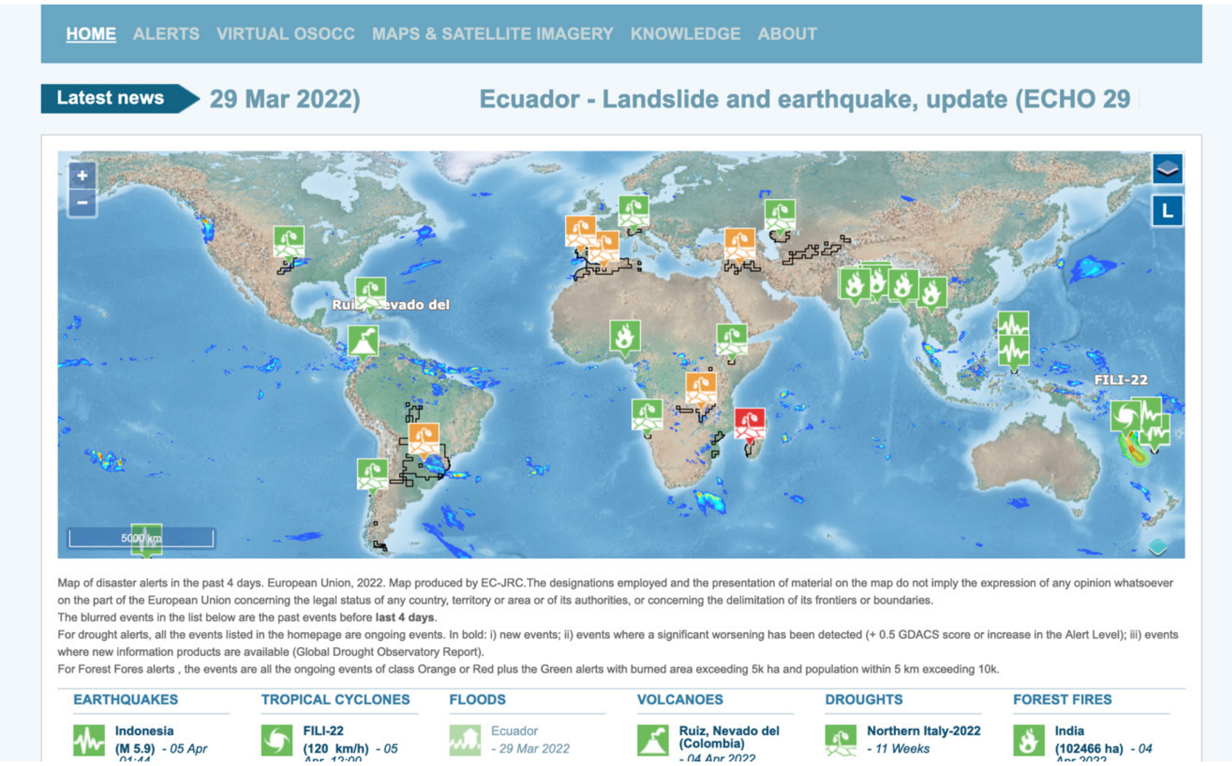

Figure 23. Illustration of GDACS interface and covered disaster categories
Source: OCHA & DHN, Decision-makers needs community of interest, https://blog.veritythink.com/post/60157407408/these-are-the-humanitarian-decision-makers

Conventionally, these models on situational awareness combine and analyse remote sensing data with models about the spread and direct impact of a hazard on the built environment, such as roads or electricity networks. These models allow us to forecast and predict where the most urgent assistance is needed and can play an important role in the rapid prioritisation of assistance and deployment of emergency services. What is currently missing in the EU platforms are elements that go beyond the direct damages and integrate the many feedback loops described earlier in the report. For instance, to ensure that the needs of the population locally are met, these methods can be combined with social media analyses or crisis mapping approaches, which showcase the demand for help from the bottom-up (e.g. Middleton et al, 2013; Palen & Anderson, 2016).

Beyond the models for understanding the damage to people, infrastructure and the resulting needs, there is also a range of tools and optimisation models to assist with decision support, such as coordination and scheduling of assistance. From humanitarian disaster response, we know there is a plethora of decision-makers involved in disaster response (Gralla et al, 2015). All these decision-makers will have to take different decisions at various phases of a crisis or disaster, which need to be aligned and coordinated.

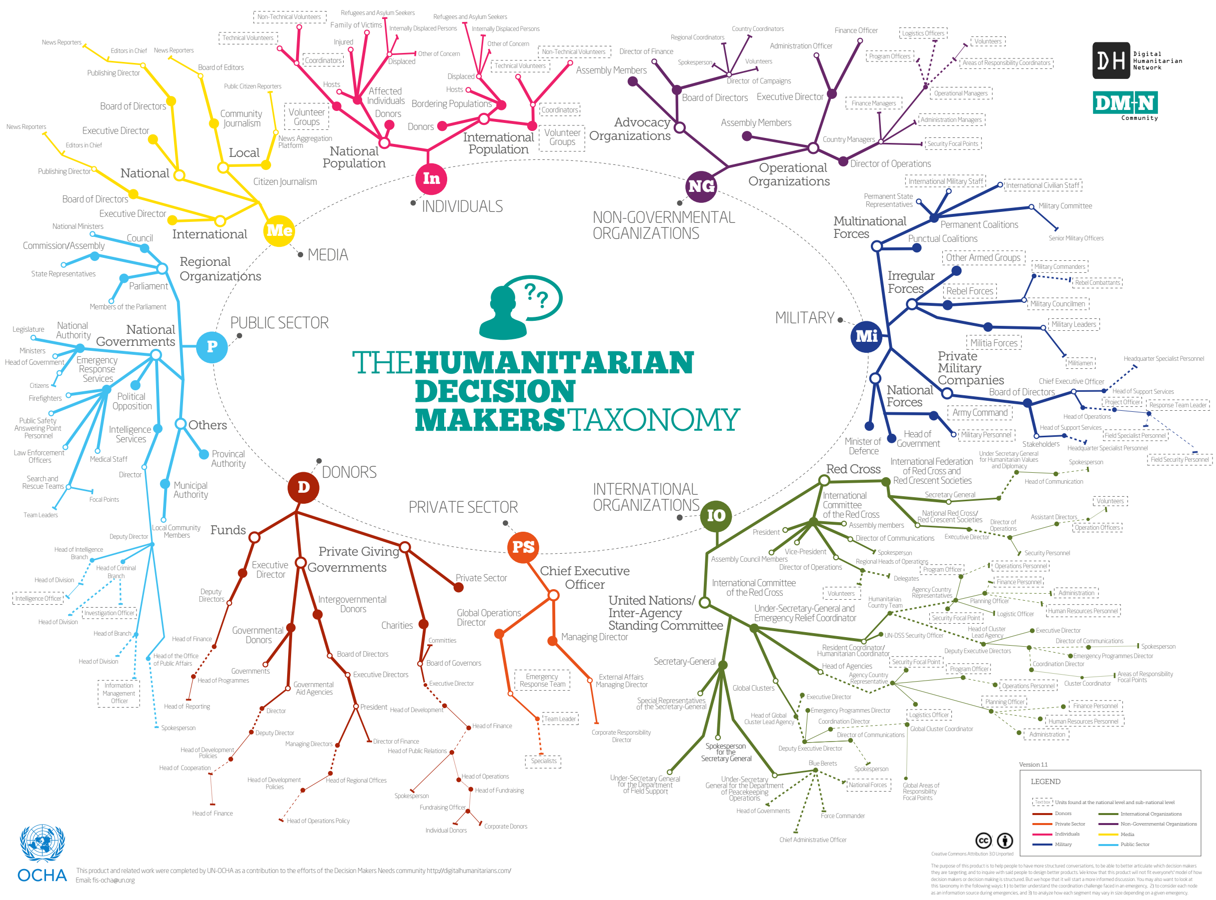

Figure 24. A taxonomy of decision-makers in humanitarian disaster response
Source: OCHA & DHN, Decision-makers needs community of interest, https://blog.veritythink.com/post/60157407408/these-are-the-humanitarian-decision-makers

On the specific decisions that need to be made in disasters, one can conventionally distinguish the prioritisation of needs, along with decisions on resources and capacities that are to be committed (programming) and where (locations and access, given the security situation) for the set-up of the coordination, information, and logistics support infrastructures (Gralla et al, 2015). In the scientific arena, the field of disaster logistics is the most prominent. It has seen a rapid rise over the last two decades and covers areas such as the location of hubs and warehouses, the scheduling of emergency teams and planning last-mile deliveries (e.g. Altay & Green, 2006; Van Wassenhove, 2006). However, many of these models have been criticised for a lack of empirical grounding (e.g. Galindo & Batta, 2013), and for not respecting constraints such as time pressure and the cognitive capacity of emergency managers (Baharmand et al, 2019a). This trend — along with the fact that models are necessarily incomplete abstractions of the situation — has led some researchers to question the (unreflective) use of models, with papers such as *Believe in the model, mishandle the emergency* (French & Niculae, 2005), especially when models are used to predict the behaviour of complex socio-technical systems, or when crises and disasters are new and unprecedented. Similar calls for caution have again been raised in the COVID-19 response (Steinmann et al, 2020).

An important trade-off is the balance between representing the complexity, dynamics and uncertainty inherent to a crisis, with concrete, timely and actionable advice. Research has shown that very dense information presented in dashboards does not improve situational awareness, if combined with coordination tasks — most likely because of information overload (Van de Walle et al, 2016). More concretely, it was shown that more dense information did not improve situational awareness if decision-makers had to simultaneously coordinate their teams and provide them with specific and tailored information (ibid). Therefore, instead of trying to compress information in complicated dashboards and graphs, a way forward is a focus on information quality, which comprises timeliness, accuracy, relevance, completeness, and consistency (Bharosa et al, 2011).

The increasing use of social media especially amplifies the risk of information overload (Mendonza et al, 2010), opening the proverbial information 'firehose'. As a result, various tools have been developed to extract social media information, such as the overview of tweet mentions in GDACS. However, in their review of specific intelligence systems based on social media, Kaufhold et al (2020) found that none of the almost 50 crisis management information systems they surveyed explicitly integrated information quality, which is a clear gap. Importantly, information overload and the constant flow and demand for information induces significant stress on decision-making (Misra et al, 2020), which in turn, lead to lower decision quality (Roetzel, 2019) and cognitive biases in time-pressured situations. While much of the management literature advocates for an adaptive approach in such complex and uncertain crises, we also know that first impressions and mental models create path-dependencies that make it hard for decision-makers to change their initial judgement (Paulus et al, 2022) — which is especially detrimental in crises, as the initial information is almost always uncertain and biased.

A way forward is in combining a better understanding of the complex and dynamic behaviour seen during disasters, with tailored advice for specific decision problems (Van de Walle & Comes, 2014; see also Box 8). Similarly, Kaufhold et al (2020) advocate for a focus on information quality and explainability of the situation that supports decision-makers in tailoring or configuring information to their needs, while allowing them to transparently filter the information that they would like to receive. These approaches should be complemented with methods and tools that rapidly communicate and visualise the results of decision-support models, even when they are fraught with significant uncertainty.

Box 8. Decision support and coordination in conflicts vs. natural disasters

Whereas most of the research on disaster management focuses on natural disasters such as floods or earthquakes, most humanitarian assistance is provided to conflicts and protracted crises — and the war in Ukraine has sharply highlighted the relevance of addressing conflicts in European crisis management.

First, many of the principles and services that are needed to respond to crises are generic. Acknowledging these generic principles, the humanitarian world has organised its response in the context of the Humanitarian Reform Agenda (2005) via the cluster system. Each cluster is set to coordinate the activities in a functional area to avoid bottlenecks and redundancies, and provides the interface between the humanitarian system and the national response (Comes, Van de Walle, et al, 2020; Jahre & Jensen, 2008). Prominent clusters are, for instance: food security; water, sanitation & hygiene; shelter; logistics; health; protection; or emergency telecommunications.

Despite these generic areas and needs that need to be addressed in virtually any crisis, there are also notable differences between conflicts and natural disasters. Most importantly, whereas natural disasters are often initiated by a rapid and sudden shock from which there is a clear trajectory to recovery, conflicts are most often protracted situations that are highly volatile and dynamic (Van de Walle & Comes, 2015). Associated with this dynamic is the nature of uncertainty. In natural disasters, time is the critical and limiting factor for decision-making, as decision-makers are under pressure to respond to the urgent needs of the population. But in the initial chaotic phase, more information typically becomes available that allows for a better-tailored response. In contrast, during conflicts decision-makers are confronted with prolonged periods of uncertainty. This includes uncertainty that is due to forecasting the adversary's actions and their consequences (Banks et al, 2016) which is amplified by information warfare and misinformation, potentially leading to a spiral of mistrust and suspicion (Comes, Van de Walle et al, 2020). Further, whereas natural disasters conventionally hit the areas that are most exposed and vulnerable to disasters, in conflicts, malicious actors can strategically target a society's most vital infrastructures — even if that involves violations of the Geneva convention. Because of the prolonged nature of the conflict, the notion of adaptivity and flexibility are especially important, whereby decision-makers adapt to newly-available information and intelligence.

7.5. Training, reference scenarios and emergency exercises

An important class of actions to improve preparedness refers to training. Relevant approaches are covered here, with an emphasis on digital tools.

Culture of and education on ethics of resilience

Resilience is a fundamental pillar of crisis management. This includes resilience of the institutions, of the emergency supply chain (e.g. medical equipment, drugs, food), of the industrial system, of the economic system, resilience of work activities (healthcare, critical services, teleworking), of the education system, resilience of people and their ethics. This latter aspect is fundamental to taking ethical decisions on resilience, at all levels in disaster situations (Zack, 2009). It is a form of ethics (Mizzoni, 2017) which focuses on the specific challenges faced during a disaster that has the potential to hit massively a large portion of the population.

Such ethics of resilience should be promoted through information, communication, education and training, with an emphasis on the necessity to adapt moral values in an emergency situation (Rajaonah & Zio, 2020). In the middle of a crisis, information and communication are the immediate means of resilience. Information was typically provided by classic media (television, radio, newspaper) but, nowadays, more and more through social networks from official and non-official sources. The latter are, as we have discussed, sometimes untrustworthy and exploit people's lack of trust in institutions. Recent examples are the huge quantity of online information on the new COVID-19, including quite a lot of misinformation, and the abundance of fake news concerning the Ukrainian war. The result is that people are not properly educated on the matter, and thus not very knowledgeable, and therefore not very aware and mindful, despite being probably over-informed. Analytics methods may support fighting misinformation spread (Antenore et al, 2021; Choraś et al, 2021).

To build resilient ethics, moral persuasive information must take human cognitive biases into account. These include both the optimistic bias, for which people tend to believe they are less at risk to health problems than their peers (Weinstein, 1989; McKenna, 1993) and the opposite pessimistic fatalism, which makes people believe that it is the end of the world that they need to prepare for, with proper stocks of life necessities, as has been seen in the recent pandemic and the Ukrainian war.

For the effects of biases to be successfully mitigated during disasters, information must be authoritative and educational, so it can effectively contribute its part to the ethics of resilience. Responsibility for one's own behaviour, altruism, solidarity, care for the other, care for the environment, a sense of sacrifice, and so on are values that should be taught as moral principles. Moral and social values can be taught through new social media that are, at the moment, a particular big hit and are showing a lot of creativity. Lessons can take many forms such as tik-tok, short comic strips, short films, daily sayings, etc. Even using sci-fi has been shown to be effective in teaching ethics (Burgess, 2020), including constitutional values such as human dignity, and cultural values, such as fairness.

Training, learning and exercises

Training exercises are essential for improving preparedness. There is a broad range of training tools that have been used in crisis and disaster management, ranging from tabletop exercises to full-scale exercises or virtual/augmented reality training. While there have been calls for the standardisation of emergency training (Alexander, 2003), there remains a lack of comparable standards, curricula, or evaluation criteria — leading to important gaps and, in the case of disasters, also a lack of institutional learning (Tatham & Altay, 2013).

Further, whereas conventionally professional emergency services and volunteers do receive training (e.g. police, firefighters; red cross societies), policymakers who have the responsibility to lead emergency management, or the general population, have far less training. This is so, even though the coordination, collaboration and decision-making under uncertainty and time pressure — all characteristic for policymaking in crises — have been identified as major aspects in crises that require training and learning (Schaafstal et al, 2001). Given the increasing importance of crises that will require improvisation, collaboration and rapid decisions throughout Europe, we conclude that there is evidence to broaden the scope of conventional training to all authorities that will be responsible for managing such events. Another important point is the lack of evaluation of the results of training and exercises. Even though much effort is put into developing and conducting exercises, often, the outcomes in terms of learning — especially over time — are unclear (Sinclair et al, 2012). In part, this is due to the lack of standards for emergency management (Alexander, 2003), since without clear standards, objectives and aims, it is unclear what should be tested for.

There is a variety of methods available for training. Many of these methods are based on crises scenarios (Alexander, 2000), although there are other approaches such as skills-based training and learning. From there, different forms of simulation have been suggested that allow users to practice and train in a spectrum of activities, ranging from information management (Muhren & Van de Walle, 2009); logistics (Lukosch & Comes, 2019), evacuation (Feng et al, 2018; 2020), first aid (Charlier & De Fraine, 2013), to planning and strategic decision-making (Noori et al, 2017). When dealing with crises with adversaries (counterterrorism, war, cyberwar etc) 'red team-blue team' exercises are important (Zenko, 2015). Simulation games are interactive environments that allow for direct engagement and provide immediate feedback to players and researchers. As such, they are specifically equipped to study complex situations. Whereas training games conventionally have the aim to train specific skills without too much conceptual detail, there is an increasing interest in multiplayer and virtual/augmented reality games that bring higher levels of fidelity (Feng et al, 2020). Moreover, whereas conventionally, scenarios have been designed from scratch and specifically for each exercise, new computational methods promise to automatically develop and compile scenarios tailored to the training goals at hand — be it for collaborative (Noori et al, 2017), or for individual training (Feng et al, 2020). The recent emphasis on digital twins (Batty, 2018) and virtual reality and augmented reality training (Congès et al, 2020) brings in another family of useful training tools.

Importantly, training should be a safe space to learn. All too often, large-scale emergency exercises that involve dozens or hundreds of actors are at the same time turned into publicity and dissemination events. Although it is important to showcase the competence of crisis management authorities and create awareness, this degree of publicity can corrupt the training and learning experience — especially if failing and learning from failure are not an option.

7.6. Harmonised data standards for data sharing in the EU

Digital technologies have advantages and risks. On the one hand, there is a significant dependency on the availability and reliability of digital technologies such as sensors, software systems and digital communication networks. The failure of these infrastructures, whether due to natural disasters or targeted cyber-attacks, might lead to a crisis in the telecom, energy or industrial sectors. This special role of digital technology requires a rethinking of crisis management, in that, a focus must be placed on the effective mitigation of the causes of incidents and this should be reflected in EU legislation. On the other hand, effective crisis management can be improved substantially through the use of digital technologies.

In both cases, appropriate means for data management and platforms for trustworthy data-sharing are key. Effective crisis management requires reliable data and information about, among other things, the current crisis situation, data and forecast models. These include simulation models to create reliable real-time forecasts and derived options for action, some of which are implemented in automated IT-driven processes, such as automated warning and evacuation reports. Data management plays a crucial role in modern crisis management. The required data must be available in good time, must be up-to-date, correct and complete. This requires the construction and operation of reliable IT infrastructures, from reliable sensors to stable, resilient digital communication networks that continue to function, even in the event of a crisis. A precise and up-to-date recording of the crisis situation is a complex task. The data required for this must be made available across borders, in high quality and in good time for joint use. Care must be taken to ensure that this data is not intentionally or unintentionally falsified, for example, to prevent targeted response measures.

Current situation at EU level

The role of data and, in particular, fair and barrier-free access to data, have been discussed in the European Commission for several years. The results were laid down in the European data strategy in 2020,[106] which aims to creat a single market for data, ensuring Europe's global competitiveness and data sovereignty. Common European data

106 cf. https://digital-strategy.ec.europa.eu/en/policies/strategy-data

spaces will facilitate the availability of more data, for use in the economy and society, while keeping under control the companies and individuals who generate the data. The strategy focuses on the economic utilisation of data.

The draft law on the Data Governance Act[107] announced as part of the data strategy, was presented by the European Commission in November 2020. It aims to create a framework by which to facilitate data sharing. According to the act, data sharing should be promoted across sectors and national borders. The core aspects are the provision of a secure infrastructure and better access to public sector data. It requires data intermediation services to be listed on a register to allow customers to be assured that service providers can be trusted. Services such as data exchange providers should also not be allowed to evaluate data for their own purposes to ensure that they represent neutral marketplaces and do not link these services to other offers, in order to avoid lock-in effects.

On 23 February 2022, the Commission proposed the Data Act.[108] The act is a regulation on harmonised rules on fair access to and use of data: it aims to ensure fairness, by setting up rules regarding the use of data generated by Internet of Things devices. The main objective of this regulation, in line with the data strategy, is to promote a data economy in Europe by opening access to industrial data in particular.

Digital technologies, platforms, communication infrastructures

The importance of data and its fair utilisation for the data economy is already covered by strategic and normative activities of the European Commission, as explained above. However, effective data-driven crisis management requires additional measures, like trustworthy digital sharing platforms, trustworthy and reliable digital communication infrastructures, as well as digital technologies like trusted sensors and actors.

Digital technologies are already available that enable real-time-informed scenario analysis to support decisions and operations for the management of a developing crisis. In central areas of critical infrastructures, which are often operated by private companies, such as in the energy sector, a large number of Internet of Things devices such as sensors and cameras are already in use to continuously monitor critical infrastructures. Collected data is fused and analysed in situational awareness centres, to create situational pictures and derive options for action. In some European countries, there are regional and national crisis plans in place as well as infrastructures for cyber crisis cooperation and management. However, the study carried out by the the European Union Agency for Cybersecurity in 2015[109] on Cyber Crisis Cooperation and Management showed that there is a considerable need for action at the European level. Strengthening

107 https://digital-strategy.ec.europa.eu/en/policies/data-governance-act

108 https://digital-strategy.ec.europa.eu/en/policies/data-act

109 https://www.enisa.europa.eu/publications/eu-level-crisis-man/at_download/fullReport

cooperation in the exchange of information and knowledge between private and public organisations was identified as a key area, to enable preventive and operational action in the event of a crisis. As of today, this is still an open issue. The increasing dependency on resilient IT infrastructures also raised the question of how to be prepared at the EU level to manage crisis situations that arise as a result of cyber-attacks on IT infrastructures. An ENISA report (2016) showed that there was a serious need for action. Harmonised measures were called for as a central action so that the member states would be able to react appropriately to cyber incidents. The creation of a European unit as a facilitator for information sharing and resource pooling was recommended as an important instrument, so that crisis coordination at EU level can take place.

Efforts were undertaken in 2021 to address these issues in a structured way. This includes in particular the recommendation of the European Commission published in June 2021 to set up a Joint Cyber Unit, a concrete implementation measure announced in the EU Cybersecurity Strategy published in December 2020.[110] The strategy aims to increase Europe's collective resilience against cyber threats. It contains two directives: one is an updated directive for better protection of network and information systems, which also has the expansion of information exchange and cooperation as a major goal, and another is a new directive on resilience of critical facilities.

The Joint Cyber Unit should be operational as early as June 2022 and fully established by June 2023 (see Figure 25 below). In its recommendation,[111] the Commission points out, among other things, that there is still no common EU platform where information gathered in different communities can be exchanged efficiently and safely, and where operational capabilities can be coordinated. It also pointed out that the necessary EU instruments for technical and operational cooperation with the private sector are still missing, both in terms of information sharing and incident response support. These deficits are to be remedied by the new Unit. The aim is that the member states and relevant EU institutions, bodies and agencies should ensure a coordinated response to and recovery from large-scale incidents and crises. For this purpose, among other things, EU Cybersecurity Rapid Reaction Teams are to be set up, but also a virtual and physical platform which will serve as an infrastructure for technical and operational cooperation between participants. For better coordination and preparedness, the Unit should also act as a platform to gather experts, enable information exchange and offer training from member state and European levels. It also aims to strengthen the use of appropriate tools for the rapid sharing of information, and cross-community EU Cybersecurity Incident and Crisis Response Plan exercises should also be planned and carried out.

110 https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2391

111 cf. https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3088

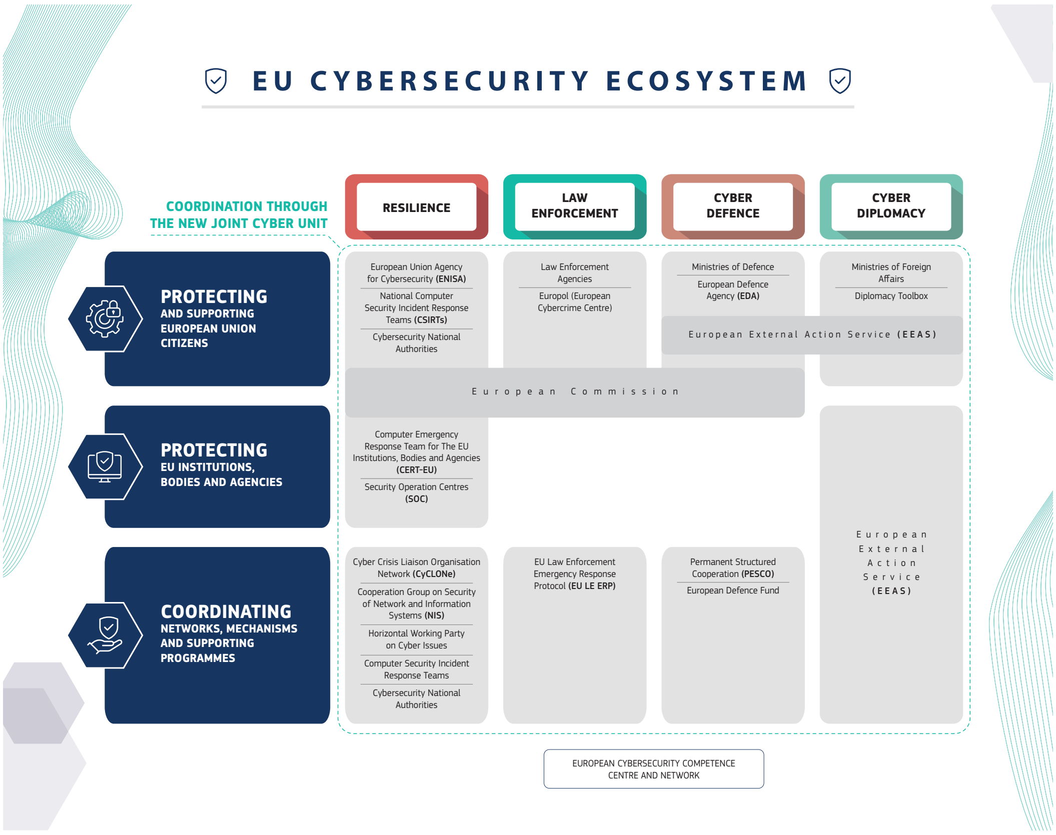

Figure 25. Joint Cyber Unit ecosystem
Source: European Commission

There is a strong need for trustworthy data management, which is currently being investigated in EU research projects. Important questions here are, among other things, verifiable data quality, the standardisation of data formats (and the possibility of standardisation itself: which data?), the real-time capability of data provision, and data fusion for the creation of situation reports.

Limits of previous measures with respect to crisis management

The importance of data for industry, but also for the public sector and society, is very well understood across the EU. With the EU Data Strategy, the Governance Act and finally the Data Act, concrete steps have been taken to promote the sharing of data through legislative initiatives and regulations. As explained, these measures are aimed at the economic utilisation of data. However, reliable data-driven crisis management requires additional measures. This includes measures to ensure that the shared data is reliable and available in a timely and up-to-date manner. The algorithms that process this data must also meet high requirements in terms of reliability, traceability and resilience against influences. Finally, the question of data harmonisation and the development of overarching standards have not been addressed yet. There is a further urgent need for action here with regard to data-driven, effective crisis management.

The regulations laid down in the Data Act insufficiently cover the needs of crisis management. Crisis situations are not explicitly addressed by the Act, even if measures for public sector bodies are required "to access and use data held by the private sector that is necessary for specific public interest purposes[;] for instance, to develop insights to respond quickly and securely to a public emergency, while minimising the burden on businesses."[112] The Data Act grants that government agencies in situations with special data requirements for public purposes should have simplified access to data from the private sector. Specifically, the text mentions public emergencies and other exceptional situations, such as a global virus pandemic, but access is regulated here in emergency situations, with ad-hoc access. Since crisis management must proactively receive continuous data access, there is clearly still a need here.

Strengthening cooperation in the exchange of information and knowledge between private and public organisations was already identified in 2015 as a key field of action to enable preventive and operational action in the event of a crisis. As of today, there is no common EU platform where information gathered in different communities can be exchanged efficiently and safely, and where operational capabilities are coordinated. In addition, there is still a lack of suitable instruments at EU level for technical and operational cooperation with the private sector. Information sharing and incident response support are still missing. However, with the initiative to set up a Joint Cyber Unit by 2023, the first steps have been taken since 2021 to eliminate these deficits. Instruments are to be developed to enable a coordinated response to and recovery from large-scale incidents and crises.

The construction of infrastructures for technical and operational cooperation between participants is a central task. Even if the question of coordinated defence against and response to cyber threats is certainly a very important issue, it is urgently necessary to set up platforms for the exchange of data for cross-border crisis management. The planned activities to strengthen cyber resilience urgently need to be expanded in order to be prepared for general crises and their management, and to enable action proactively and reactively across countries.

Box 9. Data preparedness — learning from the humanitarian domain

Information is vital for crisis response. Yet frequently data collection and intelligence gathering only start (fully) after the onset of the crisis. And even though every crisis is unique, there are several datasets that are virtually always needed to respond to a crisis, and for whose collection or sharing the EU and its member states can prepare. The humanitarian sector has developed several mechanisms that can also inform crisis response within the EU.

112 https://digital-strategy.ec.europa.eu/en/policies/data-act

Conventionally, there is a distinction between baseline datasets (or common operational data) that describe the context of a country. Such datasets entail, for instance, the topography of a country, population data, information about language, ethnic groups, cultural norms, or data about important airports, seaports, or critical infrastructures. This information conventionally is static, and needs to be complemented with dynamic datasets about the impact and evolution of the crisis (such as e.g. available via the Copernicus services), and the available capacity to respond. The latter is typically captured in the humanitarian 3W of Who does What and Where.

To prepare for collecting and curating data, it is important to know which information will be needed for different types of crises, ranging from extreme weather events to terrorist attacks. In this phase, a risk assessment is central to determine what types of events to prepare for. Then, for each event, several crucial decisions can be identified (see e.g. Gralla et al, 2015), for which data collection protocols can be prepared via a Task-to-Tool Framework: see Figure 26.

Besides the data in and of itself, Van den Homberg et al (2017) also stress the need to consider and develop available Data Services and Tooling (e.g. satellite imagery, UAVs, sensing and monitoring systems), Data Governance & Ownership, Data Literacy, and Data Sharing protocols across different organisations. Effective information sharing across member states is important to ensure common situational awareness, especially in transboundary crises. Here, a potential role of the EU could be in supporting the development of uniform data preparedness approaches for the most important transboundary crises that its member states may face.

FIGURE 3:
TASK-TO-TOOL FRAMEWORK

The scenario below shows a draft "task-to-tool" match framework focusing on post-event data needed to respond to a natural disaster. When a task-to-tool framework is developed, the data to be collected could be categorized into three broad areas: baseline data (currently defined under the Common Operational Datasets guidance), initial impact data and dynamically evolving data. Aggregate datasets, commonly used in humanitarian response, fall under the three areas and special care should be taken with these due the risk of accidentally uncovering personal or demographic identifiable information. The end goal of a task-to-tool framework is to help determine the information points, their purpose and tools to acquire data, so that responders can build evidence to make informed decisions about the actual needs of affected communities and people.

Sources: Raymond and Harrity[15] and IASC Information Management Working Group[16]

INFORMATION REQUIREMENT	PURPOSE	SAMPLE TOOLS AND TACTICS
• The number and severity of damaged structures	• Triage of most affected communities to prioritise needs assessments by ground teams	• Composite index to estimate severity ranking[17] • Analyse high-resolution satellite imagery
• Locations of critical infrastructure, such as schools and hospitals, and main roadways leading to most affected areas	• Updated, relevant maps for guiding ground teams conducting needs assessments in most affected areas	• Common Operational Datasets on Humanitarian Data Exchange • Deploy crowd mapping platforms
• Responders and capacities in-country	• Know which agencies/responders are present on the ground, and the capacities/expertise of staff to support response and coordination efforts	• Humanitarian ID[18]
• Media tracking and translation	• Understand the evolution of local conditions post-disaster and have access to local information	• Establish a reporting cycle with local Information Management Officers • Deploy Digital Humanitarian Network

Figure 26. Data Preparedness — Task to Tool framework
Source: Al Achkar and Raymond, 2016

8. Case studies

8.1. Summary

The scoping paper asks that the Advisors' recommendations are applicable to a broad range of threats and crises, and supported by case studies. Following the methodology suggested in the scoping paper, constitute good examples of a threats that can turn into complex, compound, cascading and transboundary crises, as presented in 1:

- **Wildfire management** is of increasing concern globally, driven by climate change and land-use change. In Europe in recent years, fire events have escalated way beyond their normal size and intensity and risks are increasing. The EU has developed strategies to respond to coordinate the response to these new threats, and established in 2019 a reserve of EU response capacities called RescEU, integrated into the EU civil protection mechanism, in support of the overwhelmed member states. EU monitoring and analyses are in place and well used, especially through the Copernicus programme. However, evidence suggests that more efforts should be made for risk reduction and recovery, and that a move from the modular system of the EU Civil Protection Mechanism to a more integrated system, interoperable with other existing mechanisms, would be beneficial.
- **Deliberate biothreats** pose a significant and growing threat to global security because of the unprecedented pace of global scientific development, the dual-use nature of biological materials and technologies, combined with the stated aim of terrorist groups and/or states. COVID-19 revealed that the EU was in many ways unprepared to deal with a pandemic and its cascading effects. The recent revision of the health security framework and the European Health Emergency Preparedness and Response Authority (HERA) should srenghten the EU in better preparing for and responding to cross-border health emergencies. Furthermore, to improve preparedness and response to public health risks posed by chemical, biological, radiological and nuclear incidents and attacks, the Commission is building up strategic reserves of response capacities such as the RescEU strategic stockpile, through the Union Civil Protection Mechanism and in close collaboration with HERA. The section highlights the importance of aligning with international information, regulations and guidelines such as the ones developed by the WHO, but also across member states, organisations at different levels, and different EU actors. Raising awareness and increasing legislative oversight on dual-use research in the scientific community and industry as well as for political leadership and funding institutions is crucial.

- As for **cybersecurity**, enhanced and progressively ubiquitous ICT offers unprecedented capabilities but also creates new risks, with smart environments introducing new cyber vulnerabilities. With the backdrop of increasingly complex risks and crises to manage at all levels, fast, effective, and broad exchange of multidimensional data is paramount for the success of crisis management, as well as the prevention of crises, especially in the light of the importance of ICT-supported participatory mechanisms and citizen contributions. Consequently, trustworthy ICT, providing information, data, and intelligence, is a cornerstone for successful crisis preparedness and response. However, cyberthreats have become a real concern, and ransomware is considered a prime threat, with potential dire consequences on key services. Cyberwarfare has also become a serious concern, particularly as no clear rules apply to this type of warfare. Stepping up cyber-defence against such attacks requires a multi-dimensional effort, and the EU has built up cooperations between several services. More recently, security and privacy by design approaches have been changing the landscape. Nonetheless, the adoption and deployment of strong security and privacy-preserving mechanisms is relatively slow. Luckily, there has been no cyber-crisis or no crisis of any sort caused by large-scale cyber-attacks. Europe needs to be ready well before cyber-crises or cyber-induced crises become existential threats. A renewed and multidisciplinary approach, with a broader and more proactive view, with increased weight on preventive measures and effective response investment, can contribute to better-protected networked systems and, inversely, systems that are better protecting their users.
- The case of **displaced populations** is an ongoing crisis and therefore of particular concern. UNHCR currently counts a record number of more than 100 million refugees and internally displaced persons, As populations flee their homes and countries as a result of a major crisis, receiving countries can rely on crisis management mechanisms to welcome, protect and assist refugee populations. This section reviews past refugee crises to identify important lessons. For the refugees fleeing the war in Ukraine, the EU activated a temporary protection directive on 4 March 2022. This instrument provides a strong basis for dealing with a sudden influx of displaced populations, even if long-term social integration remains a challenge. Principles of solidarity among member states, that enable the distribution of refugees among different countries of the EU, are generally viewed as important to avoid overwhelming some states only, yet this is difficult to achieve. For the longer run, no robust mechanism is currently in place to avoid a state of 'permanent temporariness' for displaced populations. For initial reception of refugees, evidence suggests that well developed contingency planning, with the application of the precautionary principle, is key. Inspiration can be taken from international organisations such as the United Nations High Commission for Refugees. Evidence shows that logistical support may be improved by enhancing cash transfers to local organisations, if the local market functions. To effectively manage and supply the refugees with what is

needed, good information systems need to be in place that allow authorities to plan for the capacities and resources that are and will be needed in different countries and regions; but data ownership, privacy and data protection raise serious concerns. Here, the EU — who has been spearheading data protection and privacy initiatives — could have a strong role to play.

This chapter concludes with the following key messages:

- While each crisis comes with its own sectoral specificities, many of these crises overlap. Each case also illustrates the proportions that each sectoral crisis can take, which inevitably calls for a broader and more integrated approach to risk and crisis management The EU needs to have mechanisms in place to coordinate and manage these and other ongoing risks and crises at the same time.
- These case studies call for:
    - increasing coordination and alignment with other levels of governance, which is especially relevant for transboundary crises
    - increasing capacity in prevention and preparedness
    - improving information and data

  These conclusions are in line with the conclusions reached in previous chapters of the report.

8.2. Wildfire management in the EU

Global patterns

Global warming changes the frequency of extreme weather conditions that drive the occurrence and spread of wildfires[113] as well as the production and drying of fuels that influence the availability of fuel for combustion (IPCC 2021). Globally, the climate crisis and land-use changes are currently driving an increase in extreme wildfires, with a 14% increase predicted by 2030 and a 30% increase by 2050 (Figure 27), with more wildfires occurring not only in regions where seasonal fires are common, but also in areas where fires do not normally occur (UNEP 2022). In particular, degradation of ecosystems such as peatlands, permafrost and forests make landscapes more flammable and results in increased frequencies of wildfires and also substantial increases in carbon emissions. Restoring ecosystems such as wetlands and peatlands are therefore important to prevent fires and create buffers in the landscape that at the same time capture and store carbon (UNEP 2022).

113 Wildfires defined as unusual free-burning vegetation fires that pose a risk society, the economy or environment (UNEP 2022)

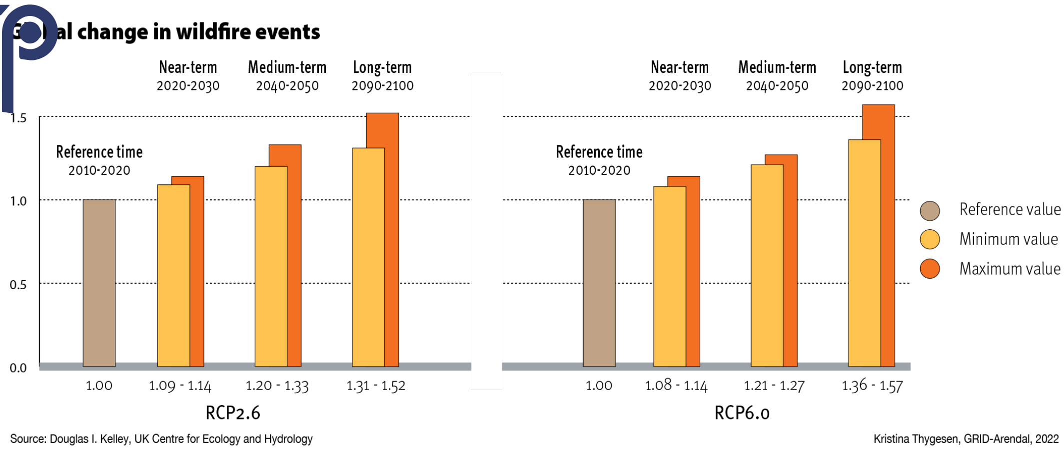

Figure 27. Global changes in wildfire events
Source: UNEP (2022)

By the end of the century, the likelihood of catastrophic wildfire events will increase by a factor of 1.31 to 1.57. Even under the lowest emissions scenario, we will likely see a significant increase in wildfire events (UNEP 2022).

Wildfires in Europe

In Europe, about 45 000 forest fires occur annually, burning half a million hectares of forests and rural lands (EEA 2022). Between 1995 and 2004, more than 4 million hectares burned in the Mediterranean Region alone. Summer wildfires are a natural and often necessary part of the life of Mediterranean forests. In the decade before 2016, around 48 000 forest fires burned 457 000 hectares annually across the five southern European nations where wildfires are most prevalent: Spain, France, Portugal, Italy and Greece. But too often in recent years, fire events have escalated far beyond their normal size and intensity and risks are increasing (Figure 28). In 2017 and 2018, large wildfires claimed hundreds of lives across an area stretching from Turkey to Spain, while countries in central and northern Europe, including Sweden, were also scorched. Such unprecedented fire events are inevitably linked to extreme droughts and heat waves. Modugno et al (2016) also pointed out that the landscape structures around many urban areas had changed and that increased proximity to landscape elements with high forest fuels has increased the fire risk to people and property.

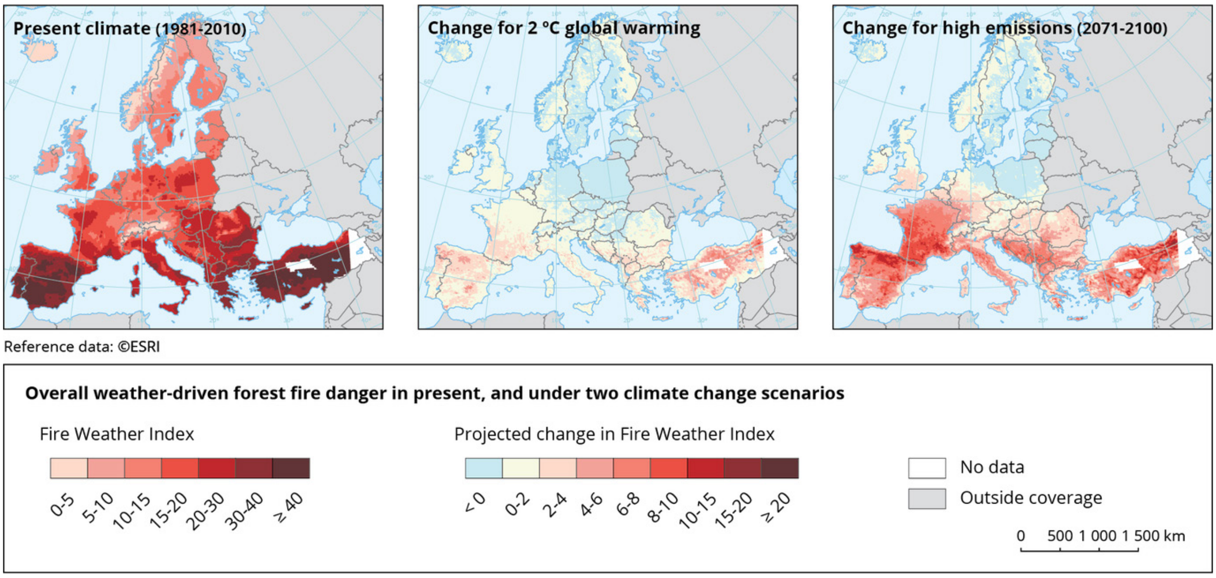

Figure 28. Changes in fire weather index under different climate change scenarios
Source: EEA 2022

Large-scale fires have a dramatic impact on biodiversity both above and below ground, as well as severely affecting local economies. In addition, and becoming increasingly serious, large-scale fires have a double impact on CO_2 emissions: fires destroy carbon capture and storage capacity and at the same time release large amounts of CO_2 into the atmosphere. In 2017, CO_2 emissions from extreme wildfires across southwestern Europe (namely the Iberian Peninsula, southern France and Italy) were the highest since at least 2003, reaching approximately 37 teragrams of CO_2. The increasing risk of large-scale fires affecting both forested and agricultural landscapes may therefore jeopardise ambitious plans to use landscapes for the necessary massive increase in carbon capture and storage. For example, under the European Green Deal, the EU biodiversity strategy for 2030 commits to planting at least 3 billion additional trees in the EU by 2030 to enhance carbon capture and storage. This massive tree planting programme must be carefully designed to avoid adding substantial flammable fuel in many landscapes across Europe.

Decision-making, coordination and governance arrangements within the EU

The section of this report entitled 'Capacities to assist the overwhelmed member state', p.72, introduces the capacities in place that allow the EU to assist overwhelmed member states in the fight against wildfires. RescEU, an EU Civil Protection Mechanism sub-programme, has received substantial resources since 2019 (budget approximately 1,4 billion euros during 2021–2027), with equipment like special aeroplanes and helicopters and coordination emergency capacities in place. Several studies have suggested additional measures of this emergency capacity. Monet et al (2020) suggested that the EU should move from the modular system of the EU Civil Protection Mechanism to an integrated, robust, and unique European Command System, which clearly must be fully interoperable with other existing mechanisms. Montiel-Molina (2013) suggested a framework Directive to be considered as the best legal instrument for promoting the concept of integrated fire management in Europe.

On a general level, the new EU strategy for adaptation to climate change adopted in February 2021 sets out how the European Union can adapt to the unavoidable impacts of climate change and become climate resilient by 2050, including addressing risks of increased wildfires. Similarly, the new EU Forest Strategy for 2030 adopted in July 2021 recognises the growing threats to European forests from climate change, which can increase the risks of forest fires.

Among member states, communities have learned over time to cope better with the average annual fires in hot and arid regions across southern Europe, with more sophisticated fire prevention strategies leading to an overall decline in the number and size of fires since 1980. There are many natural solutions, including starting controlled fires using prescribed burning, managing landscapes by grazing animals to reduce the amount of flammable material in the landscape, as well as removing trees too close to people's homes (UNEP 2022). Spain, one of the EU countries with the most forested land, has developed a number of preventive measures and emergency responses. These have enabled it to significantly reduce both the number and average size of forest fires, despite climbing temperatures and a rural exodus (EEA, 2022).

Box 10. Governance and Risk Reduction in Portugal

Following the tragic fires of 2017 which resulted in 117 fatalities and over 540 000 hectares burned, the Government of Portugal undertook an ambitious process to develop a new integrated wildland fire management plan with the goal of protecting Portugal from severe wildland fire.

The vision in the resulting 2020–2030 National Plan for Integrated Wildland Fire Management[114] is "a Portugal protected from severe rural fires" with the mission to "protect people and property from rural fires and develop rural land, ensuring ecosystems are properly tended to". The strategic objectives of the National Plan are:

- **valuing rural areas:** recognising rural areas as enablers of wealth and sustainability
- **active management of rural areas:** preserving rural areas through the use of fire management practices in line with citizens' well-being and safety.
- **behaviour change:** promoting the adoption of responsible behaviours for citizen safety and the preservation of a productive and safe territory, reducing ignitions, and improving decision-making processes for individual and collective protection
- **efficient risk management:** implementing risk management throughout the whole value chain in order to reduce losses, with clear priorities and effective use of public resources.

114 https://www.agif.pt/app/uploads/2019/05/PNGIFR_ENGLISHVERSION_menor.pdf

The National Plan has the following targets:

- to design and implement a national strategic programme for large-scale fuel reduction
- to ensure that burned areas of more than 500 hectares amount to less than 0.3% of fires
- to reduce ignitions on high fire danger days
- to add value to biomass by connecting harvesting and processing in rural areas
- to build up the skills in agencies for effective risk management

Source: UNEP 2022

Monitoring and analyses in Europe is carried out by the European Forest Fire Information System (EFFIS), together with the European Commission's Joint Research Centre. EFFIS monitors trends in forest fires and reports on the number of fires and the burned area, with data on the latter being considered more robust and policy relevant. Since 2015, EFFIS is part of the EU Copernicus Programme, under the Emergency Management Service. In summer 2021, Copernicus was activated 17 times for rapid mapping initiatives, indicating the value of remote sensing for crisis management.

Assessment

Although the EU has taken substantial steps to strengthen its overall emergency and coordination capacity, there is more to do when it comes to being proactive and reducing the prevalence and ferocity of fires. The United Nations Environment Programme (UNEP, 2022) recommended a five-pronged strategy (Figure 29, p.214):

- review and analysis
- risk reduction
- readiness
- response
- recovery

The EU has taken significant initiatives to improve review and analysis through EFFIS and the Readiness and Responses through the RescEU mechanism. However, risk reduction and recovery are areas that need much more attention from both EU-wide mechanisms and member states. Besides reducing the rate of climate change, risk reduction would include cutting back on the fuel through effective land management and community-based activities and training.

UNEP (2022) pointed out that, in general, direct emergency responses to wildfires often receive more than 50% of available funding, while planning and prevention typically receive less than 1%. UNEP has a general recommendation that investments are rebalanced, with 50% going to review and analysis and risk reduction, about 30% to readiness and response, and 20% to recovery.

The conclusion is that the EU and member states should substantially reallocate public spending on wildfires, with more spending on proactive preventive initiatives and better coordination of monitoring and analysis.

REVIEW AND ANALYSIS

Collection of data and information	**Review of policies, procedures, and approaches to integrate fire management**	**Analysis of data and stakeholder engagement**
Development of fire behaviour models	Integrate fire management	Development of integrated fire management plans
Post-fire assessment and analysis		
Identify critical areas where intervention and investment are needed to support risk reducion		

RISK REDUCTION

Awareness and education	**Landscape management**	**Fire use laws and enforcement**	**Community based fired management**
Ignition avoidance/restriction of high-risk activity	Fuel management	Building codes	Promote the safe management of fire through education
Personal evacuation plans	• Hazard reduction • Indigenous/traditional approaches • Grazing/mowing • Support ecological needs	Regulate fire use	Homeowner actions
Asset protection		Ignition reduction strategies	
Training	Firebreak creation and maintenance		
	Land use planning		
	Fire regime restoration and management		

READINESS

Fire surveillance and detection	**Threat/danger forecasting**	**Pre-suppression readiness**
Early warning systems	Fire danger rating systems	Firefighters on standby
Public notification		Personnel and equipment resourcing (capacity)

RESPONSE

Adaptive suppression	**Suppression resource**	**Community health and safety**	**Post-fire impact planning**
Safe	Capacity maintenance	Evacuation	Recovery assistance plans
Adequate • Rapid initial attack	Resource sharing/requests	• Emergency food, water, and shelter • Emergency health care	Loss assessment tools
Appropriate • Right resource mix		Support mobilization	
Effective • Contained and control, if possible			

RECOVERY

Community aid	**Environment**	**Infrastructure**
Emergency housing	Wildlife rescue	Loss assessment
Finance	Environmental restoration	Repair
Longer term recovery assistance plans	Fire regime restoration	

Figure 29. Integrated fire and landscape management to handle risks
Source: UNEP, 2022

Key messages

In the context of climate change, more wildfires can be expected across the EU.

The increasing trend of wild and forest fires is widely recognised.[115],[116] Beyond the investments in RescEU that have been made already, the EU and its member states should substantially reallocate public spending on wildfires to increase their response capacity. Following the recommendation of UNEP, more investment is needed for proactive prevention initiatives in particular, compared to the current focus on response, along with better coordination, monitoring and analysis.

There is evidence to suggest that it would be beneficial for the EU to move from the modular system of the EU Civil Protection Mechanism to an integrated, robust, and unique European Command System, which must be fully interoperable with other existing mechanisms. A framework Directive has been suggested as the best legal instrument for promoting this concept of integrated fire management in Europe.

8.3. The case of cybersecurity

Accelerating and expanding digitalisation has been transforming activities and processes across society into 'smart' ones, with increased efficiency, transparency, and sustainability. But enhanced and progressively ubiquitous ICT are a double-edged sword: they offer unprecedented capabilities but also create new risks, with smart environments introducing new cyber vulnerabilities if the appropriate cybersecurity mechanisms are not in place. A wide gamut of such vulnerabilities has been exploited over the years, leading to significant incidents (e.g. network outages, data leaks, computing system intrusions, denials of service), with significant damages and monetary costs for the affected organisations and users.

This has created increased awareness and a clear understanding that cyber-threats need to be addressed, especially since the capabilities of potential perpetrators are enhanced by a wide range of available tools that do not require technical sophistication. Cyber-attacks — that is, deliberate adversarial actions, rationally or maliciously motivated, that harm networked information systems and their users and owners — have prompted a significant pan-European response. Despite the existence of a wide range of cybersecurity mechanisms integrated in networked information systems, and the existence of appropriate measures to improve resilience to benign failures, cybersecurity failures are perceived as a 'clear and present danger',and information infrastructure

115 https://publications.jrc.ec.europa.eu/repository/bitstream/JRC126766/annual_report_2020_final_topdf.pdf

116 https://publications.jrc.ec.europa.eu/repository/bitstream/JRC128678/JRC128678_01.pdf

breakdowns are categorised as the top mid-term technological risk (World Economic Forum, 2021).

At the same time, regular economic, environmental, geopolitical and societal risks have led to a series of major incidents, failures, disasters, and eventually crises of different types and magnitudes. This has led to the creation of an extensive system of crisis management systems, structures, and mechanisms at national and European levels, as described throughout this report (for cybersecurity, see p.78). The fast, effective and broad exchange of multidimensional data is vital to the success of any crisis management system, as well as to preventing crises, especially in the light of the importance of participatory mechanisms and citizen contributions (6). Consequently, trustworthy ICT providing information, data, and intelligence (7) is a cornerstone for successful crisis prevention and response. Cybersecurity and the resilience of networked information systems are key enablers, both at national and European level.

There are thus two objectives with regard to cybersecurity in crisis management:

- preventing and responding, effectively and in a timely manner, to cyber-crises
- reinforcing crisis management systems through trustworthy ICT which is secure and resilient, and protects privacy

Achieving the first broader objective can lead, with appropriate refinements, to addressing the second challenge. The intricacies at EU level are covered in section 7.6, p.201.

Background: Cyber-threats

The scope of cyber-threats and cybersecurity is very broad, with a very extensive literature. A growing community of researchers and practitioners investigates and identifies vulnerabilities, assesses risks, designs defensive mechanisms to safeguard systems and their users, analyses such cybersecurity mechanisms, assesses their efficiency, and builds secure versions of ICT systems. The challenge lies in the fact that such networked systems, designed and built with specific functionality and purpose, typically operate in an adversarial environment. Users and devices, inside or outside a system in question, could act in arbitrary ways, deviating from their specified roles and operation, trying to exploit or disable the targeted systems. Fundamentally, cybersecurity seeks to provide solutions that allow secured systems to manage adversarial actions, preventing attacks and maintaining the ability to operate as intended in spite of the attacks.

The more interconnected and open ICT systems are, the easier it becomes for wrongdoers to perpetrate attacks and avoid being identified. Rich connectivity allows a remote attack essentially on any part of the internet, e.g. any server or part of the network infrastructure. Large numbers of computers running the same software version and the same hardware can be compromised, e.g. by malware, once a new vulnerability is discovered. System parts that are physically unattended or easier to penetrate, such as Internet of Things devices, can be the stepping-stones for attacks. The more diverse and the less technically well-versed the user base is, the more likely it is to fail to prevent, or even unwillingly to facilitate, cyberattacks, for example, by not properly maintaining their computers (e.g. by failing to install the latest software versions that eradicate known vulnerabilities) or by failing to use the appropriate defence mechanisms (such as malware detection software, or properly configured firewalls).

Figure 30. ENISA Threat Landscape — 2021: most prominent threats
Source: ENISA, 2021

The fast rollout of ICT, services and applications can often lead to relatively immature systems in terms of security (and privacy) protection, with retroactive remedies (e.g. software updates, dissemination of patches) often preceded by incidents of different magnitudes. The increasing system complexity can make security (and privacy) requirements harder to achieve, even if system components may satisfy them in isolation but when brought together. Individuals or small organisations may typically be among those that lack the preparedness and resources to safeguard their ICT systems; even though they may not be primary targets themselves, compromise of their computers and networks can be a stepping-stone for larger-scale attacks, for instance by using the exploited machines as bots for large-scale distributed denial of service attacks. All in all, the evolving ICT landscape leaves space for cyber-attacks, perpetrated by different types of adversaries: hackers (sometimes classified as 'activists'), criminals (including those that can be classified as 'terrorists'), and state-level actors. They typically have diverse motivations and objectives, and their capabilities, targets, and methods can vary.

The threat landscape evolves accordingly, with different types of attacks prominent in different periods. The European Union Agency for Cybersecurity (ENISA), for example, publishes a yearly report on the most relevant threats and the affected sectors (ENISA, 2021). Figure 30 illustrates the landscape in 2021, with a prime threat being ransomware, malicious software that encrypts files on the victim's computer, blocking access to data or even the entire computer until the victim sends a payment to the perpetrator. The monetary cost for the attacked individual or organisation includes both the ransom and the cost of suspension of everyday activities, as well as costs to eradicate the vulnerability and resume operation. Depending on the form of the attack, the effects can be far reaching felt across the society: for example, in July 2021 a ransomware attack on a US tech provider incapacitated the checkouts across 800 branches of a major Swedish supermarket, preventing any purchases for almost a week. Similar attacks on healthcare providers, schools, and local governments, with thousands of incidents in the US, for example,[117] suggest both increasing risks (the shutdown of critical systems in a hospital could cost lives), and increasing breadth and scope of cyber-attacks.

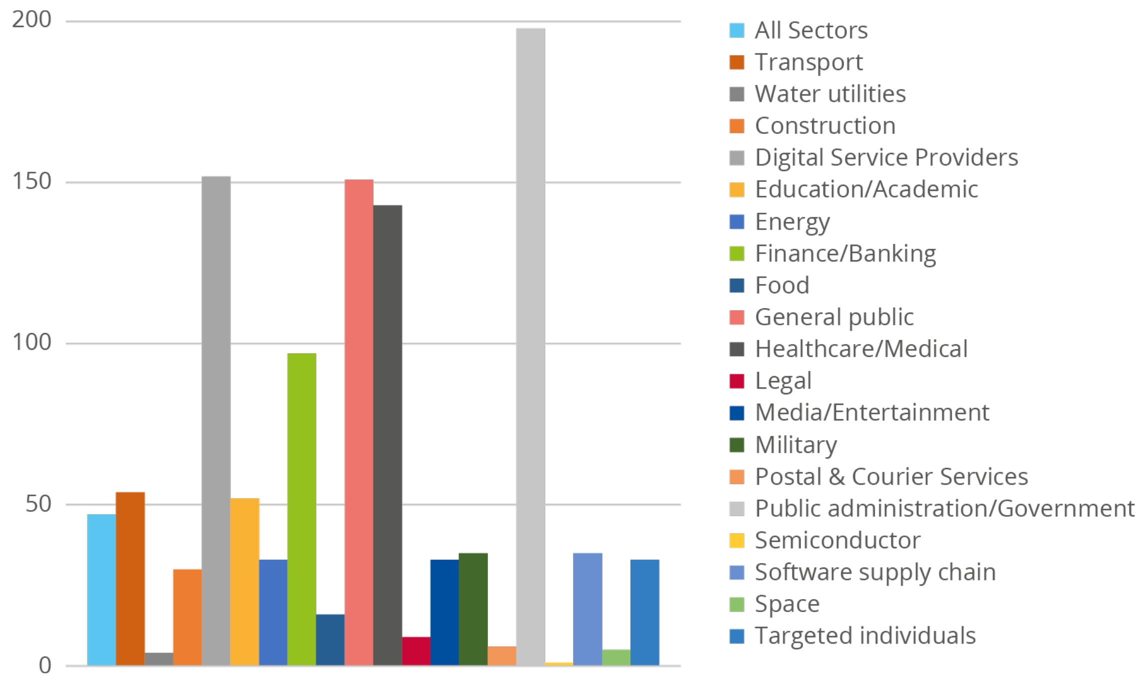

Figure 31. ENISA Threat Landscape 2020–2021: affected sectors, numbers of incidents
Source: ENISA, 2021

117 https://www.zdnet.com/article/2300-local-governments-schools-healthcare-providers-impacted-by-ransomware-in-2021/

In fact, practically every sector can be affected, as shown in Figure 31: cyberattacks, targeting every part of society's activities, now enabled and expanded by new means. Remote attacks make it difficult to attribute attacks to specific people, computers and locations, because even modestly sophisticated attackers can conceal themselves using virtual private networks or other forms of encrypted communication protocols, services and cryptocurrencies.

International or national law enforcement agencies combat cyber-crime, e.g. the Europol Cybercrime Center (EC3)[118] or the FBI in the US (FBI, 2021). The motivation for expanding these activities is clear: damages and monetary losses are very significant and increasing, as shown in Figure 32 for the US: approximately 0.03% of the US's GDP (or higher, given that a significant number of incidents are not reported, or not precisely accounted for). Moreover, an increasing investment in more sophisticated defence measures has not yet counteracted this trend.

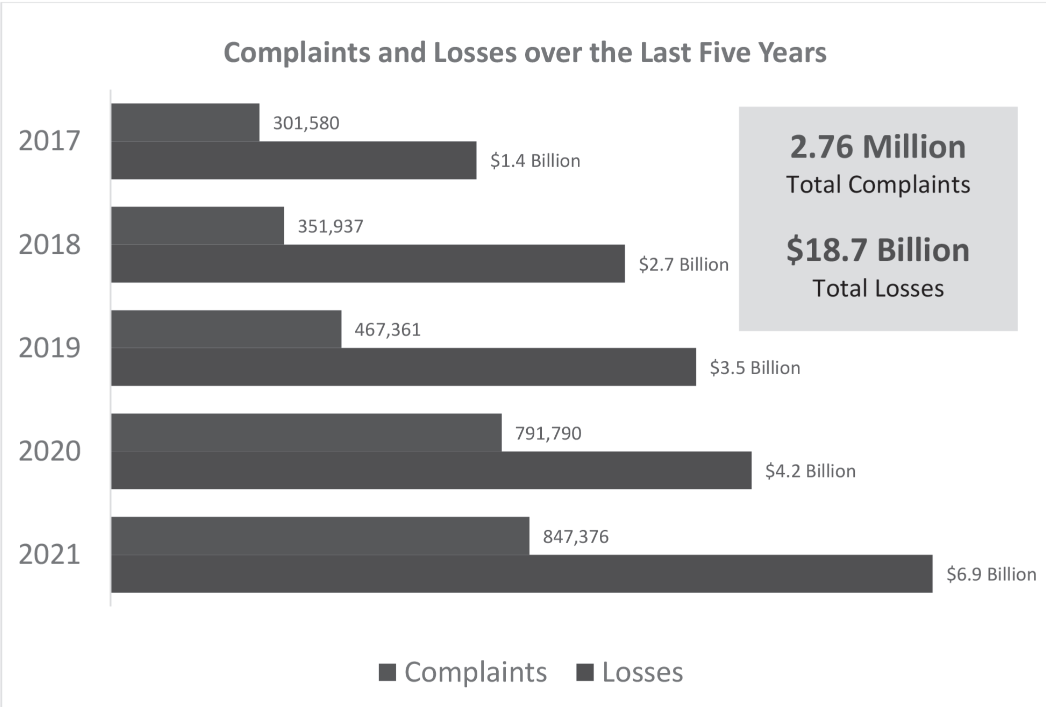

Figure 32. Increase in numbers of complaints and estimated losses due to cyberattacks
Reproduced from Federal Bureau of Investigations (2021), FBI Annual Internet Crime Report

From a technical point of view, it is noteworthy — and alarming — that old forms of attack remain prevalent. Distributed denial of service attacks, for instance, first occurred in February 2000 with an estimated loss of $7.5 million; they remain a major threat, combined with extortion of targeted organisations, and they have become more sophisticated, more frequent, and available to non-experts. Similarly, phishing attacks

118 https://www.europol.europa.eu/about-europol/european-cybercrime-centre-ec3

(emails or other interaction with users to mislead them into revealing private information), identity theft, and online fraud evolve and remain prevalent in spite of increasing user awareness. Seemingly unrelated events can increase vulnerability further: for instance, social distancing and lockdowns prompted by the COVID-19 pandemic increased the use of many online services, including e-government and e-commerce, bringing a related increase in cyber-attacks, including mobile malware to compromise two-factor authentication[119] and online fraud, using social engineering and other methods (Europol, 2021).

Cyber-crises and crisis management

The breadth of cyber-threats and their far-reaching effect have the potential to undermine any aspect of societal activity. The large number of adversaries, including those that can essentially 'hire' cyberattacks, contributes to the volume and cost of incidents.

Setting aside some instances of collaborative 'hacktivism' several years ago, most malicious actors act independently. However, state actors (organisations under the control of governments) have also led large-scale, coordinated attacks against network infrastructures of specific targeted countries. Following early examples of cyber-conflict such as the attack against Estonia in 2007, cyber-warfare has now emerged as an increasingly important threat. It is therefore vital for states to ensure sufficient cybersecurity of all infrastructure, whether judged critical or not, since cyber-offensive operations can target multiple domains. Cyber-warfare is sometimes unrelated to classical warfare, rather seeking to destabilise key activities, influence society and harm the state through coordinated, large-scale attacks. But it can also be associated with rising political tensions prior to traditional warfare; cyber-offensives could signal the intent and readiness to engage, extract critical information, influence public opinion and political decisions, or even possibly harm critical functions as part of a planned escalation. Finally, it can be part of an ongoing confrontation, complementing traditional warfare, e.g. attacking communications, or mounting cyber-attacks against physical infrastructure to reduce the ability of the opponent to fight in a conventional war.

The complexity of the issue is clear. There are analogies to traditional warfare, but also significant differences. For instance, while it is clear what counts as an offensive move in the traditional context (crossing a land border, invading airspace or territorial waters), it is not equally clear what constitutes violation of sovereignty with a cyber-offensive, or what justifies international condemnation, sanctions, or retaliation.

Stepping up cyber-defence against such actors requires a multidimensional effort. The European Defence Agency cooperates with the European Union Agency for

119 User authentication not only based on her password (something she knowns) but also an additional piece of evidence to corroborate her identity, e.g. a smartphone (something she has).

Cybersecurity, Europol and the Computer Emergency Response Team for the EU Institutions, Bodies and Agencies.[120] In parallel with the new cybersecurity strategy,[121] the European Cybersecurity Certification Group is responsible for implementing the 2019 cybersecurity act, the revised Network and Information Security directive, and the new Cybersecurity competence center, among others (European Defence Agency, 2021).

Assessment

Digitalisation has many benefits, and it is natural that dependence on smart environments grows in essentially every societal activity, including critical infrastructures. Often, the public perceives an ICT solution as a panacea, and the more exotic the solution seems, the more it can appear out of reach of adversaries. To an extent, this may reflect the historic evolution of the internet, which initially operated in a closed and controlled environment, where solutions could be deployed first and security considerations follow later.

More recently, security and privacy-by-design approaches have been changing the landscape. Nonetheless, the adoption and deployment of strong security (and privacy-preserving) mechanisms is relatively slow, especially in areas which rely heavily on specific technologies and legacy systems. This is likely to remain a challenge in areas with systems that have long lifecycles but still require updates. Parts of the most critical ICT-based systems may still be far from the desired level of security; hence the emphatic statements sometimes found in popular technical and financial publications, such as *The internet is broken* (MIT Technology Review, 2005) or *Why everything is hackable: Computer security is broken from top to bottom* (The Economist, 2017).

As well-founded as such warnings may be, the internet has nonetheless continued to function, evolve and propel our economies. It is highly distributed, thus inherently robust, and the painstaking efforts of many system administrators have kept the networking infrastructure running despite misconfigurations and attacks, while the increasing deployment of security countermeasures on the network 'edge' maintains the balance. Experience teaches that there are cycles of initial excitement, broad acceptance, and eventual dependence on a new technology and related services; this can be followed by disappointment and distrust after major incidents (e.g. outages, monetary loss, or the revelation of vulnerabilities that do not directly affect most users), but the cycle downturn probably lasts for a relatively short time.

Both vulnerabilities and risks are clear, considering the relatively weak cybersecurity mechanisms in many systems, the significant damages caused by cyberattacks, the increasing trends, along with the repeated assertions of impending doom, the

120 https://www.consilium.europa.eu/en/policies/cybersecurity/
121 https://digital-strategy.ec.europa.eu/en/policies/joint-cyber-unit

emergence of powerful malicious actors, cyber-offensives and possibly cyber-warfare. Nonetheless, to date there has been no cyber-crisis, and indeed no crisis of any sort caused by large-scale cyber-attack emergencies and their cascading effects. This may sound surprising, but the impact of any major incidents so far is dwarfed by the impact of climate, medical and financial crises at different scales (regional, national, continental or global).

However, there is no guarantee that this will continue to be true in the future. Cyber-technologies are increasingly connected to the physical world. Cyber-crises could not only emerge and persist, but they could also exploit other crises (e.g. a pandemic leading to an increase in cyber-attacks and the deterioration of privacy). Worse, cyber-crises could trigger a 'chain reaction', degrading the response to, aggravating, or creating other crises by targeting critical infrastructures and sectors. Europe needs to be ready well before cyber-crises or cyber-induced crises become existential threats.

Finally, it important to understand that pervasive digitalisation is both generally welcome and irreversible. Ideally, it should improve processes without introducing new vulnerabilities, or even eradicate risks inherent in the physical processes it replaces.

Key messages

Cybersecurity has been traditionally thought of as a nuisance and a cost. Even technically competent stakeholders are frequently aware of vulnerabilities ahead of time, but invest in addressing them only when they see clear evidence that a particular vulnerability can be exploited. This is understandable, but a renewed approach, with a broader and more proactive view, with increased weight on preventive measures and effective response investment, would contribute both to better-protected networked systems and systems that are better at protecting their users.

It is important to increase awareness, enhance skills, and enable individuals to secure themselves and protect their privacy. In this context, we should cultivate social responsibility and cohesion in cyberspace, and explore the feasibility of extending notions of insurance and liability to that domain.

We must continue and intensify the promotion and adoption of strong countermeasures, including key security and privacy tools and services. We must adhere to security and privacy by design, mandate certification schemes, especially in critical sectors that digitalisation is transforming more quickly, such as transportation, logistics, energy and health. In addition, we need strong incentives for all stakeholders to achieve those objectives, along with mandates to design and implement redundancy for resilience in both cyber- and cyber-physical systems.

It is important to achieve all the above while respecting privacy, leveraging approaches that do not put strong security at odds with privacy-enhancing technologies. This is important especially for crisis management and response that leverage participatory resilience schemes.

Last but not least, it is important to work in a multidisciplinary manner, towards concrete cyber-crisis response preparedness and mechanisms that can be very well defined, in analogy to climate or health crisis management that can offer concrete help to other state members.

8.4. The case of deliberate biothreats

Background: biological safety and security

As described elsewhere in this report, crisis management has to contend with increasingly complex and compound crises. Decision-makers and governments must increasingly ready themselves for cascading and transboundary threats that emerge in far-away domains and manifest themselves in unsuspected and undesirable ways (Boin, 2019; Perrow, 1984; Renn & Lucas, 2021). Such complexity implies that hitherto smaller events or crises can cascade into other sectors, regions and countries. The ongoing war in Ukraine and the COVID-19 pandemic have demonstrated that crises that happen outside of the EU can also have severe implications for and within it. This would be the case with a deliberate release of infectious agents.

On a global scale, epidemics of infectious diseases are occurring more often, and spreading faster and further than ever, in many different regions of the world (WHO, 2018). The background factors of this threat are biological, environmental and lifestyle changes, among others, including the possibility for malicious manmade threats.

Threats to public health do not stop at national borders, as shown by the currently ongoing COVID-19 pandemic (Cucinotta & Vanelli, 2020), as well as by possible spread of infectious diseases during the war in Ukraine. Diseases can spread rapidly across borders through travel, trade in food and feed, insects and other disease carriers (Erbach, 2012). In some forms, biological agents can be weaponised for use in bioterrorism or other crimes (US Department of Labor, 2021).

Biological weapons disseminate disease-causing organisms or toxins to harm or kill humans, animals or plants. They can be deadly and highly contagious. Diseases caused by such weapons could spread rapidly around the world. The consequences of the deliberate release of biological agents or toxins by state or non-state actors could be dramatic. In addition to the tragic loss of life, such events could cause food shortages, environmental catastrophes, devastating economic loss, and widespread illness, fear and mistrust among the public.[122]

A biothreat is defined as the threat posed by a harmful biological agent — this includes bacterial, fungal and viral pathogens and toxins produced by a variety of organisms (Table 2). The threat is often categorised as caused by bioterrorism or biological warfare, and political mechanisms for prevention of these are focused similarly, although the terminology is not clearly defined. On the other hand, medical or other reactive countermeasures do not necessarily differ from the disease threats of purely natural origin. In fact, most biothreat agents derive from nature, in comparison from other chemical, biological. radiological and nuclear (CBRN) threat agents that are often of synthetic origin.

The US Centers for Disease Control and Prevention and National Institute of Allergy and Infectious Diseases have classified infectious disease causing high-priority agents into three categories, A, B or C, depending on their risk to national security. Category A bioterrorism agents cause diseases that result in high mortality rates and have the potential for major public health impact; they might cause public panic and social disruption; and require special action for public health preparedness. Furthermore, Category A organisms can be easily disseminated or transmitted from person to person. These diseases and causative agents are:[123]

- anthrax (*Bacillus anthracis*)
- botulism (*Clostridium botulinum* toxin)
- plague (*Yersinia pestis*)
- smallpox (*Variola major*)
- tularemia (*Francisella tularensis*)
- viral haemorrhagic fevers, including filoviruses (Ebola, Marburg) and arenaviruses (Lassa, Machupo)

According to the National Institute of Allergy and Infectious Diseases, biological warfare agents are microorganisms like virus, bacteria, fungi, protozoa or toxins produced by them, that give rise to diseases in humans, animals or plants when deliberately dispersed in an area (Thavaselvam & Vijayaraghavan, 2010).

According to the World Health Organisation (WHO), biological weapons are microorganisms or other toxins that are produced and released deliberately to cause disease and death in humans, animals or plants. Biological agents can pose a difficult public health challenge causing large numbers of deaths in a short amount of time

122 https://www.un.org/disarmament/biological-weapons/

123 Definitions of the mentioned diseases can be found on the US Centers for Disease Control and Prevention website: https://emergency.cdc.gov/agent/agentlist-category.asp

while being difficult to contain. Bioterrorism attacks could also result in an epidemic, if contagious agents were used. Biological weapons are a subset of a larger class of weapons referred to as weapons of mass destruction, which also includes chemical, nuclear and radiological weapons. The use of biological agents is a serious problem, and the risk of using these agents in a bioterrorist attack is increasing.[124] Biological agents neither recognise nor respect political or geographic boundaries. Naturally-occurring and self-replicating, they pose a unique threat to global security.[125]

Agents that can be used as biological warfare or bioterrorism-related incidents

	Agents	Disease	Route of infection	Possible release
Bacteria	*Ba. anthracis*	Anthrax	Aerosol	Spores
	Y. pestis	Plague	Aerosol	Vegetative cells
	Br. melitensis	Brucellosis	Aerosol	Vegetative cells
	Br. abortus			
	Bu. mallei	Glanders	Aerosol	Vegetative cells
	Bu. pseudomallei	Melioidosis	Aerosol	Vegetative cells
Viruses	Variola virus	Smallpox	Aerosol	Virus particles
	Ebola virus	Ebola hemorrhagic fever	Aerosol	Virus particles
	Marburg virus	Marburg hemorrhagic fever	Aerosol	Virus particles
Toxins	*C. botulinum*	Botulism	Ingestion food/water	Toxin
	Staphylococcus aureus	Staphylococcal enterotoxin type B (SEB)	Food/water	Toxin
	Ricin (plant)	Ricin toxin	Food/water	Toxin
	Trichothecene (fungus)	Trichothecene T2 toxin	Food/water	Toxin

Table 2. Agents that can be used as biological warfare or bioterrorism-related incidents
Source: Biological warfare agents (nih.gov)

The unprecedented pace of global scientific development and the dual-use nature of biological materials and technologies, combined with the stated aims of terrorist groups and states of concern, contribute to the significant international security threats posed by biological proliferation and terrorism. Although less publicised and under-addressed compared to other concerns about weapons of mass descruction, biological weapons and materials pose a significant and growing threat to global security.[126]

The Global Health Security Index assesses health security and related capabilities across the 195 countries that are parties to the WHO International Health Regulations 2005 (WHO, 2016). The overall finding of a report in October 2019 (pre-COVID-19) was that national health security is fundamentally weak around the world. According to the report, no country was fully prepared for epidemics or pandemics, and every country had important gaps to address (Cameron et al, 2019). Collectively, international preparedness was also considered weak. Furthermore, less than half of countries had submitted Confidence-Building Measures under the Biological Weapons Convention.[127] A

124 https://www.who.int/health-topics/biological-weapons#tab=tab_1

125 https://www.gpwmd.com/bswg

126 https://www.gpwmd.com/bswg

127 https://www.un.org/disarmament/biological-weapons

second evaluation published in December 2021 concluded that all countries still remain unprepared for future epidemic and pandemic threats (Bell & Nuzzo, 2021).

'Biological safety', or 'biosafety', broadly refers to the policies, regulations, and arrangements that aim to prevent the unintentional (accidental) release of biological agents and toxins in the environment, including naturally occurring infectious diseases affecting human, animals, or plants. 'Biological security', or 'biosecurity', refers to the policies, regulations, and arrangements that aim to prevent the deliberate release of biological agents and toxins (CSD, 2020; Novossiolova et al, 2019). However, and despite their different focus, both biosafety and biosecurity preparedness are developed together. This is the case e.g. in the WHO Monitoring and Evaluation Framework for the International Health Regulations, and its voluntary Joint External Evaluations for public health emergencies, including those posed by biological agents. The targets of the Biosafety and biosecurity technical area are a whole-of-government multisectoral national biosafety and biosecurity system with dangerous pathogens identified, held, secured and monitored in a minimal number of facilities according to best practices; biological risk management training and educational outreach conducted to promote a shared culture of responsibility, reduction of dual-use risks, mitigation of biological proliferation and deliberate use threats, and ensuring safe transfer of biological agents; and putting in place appropriate country specific biosafety and biosecurity legislation, laboratory licensing and pathogen control measures.[128]

Box 11. International Health Regulations

The International Health Regulations (2005) are the international legal instrument designed to help protect all states from the international spread of disease. The Regulations entered into force on 15 June 2007. They are currently legally binding upon 194 states around the world, including all WHO member states (WHO, 2009).

At the European level, the COVID-19 pandemic has shown that the EU's mechanisms for managing health threats suffer from general shortcomings that require a more structured Union-level approach if we are to deal better with future health crises, including those caused by deliberate manmade threats. The revision of the health security framework proposes a stronger and more comprehensive legal framework within which the Union can prepare for and respond to health crises (European Commission, 2020).

Measures for controlling the spread of infectious diseases include monitoring and reporting, hygiene and vaccination. Impacts on human health can be minimised through medication and medical care (Erbach, 2012).

128 https://extranet.who.int/sph/ihr-monitoring-evaluation

Disease categorisation

The agents in the Agency guidance fall into three categories. These are described in the table below, compared with the categories applied by the United States Centers for Disease Control and Prevention (CDC):

European Medicines Agency categories	CDC categories
I Major infectious diseases for which treatment exists Anthrax, plague, tularemia, smallpox, viral haemorrhagic fever, botulism, brucellosis, Q fever, glanders, melioidosis. **II Other bacterial infections for which treatment exists** Psittacosis, epidemic typhus (*Rickettsia prowazekii*), tuberculosis, shigellosis, salmonellosis, cholera. **III Biological agents for which currently no specific treatment can be recommended** Enterohaemorrhagic *Escherichia coli*, cryptosporidiosis, viral encephalitis (Venezuelan equine encephalitis, Eastern equine encephalitis, Western equine encephalitis), nipah virus, additional viral haemorrhagic fevers (tick-borne encephalitis virus, yellow-fever virus, hantavirus, marburg and ebola virus), staphylococcal enterotoxin B, *Clostridium perfringens* epsilon toxin, ricin toxin.	**Category A diseases/agents** Organisms that pose a risk to national security because they can be easily disseminated or transmitted from person to person, result in high mortality rates and have the potential for major public health impact, might cause public panic and social disruption, and require special action for public-health preparedness. **Category B diseases/agents** Agents that are moderately easy to disseminate, result in moderate morbidity rates and low mortality rates, and require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance **Category C diseases/agents** Emerging pathogens that could be engineered for mass dissemination in the future because of availability, ease of production and dissemination, and with potential for high morbidity and mortality rates and major health impact.

Table 3. Disease categorisation
Source: https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/biological-chemical-threats

Decision-making, coordination and governance arrangements within the EU

Preparedness for the deliberate use of a biological agent requires collaboration of the intelligence community, law enforcement agencies, public health professionals, and the biomedical sciences (WHO, 2002). This could be called 'one health', 'whole-of-government' or even 'whole-of-society' preparedness.

As these disciplines do not routinely work together, the meaning of some terms, notably 'surveillance' and 'verification', has different interpretations. 'Surveillance', as used in public health, pertains to routine systems for monitoring diseases with a high burden, tracking outbreaks of epidemic-prone diseases, and detecting new diseases; 'verification' pertains to the procedures followed when investigating an outbreak and identifying the causative agent. However, the Biological Weapons Convention has no established verification mechanism for the alleged use of these weapons[129] (Sissonen et al, 2012). The role of scientific evidence created by engaging whole-of-society approaches is suggested in 5; and a global and national strategic biothreat reduction programme using the 'one health' approach is described in 'The case of deliberate biothreats', p.223 of this report.

129 https://www.un.org/disarmament/biological-weapons/

Since the outbreak of the COVID-19 pandemic, the European Commission has been working on all fronts to support biosafety of workers. As part of this work, in June 2020 the Commission updated the Biological Agents Directive to include SARS-CoV-2.[130] At the request of the European Commission, the European Medicines Agency published guidance on the use of medicines for the treatment and prevention of biological agents.[131] This guidance explains the various types of agents that could be used maliciously and the medicines that can be used to prevent or treat their effects. EMA published the first version in 2002 and has updated the guidance regularly since then.[132]

Infectious disease and bioterrorists do not respect politics or borders and can corrupt citizens' trust in public organisations (see p.146). The current COVID-19 pandemic demonstrates the ability of an infectious disease to disrupt our societies and economies, terrify citizens, overwhelm health systems and cause elevated levels of serious disease and mortality. The pandemic also revealed that the EU was largely unprepared to deal with it, and the response was reactive rather than based on well-prepared plans. The Health Emergency Preparedness and Response Authority (HERA) has been established by the European Commission in response to the pandemic to implement the lessons learned. As also mentioned on p.80, it will focus, coordinate and drive the extensive capabilities and expertise of EU members states, EU agencies, Centres of Excellence, Commission Directorates General and industry in preparing and responding to cross-border health emergencies in the future, such as pandemics and other biothreats.[133]

EU Decision 1082/2013/EU on serious cross-border health threats provides a legal basis for collaboration among EU member states, and among international and European level institutions on preparedness, prevention, and mitigation in the event of a public health emergency. Notably, the authors of one 2018 pre-COVID-19 study concluded that infectious disease outbreaks remain an ongoing threat in the EU, and that efforts are required to ensure that core public health capacities for the full range of preparedness and response activities are sustained (Kinsman et al, 2018), whereas the authors of a later study note that the European Union was not ready for COVID-19, despite the history of the spread of serious infectious diseases and the presence of special services and road maps (Vedernikov, 2021). According to the authors, the complex politics of public health at the EU level have led to the fragmentation of its governance for effective pandemic responses. Health should be of high importance in the political agenda, and robust health reforms at the local, regional, national, and EU levels are highly recommended

130 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02000L0054-20200624

131 https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/biological-chemical-threats

132 https://www.ema.europa.eu/en/documents/regulatory-procedural-guideline/european-medicines-agency/committee-proprietary-medicinal-products-guidance-document-use-medicinal-products-treatment_en.pdf

133 https://www.friendsofeurope.org/insights/hera-and-the-eus-disease-and-biothreat-preparedness/

(Gontariuk et al, 2021). According to these authors the COVID-19 pandemic has shown, that spreading of infectious diseases through points of entry is a serious problem. The authors call for European collaboration between points of entry to agree upon the importance of infectious disease management, and to jointly build a trained and prepared workforce that is ready to face the next crisis (de Rooij et al, 2021).

The Union Civil Protection Mechanism (UCPM), which is presented as the main management instrument of the EU, is mainly a post-incident handling tool and so underdeveloped for CBRN terrorist attacks (Kaunert et al, 2018); according to a workshop report on EU preparedness against CBRN weapons, the use of EU mechanisms and member states' military assets is one of the possibilities for strengthening prevention capacities that must be explored more thoroughly.[134] Moreover, a recently published report on International and EU Regulation of Countering the Hostile Misuse of CBRN materials and knowledge argues that "upholding the international norms against WMD non-proliferation enshrined in the existing international and EU regulations and arrangements in the area of WMD arms control and disarmament, relevant export and import control, and counter-terrorism is an essential requirement for preventing the hostile misuse of CBRN materials and knowledge" (CSD, 2020). More recently, the Commission has been building up strategic reserves of response capacities through the EU Civil Protection Mechanism. to improve the EU's preparedness and response to public health risks such as CBRN threats, This includes a RescEU strategic stockpile, established in close collaboration with HERA.[135]

A WHO manual provides information on diseases that have been selected because they represent potential international threats for which immediate responses are critical. Nearly all of them are subject to WHO's International Health Regulations (2005) monitoring, and are part of the Global Health Security Agenda (WHO, 2018).[136]

A Finnish perspective on strategic biothreat reduction: One Health and civil-military collaboration

The Finnish *Strategy to Secure Vital Functions to Society* is described in Finland's Security Strategy for Society (see Box 12, p.230). It is a government resolution for preparedness and guides actions taken by the government's administrative branches. The Strategy is monitored by the Security Committee, which consists of the Permanent Secretaries of different ministries and is chaired by the Permanent Secretary for Defence. The Committee oversees the coordination of national health security, including health threats posed by malicious use of biological agents.

134 https://www.europarl.europa.eu/RegData/etudes/STUD/2019/603875/EXPO_STU(2019)603875_EN.pdf

135 https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2218

136 https://ghsagenda.org/

Comprehensive Security is a Finnish model for preparedness cooperation. The vital functions of society are taken care of through cooperation between different authorities, the business community, non-governmental stakeholders and citizens. They must be secured in normal conditions as well as in crises.

A particular strength of the Finnish system is the long tradition of intersectoral cooperation — not only 'one health' but a 'whole-of-government' and even 'whole-of-society' approach. By law, each branch of government is required to provide assistance to another branch if a request is made. In addition, a number of formal and informal (but systematic) cooperation bodies provide platforms for concrete cross-sector cooperation within society.

The Ministry for Foreign Affairs has responsibilities related to non-proliferation, the Bioweapons Convention, and a number of other international initiatives and treaties relevant to this field. The Ministry of Defence is in charge of the national defence policy and national security as well as international cooperation in defence policy matters. It is responsible for coordinating the comprehensive defence approach and oversees the Finnish Defence Forces. It also oversees export, transfer, transit and brokerage of defence materiel. In the Defence Forces, special health services are outsourced by strategic partnerships to the public health system. Field medicine, primary healthcare and some highly specialized functions, including biological and chemical defence are provided by medical specialists within the Defence Forces. The Centre for Biothreat Preparedness is a Joint Programme of the National Institute for Health and Welfare, the Food Safety Authority and the Defence Forces.

The challenges posed to peace, security and development are increasingly interconnected. Several efforts at the interface of public health and security also support the development of global biorisk management processes, biosecurity and non-proliferation. Furthermore, possible intentional misuse of biological and other CBRN agents need to be considered in civil-military cooperation.

Box 12. The Finnish Security Strategy for Society

The Security Strategy for Society lays out the general principles governing preparedness in Finnish society. The preparedness is based on the principle of comprehensive security in which the vital functions of society are jointly safeguarded by the authorities, business operators, organisations and citizens.

The Strategy is a government resolution that harmonises the set of national principles regarding preparedness and guides the preparedness actions taken by the administrative branches. Since comprehensive security is built in cooperation it involves the authorities, businesses, NGOs and communities, and citizens. Each administrative branch is responsible for implementing the Strategy within its competence. The Security Committee monitors the Strategy's implementation and coordinates cooperation measures together with the ministries' Heads of Preparedness.

Vital functions are essential for the functioning of society and they must be maintained in all situations (Figure 33, p.231).

The crisis management model of Finland follows the principle of competent authority (see Figure 34). At state leadership level, the competent ministry is in charge of the activities and, if necessary, coordinates the cooperation between ministries. The Prime Minister is in charge of the government activities, represents Finland in the European Council, and is responsible for the coordination of the preparation and consideration of matters within the Government's purview. The Prime Minister also chairs meetings of the government plenary sessions and cabinet committees and is in charge of cabinet negotiations. Many crises have foreign policy implications, and in these cases, Finland's foreign policy is jointly managed by the President of the Republic and the Government.

Figure 33. The functions vital for society
Source: turvallisuuskomitea.fi

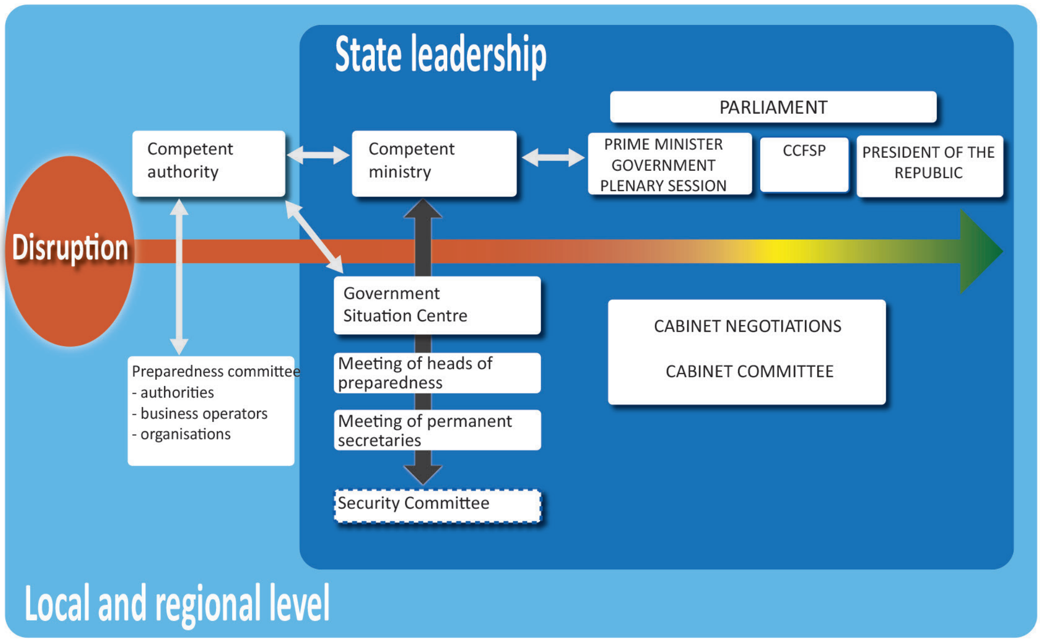

Figure 34. Crisis management model in Finland
Source: turvallisuuskomitea.fi

Future scenarios and key messages

The unprecedented pace of global scientific development, the dual-use nature of biological materials and technologies, combined with the stated aim of terrorist groups and/or states, contribute to the significant international security threats posed by biological proliferation and terrorism. Although less publicised and under-addressed compared to other WMD concerns, biological weapons and materials pose a significant and growing threat to global security.[137]

Raising European awareness on dual use and biothreat issues may add resilience against hybrid threats based on misinformation to sow distrust towards authorities during times of crises. Furthermore, the increasing likelihood of emerging novel disease X outbreaks from wild animal sources, such as COVID-19, shows the critical importance of early detection of unusual illness or circulation of pathogens — prior to human disease manifestation (Aarestrup et al, 2021; Young et al, 2021). Monitoring of naturally occurring diseases and scientific confidence building measures will facilitate detection of possible deliberately disseminated biological agents.

Although the EU has taken substantial steps to strengthen the overall EU crisis management and coordination capacity against cross-border infectious disease threats, and it participates in all relevant global mechanisms for malicious biothreat reduction,

137 https://www.gpwmd.com/bswg

more 'one health' approaches within and between member states is needed (Aarestrup et al, 2021.; Vybornova & Gala, 2019). Capacity building and stronger resilience of health systems, accepting a degree of redundancy, will support readiness against biothreats. EU-wide stockpiles of materiel for protection and medical treatments against animal (Dungu, 2020) and human biothreat agents and other infectious diseases, such as RescEU, should be coordinated and developed together with capacities built to manage other health security and CBRN threats.

Decision-making and coordination between different actors such as RescEU, HERA (Destoumieux-Garzón et al, 2022) and ECDC (Albiger et al, 2018) should be clarified, and their performance and coordination during a crisis should be improved through simulation exercises and training (de Rooij et al, 2020). Furthermore, raising awareness and increasing legislative oversight on dual-use research in the scientific community and industry as well as for political leadership and funding institutions is advised, ensuring that financing is available to fill gaps in epidemic and pandemic preparedness.

Box 13. Global mechanisms against deliberate biothreats

The Biological Weapons Convention prohibits the development, production, acquisition, transfer, stockpiling and use of biological and toxin weapons. It was the first multilateral disarmament treaty banning an entire category of weapons of mass destruction. The Convention is a key element in the international community's efforts to address the proliferation of weapons of mass destruction, and it has established a strong norm against biological weapons. The Convention has reached almost universal membership, with 183 States Parties and four Signatory States.[138]

In **UN Security Council Resolution 1540 (2004)**, the Security Council decided that all states shall refrain from providing any form of support to non-state actors that attempt to develop, acquire, manufacture, possess, transport, transfer or use nuclear, chemical or biological weapons and their means of delivery, in particular for terrorist purposes. The resolution requires all states to adopt and enforce appropriate laws to this effect, as well as other effective measures to prevent the proliferation of these weapons and their means of delivery to non-state actors, in particular for terrorist purposes.[139]

The Global Partnership Against the Spread of Weapons and Materials of Mass Destruction works to mitigate the threat of terrorist use of weapons of mass destruction, one of the gravest threats to international peace and security. The Partnership is a G7-led, 31-member international initiative aimed at preventing the proliferation of CBRN weapons and related materials.[140],[141]

138 https://www.un.org/disarmament/biological-weapons/

139 https://www.un.org/disarmament/wmd/sc1540/

140 https://www.gpwmd.com/

141 https://extranet.who.int/sph/news/global-partnership-against-spread-weapons-and-materials-mass-destruction

The IHR Monitoring and Evaluation framework helps to provide a comprehensive overview of the current status of IHR country capacities, as well as providing a basis for evidence-based policymaking.[142] It consists of four complementary components:

- mandatory annual reporting
- voluntary external evaluations
- simulation exercises
- after-action reviews

The Global Health Security Agenda is a group of more than 70 countries, international organisations, non-governmental organisations and private sector companies that have come together to achieve the vision of a world safe and secure from global health threats posed by infectious diseases. It leverages and complements the strengths and resources of multisectoral and multilateral partners to address priorities and gaps in efforts to build and improve country capacity and leadership in the prevention and early detection of, and effective response to, infectious disease threats.[143]

8.5. The case of displaced populations

As Europe is receiving millions of refugees from Ukraine, this section reviews past refugee crises to identify important lessons. While in the recent past, Europe has dealt with an estimated 1.2 million refugees largely from Syria in 2015, the cascading effects from the ongoing war in Ukraine have led to projections of up to 7 million refugees seeking protection in Europe. As of 22 April 2022, the International Migration Observatory estimates that there are 7.7 million internally displaced people in Ukraine, 17% of the country's population,[144] and UNHCR reports that more than 5 million refugees have fled the country.[145]

In response to the influx of refugees, the EU activated a temporary protection directive on 4 March 2022, to provide "in the event of a mass influx or imminent mass influx" immediate and temporary protection to persons fleeing their country who are unable to return home.[146] While this instrument provides a strong basis on which to ensure the protection of refugees and their rapid access to the labour market, education, and social protection services, there are other vital elements that need to be considered in order to host the projected 4–7 million refugees. Importantly, the reception, wellbeing and integration of

142 https://www.euro.who.int/en/health-topics/health-emergencies/international-health-regulations/monitoring-and-evaluation

143 https://ghsagenda.org/

144 https://reliefweb.int/report/ukraine/one-six-people-internally-displaced-ukraine

145 https://data2.unhcr.org/en/situations/ukraine

146 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2022.071.01.0001.01.ENG&toc=OJ%3AL%3A2022%3A071%3ATOC)

refugees takes place against the backdrop of dynamic multisectorial and cultural issues and services (Olorubunta & Banomyong, 2018).

As stressed by the temporary protection directive, solidarity among member states is key. The principle of burden-sharing was one of the key lessons from the Kosovo refugee crisis (Barutciski & Suhrke, 2001). Although human rights activists criticised the distribution mechanisms as a violation of the principle of unconditional asylum, the principle is now viewed as an instrument to avoid the massive concentration of refugees in a potentially overwhelmed state or location.

Burden-sharing includes hosting refugees as well as sharing the economic and social strains. While volunteerism provides surge capacity, for the longer run structural solutions are needed to avoid a state of constant 'temporariness', by which such a brittle situation is continuously extended (Ward 2014). In addition, important budgetary and financial coordination challenges need to be solved. The Syrian refugee crises not only cost several hundreds of millions of euros (both in terms of direct assistance, paid to Turkey, and paid to humanitarian funds), but it also led to struggles both vertically (between countries hosting refugees and those that were providing major financial assistance), as well as horizontally as budgets were shifted between European Commission Directorates General (den Hertog, 2016). Finally, experience from refugee crises in other parts of the world shows that burdens include not only housing and infrastructural capacity, but also education and integration as well as the economic support of the host population (Polzer, 2008). The combination of government capacity, legitimacy and trust are especially crucial for refugees to comply with government policies (Demiroz & Unlu, 2018).

Planning, decision-making & logistics

Lessons from the Kosovo refugee crisis in 1999 and other crises such as the exodus of Rohingyas to Bangladesh point to several phases that are to be considered (Kondaj, 2002):

- reception and arrival of refugees at the borders
- accommodation and distribution to refugee camps, collective centers or host families (possibly in various waves)
- repatriation
- rehabilitation

Since the possibility of rehabilitation to Ukraine is for now only a distant possibility, the focus is here on the first two phases.

Initial reception and arrival

Hosting a massive influx of refugees puts a strain on virtually all supply and logistics systems. The refugees will need shelter, protection, medical services, food, water etc. Reports from Ukraine are highlighting that there are already shortages of crucial supplies such as heaters, medication, milk powder and sanitation products.

Realising the need for improved contingency planning confronted with major refugee crises, the United Nations High Commission for Refugees developed a Preparedness Package for Refugee Emergencies.[147] The package includes concrete checklists and tasks in the areas of:

- risk analysis
- management and crisis response
- protection (e.g. contact lists of key organisations, registration system, data sharing protocols, common operational data sets; availability of information on legal procedures; child protection services; feedback mechanisms)
- tracking and monitoring systems for vital areas such as food security; water, sanitation and hygiene
- shelter
- health

It also includes protocols for logistics preparedness (ranging from customs agreements to market surveys about the available products and goods). Essentially, the approach advocated evolves around preparing for various scenarios of different severities, yet without formally assessing the likelihood of those scenarios occurring (Kelley, 2017). As such, it is advised to follow the precautionary principle and robust approaches to prepare for all eventualities to ensure that resources, plans, processes and protocols are put in place to ensure that refugees can be received even if the situation quickly deteriorates.

Accommodation and distribution

While the UN system has been developed for global refugee crises in countries that are often fragile or have limited infrastructure capacities, the EU is much better positioned to receive refugees. Data from different complex emergencies and refugee crises across the world show that the mortality rate in the Kosovo crises was relatively lower compared to other conflicts and complex emergencies, reflecting the better baseline situation. Importantly, besides the war trauma, an increase in casualties related to chronic disease such as diabetes was reported, highlighting the need for functioning public healthcare in refugee crises (Salama et al, 2004).

147 https://emergency.unhcr.org/entry/34912/preparedness-package-for-refugee-emergencies-ppre

A difference between the EU and other countries that are confronted with refugee crises is the tremendous surge of volunteering capacity, both in the response to the 2015 refugee crisis and the ongoing influx of refugees from Ukraine. This points to the mobilisation potential and engagement of civil society. Although much research is focused on the logistics of refugee camp management (Karsu et al, 2019; Smadi et al, 2018), the decentralised and distributed management of dispersed refugees who settle within different regions or cities is logistically much more demanding (Ward, 2014). Yet distribution is a prerequisite for integration and freedom of movement, at least within a single member state. In this phase, typically the initial ad-hoc aid systems (e.g. for food, water and health care) are replaced by more structural approaches which include cash transfers and integration in the existing social and educational systems (Kelley, 2017). Yet even for a camp environment it is important to provide safe and suitable shelters for both short-term and long-term accommodation: the precarity of refugee camp environments was exposed by the fire that destroyed the Moria camp on Lesbos in 2020 (Pascucci, 2021).

From a logistics perspective, some lessons can be drawn from the war in Crimea and the resulting refugee crisis in 2014, although it was on a smaller scale than today. Findings highlight that cash transfers are more effective and efficient than organising aid convoys, as long as markets are functioning and the required goods can be bought locally (Piotrowicz, 2018). When convoys were organised, the standardised goods bought from wholesalers were superior to unsolicited donations, confirming earlier findings on the problem of material convergence from the disaster logistics field (Holguín-Veras et al, 2014). Even though cash transfers (and specifically multi-purpose cash transfers) are described as favourable, Bailey & Aggiss (2016) report several implementation problems in Ukraine, mostly related to a lack of standards, unclear roles and responsibilities, and a lack of accountability. Little evidence was found of the misuse of cash or security issues, confirming earlier findings (Evans & Popova, 2017).

Data and intelligence

To effectively manage the situation and supply refugees with what is needed, good information systems need to be in place that allow authorities to plan for the capacities and resources that are (and will be) needed in different countries and regions. This is especially true in a decentralised setting that relies on the distribution of refugees across different countries, and the efforts of many private and volunteer initiatives. Data portals such as the UNHCR's refugee dashboard[148] provide a generic overview of the situation.

148 https://data2.unhcr.org/en/situations/ukraine

Further, there are efforts to collect more granular information, such as based the dashboard on changes of population density in host countries based on Facebook data.[149] While such mobile phone-based data, collected by private companies, can provide interesting insights in near real time, there are serious concerns about data ownership, privacy and data protection. Several scholars call for more attention to the implications of using social media data, especially for the most vulnerable refugee populations such as minors. What are the implications of using social media to seek help, or sharing images of damaged property or physical injuries, and what are the implications if these privately-owned channels become a part of public crisis response (Crawford & Finn, 2015)? Other concerns regard the so-called 'mosaic effect', by which the addition of a data point is the 'missing piece of the puzzle' that makes it possible to identify and target individuals or specific sociodemographic groups (Raymond, 2017). Insights on data preparedness can be found in Box 9, p.205, learning from the humanitarian context.

Here, the EU — which has been spearheading data protection and privacy initiatives — could have a potential role in defining, implementing and setting standards and codes of conduct that respect privacy and protect those who are most vulnerable, while ensuring that information is provided in a safe and secure way to those who need it to organise the crisis response.

8.6. Conclusions

The four case studies presented in this chapter demonstrate the breadth of complex, dynamic and transboundary crises with which the EU is confronted. Each crisis comes with its own sectoral specificities, which correspond to its own set of EU mechanisms. Yet importantly, many of these crises overlap. As the Ukrainian war continues, the EU is confronted with cyber-attacks, and the risk of biothreats and CBRN attacks is of increasing concern. Meanwhile, in mid-June 2022, the EU was hosting almost 5 million Ukrainian refugees while wildfires linked to the extraordinary heatwave in Spain and Southern Europe forced thousands of people to evacuate. Therefore, the EU needs to have mechanisms in place to coordinate and manage these and other ongoing risks and crises at the same time, highlighting the need for efficient crisis management, but also the need to coordinate across sectors and response mechanisms, especially as capacities such as RescEU serve multiple crises. Further, this interplay of different risks and crises related to conflict, war and climate change also highlight the need to integrate and coordinate risk and crisis management, as we argued in 2. While the cyber-threats and biothreats remain risks for now, they might turn into a crisis soon, requiring us to

149 https://www.crisisready.io/2022/interactive-dashboard-population-density-changes-of-border-countries-to-ukraine/

prepare response strategies while taking into account the resources and capacities already committed to other crises.

As such, each case illustrates the proportions that each sectoral crisis can take, which inevitably calls for a broader and more integrated approach to risk and crisis management. They all call for:

- **Increasing coordination and alignment with other levels of governance.** This is especially relevant for transboundary crises. This is in line with the findings of 1, which calls for coordination of activities and organisations across all phases of the risk and crisis management cycle. In addition, 3 identifies the transboundary crises as one of the current gaps in the EU's portfolio, and stresses that increasing capacity here might be expected.
- **Increasing capacity in prevention and preparedness.** 3 describes the various mechanisms that the EU has in place and highlights the recent turn to resilience as the dominant concept for preparedness. In 1 we discussed that this necessarily entails improved flexibility and response diversity across all sectors, which is also evidenced by all four cases. Because of the time pressure that are inherent to crises, preparedness entails dedicated science structures (5), as well as intelligence and data (7). On the prevention side, 4 argues for improved prevention and outlines possible ways to achieve this.
- **Improving information and data.** It is uncontested that information is crucial to strategic crisis management. Across all cases, it is evident that both data and intelligence (7) as well as safe, secure and reliable information systems need to be in place as the backbone for any crisis management activity. While for the first, the specific data and information that is needed varies per case, there are several aspects of a crisis, about which information is always needed (such as type and nature of the threat, the population affected, and the most urgent needs). Therefore, data preparedness — which entails both the preparation of the data as well as questions of ownership, distribution and information management — can be an important aspect. Further, because for many of the case studies there is a real risk of cyber-warfare and increasing distrust or mistrust, focusing on participatory approaches that strengthen trust and equality (6) accompanied by dedicated and early risk communication (4) are crucial.

9. Conclusions and evidence-based policy options

9.1. Conclusions

The European Union is confronted with an increasing number of crises with growing complexity, causing tremendous human suffering. Crises amplify existing inequalities and can have devastating consequences for both the economy and the environment. Between 1980 and 2020, natural disasters alone affected nearly 50 million people in the European Union and caused an economic loss of €12 billion per year,[150] on average. Forecasts predict that we will be faced with an increasing frequency and magnitude of crises. The crises the EU is faced with range from the war in Ukraine to the COVID-19 pandemic. The EU is dealing with the consequences of crises, such as the hosting of millions of refugees, as well as preparing for potential food insecurity and possible energy shortages. At the same time, the newest IPCC reports continue to stress the stark implications of climate change. A common element to all these crises is that they are transboundary in nature.

Even though the EU was never intended to be a crisis manager, it is slowly growing into this role. In response to emerging risks and crises over the past decades, the EU has developed a range of instruments and mechanisms, which we have reviewed in this report. These instruments and mechanisms are continuously adapted to new situations, as shown by the example of RescEU in the COVID-19 response. However, most are designed for crises in which one member state asks for support from others via the EU's Civil Protection Mechanism, or for external crises, by which assistance to European citizens or humanitarian aid are provided via the External Action Service or the Humanitarian Aid Operations wing of the Directorate General for European Civil Protection and Humanitarian Aid Operations.

In this report, we focus on the cross-cutting and generic aspects that are typical of different types of crises. The crisis taxonomy that we put forward in 1 describes the drivers of crisis management. While conventionally there is a focus on sudden onset shocks, we are likely to see more protracted or longer-term crises. In combination with the prevalence of compound risks and polycrises, this longer duration and unclear resolution of crises blur the lines between risk and crisis management. It requires an integrated vision and coordination of the different activities and organisations across all phases of

150 https://www.worldbank.org/en/news/feature/2021/06/04/economics-for-disaster-prevention-and-preparedness-in-europe

the management cycle, under different timescales and levels of situational awareness and uncertainty.

Even though risk and crisis management often focus on specific member states or sectors, we are increasingly seeing that crises cannot be contained within a specific region or sector. We are confronted with transboundary crises with important cross-sectoral cascading effects. From our review of the evidence, we conclude that there are important gaps in the risk and crisis management capacity of the EU, especially in these two areas. Policy options that synthesise this evidence, especially in the areas of risk and crisis management, are provided in section 9.2, p.242.

To manage transboundary risks and crises, it is increasingly important to consider the potential cascading nature of crises across infrastructures, with consequential impacts on society, environment, and economy. Responses on multiple geographical and temporal scales need to be aligned, rather than aiming at the one 'right' level. Here, a potential role of the EU is to facilitate coordination, and act as a broker to align the member states. Furthermore, we see a role for the EU in training and setting standards that guide risk management, decision-making and information-sharing.

It is difficult to provide a complete list of disaster scenarios that we can prepare for. Conventional approaches to risk management focus on risk matrices, with direct, tangible and immediate damages, stable prices, ceteris-paribus assumptions (e.g. cost-benefit analysis) and static information compiled in dashboards. These approaches are inadequate to manage the crises to which Europe is confronted. They do not capture the many indirect and long-term implications of crises and risks, the many feedback loops between different systems and scales, the dynamics of constantly-changing situations, the corresponding volatility of decision preferences, and thereby also costs (both direct and indirect). Rather, in response to the wickedness of a crisis situation, a flexible and cross-sectoral response to a large variety of scenarios is key, ideally combined with both the local ability to sustain the critical functioning of society and the economy, and the possibility to operate autonomously for extended periods of time. (An example of a cross-sectoral approach at member state level, in Finland, is presented on p.229.)

In this Evidence Review Report, 5 focuses on the role of science in situations of crisis. While writing this report, many of the Working Group members were grappling with the ongoing COVID-19 pandemic in their universities and institutions, while also fulfilling a role as advisors in improving crisis and risk management, both nationally and across Europe. At the same time, the focus of the Report changed over the course of time. In 2021, when the review started, the discussion was dominated by the COVID-19 response and recovery, and the dire prospects of climate change discussed at COP26 in Glasgow. In early 2022, the Russian invasion and war in Ukraine stressed the urgency of questions related to European safety and security. These sudden and drastic shifts of attention are typical for crisis response and crisis management research. Yet they put scientists under pressure to deliver results quickly and communicate clearly. Often, there is little space for considering uncertainties, scenarios, and nuances — even though it is common knowledge that the uncertainties can be overwhelming, especially in the first phase of a crisis. In 5, we reflect on these challenges and review the evidence, regarding principles for successful science policy advice as well as the specifics of crisis situations.

Crises are also known to hit the most vulnerable the hardest. They can even amplify existing inequalities. The protests and demonstrations against COVID-19 restrictions in Europe highlighted how vulnerable our societies and democracies are. We reviewed the evidence, both in terms of how crises impact on existing inequalities and how inequalities influence crisis response, stressing that increasing inequality can lead to an erosion of trust. From the review of evidence, we conclude that for EU crisis management to work, it needs to work for everyone.

New forms of communication and information technology offer new avenues to engage citizens and empower them to participate in crisis preparedness and management. While threats such as misinformation may spread in closed echo chambers, we also stress the many opportunities that involving civil society can bring — producing a better informed, tailored, and localised response. As the hosting of refugees from the Ukraine shows, many of these efforts are ad-hoc, and not well-connected to the formal response system. We see here opportunities for further improvements, by building participatory resilience.

We further emphasise the role of the EU and its role to coordinate and support on the level of data preparedness, data sharing and intelligence in 7, where we review a range of methods and tools that are now available to support crisis preparedness and response. We conclude that those techniques and tools are most useful when tailored to the complexity of the situation at hand, and can support flexible and adaptive risk and crisis management. At the same time, as collaboration and coordination between different crisis management authorities must be improved in the light of increasingly complex crises, we also stress the need to develop data preparedness protocols, harmonised data standards and clear information management guidelines.

9.2. Evidence-based policy options

We complete our report by putting forward a range of options that may serve policymakers in choosing paths to strengthening the EU's strategic crisis management. These policy options build on the main conclusions offered in each chapter.

Governance and institutions

The EU was never designed as a crisis manager. The responsibility for managing risks, crises and disasters lies with the EU's member states, and the principle of subsidiarity must be respected. At the same time, as described in 3 and 7, the EU has built a variety of tools and capacities over the years that can be used to collect, analyse and share critical information, warn member states about impending threats, and organise a joint crisis response. Given the success of the EU in this area, the rise of systemic, interconnected and transboundary crises makes it reasonable for the EU to continue investing in its competencies to manage (transboundary) risks and crises, as well as information-based tools and capacities. This leads us to the following options.

Option 1A: Establish a European risk and crisis governance board

The board could serve as an institutional setting that helps monitor and analyse cross-sectoral risks and crises; develop common approaches for transboundary impacts; offer training and resilience capacity building and oversee the science-policy interface for strategic crisis management. A board is particularly needed for overall preparation and coordination, as a means to prevent, mitigate and reduce potential breakdown risks and transboundary crises (see the proposed taxonomy of risks in 4). It should be both representative and inclusive.

Even though we see an increasing number of specialised bodies in specific sectors — such as HERA for health crises — there is ample evidence presented in this report that to confront complex crises, there is a need to coordinate across sectors and society. Furthermore, evidence was presented that suggests the need to link risk and crisis management as a means to confront protracted and polycrises.

A European risk and crisis governance board could combine domain knowledge from different fields, such as health, cyber, or food systems, with dedicated risk and crisis management expertise related to governance and coordination, information management and logistics. The board could also be mandated to monitor potential breakdown risks, create an early warning vigilance system that collects and centralises monitoring and data streams; develop common approaches for dealing with transboundary consequences; offer training to national and regional disaster and emergency management institutions and to relevant decision-makers and policymakers that often lack training (see p.245). The board could be mandated to develop emergency and contingency plans for crisis preparedness, responsible for developing an early warning system, and a sounding board for advice in crisis situations. During the unfolding of a crisis, the board would not be a centralised 'command unit' but rather provide guidance to more flexible, decentralised units for a response that is closer to the locations in which crisis management is needed.

To complement this European risk and crisis governance board and ensure embedding within the different European institutions, the option is complemented by:

Option 1B. Establish cross-disciplinary and inclusive risk management taskforces, situated within existing European institutions

These taskforces could be required to assess, monitor, and regulate the physical, financial, and political (governance) links between different risk domains. They could serve as liaison between the European risk and crisis governance board and the institutions that design and implement policies or monitor the outcomes of governance measures. 4 presented evidence suggesting that institutional fragmentation and disciplinary thinking pose constraints to this type of risk management structure. To address this, the taskforces could meet regularly at a European level to exchange observations, strategies and regulatory experiences, or could be overseen by the European risk and crisis governance board (see above).

Option 2. Establish an EU-wide information and communication taskforce, responding as soon as a potential crisis arises

The pace of the COVID-19 crisis and the war in Ukraine have once more highlighted the dynamics of crises. Throughout the report, we have presented evidence about the importance of transparent and trustworthy risk communication (4) and the need to engage with the public to build trust (6). This is especially true for a supranational body such as the EU, which is easily seen as 'too remote', and may become a scapegoat. In 7, we also present evidence on the perils of misinformation and disinformation, the need to continuously pre-bunk and debunk information and to invest in data literacy.

While there is ample evidence indicating the need for good, transparent crisis and risk communication, policymakers and public bodies are often absorbed with the management of the crisis itself, without the time for careful engagement with the public. There is, for instance, evidence that the communications aspect of the response to COVID-19 has been slow or flawed in several countries, while in other countries, it has overwhelmed and traumatised the public. This leads us to the following option:

To address the needs of different audiences in different countries and regions, centralised crisis communications could be complemented by decentralised hotlines, social media and localised services, with staff trained to recognise the different needs of target groups and communicate accordingly. Social media monitoring, active communication, continuous debunking and pre-bunking should be within the toolbox of the taskforce.

Option 3. Reform the science advisory system for crisis and risk management in the EU

During the COVID-19 crisis, the transmission of information and advice, from the scientific assessment to policymakers' decisions about risk evaluation, management and communication has worked relatively well. However, when policymakers have ignored scientific advice, or delayed acting upon it, the human costs have been high. The EU should therefore review the effectiveness of its current model of science-policy integration in light of COVID-19 experiences, and acknowledging the fast pace and pressure under which scientific evidence has to be provided during crises. The evidence reviewed in 5 indicated three major shortcomings:

- There is a lack of European interdisciplinary and transdisciplinary research that studies the interlaced issues of modern crises and provides interdisciplinary and transdisciplinary advice for policymaking.
- There is currently a lack of funding for rapid disaster research in the immediate aftermath of crises and disasters, leading to important data gaps that hamper policy advice.
- There is a lack of cross-sectoral infrastructures and standards by which to formulate robust policy advice across different sectors or disciplines.

The proposed advisory system could provide the infrastructure for data management, open science and data sharing, and also establish mechanisms for rapid research that allows for data collection in the immediate aftermath of crises (following the example of the National Science Foundation in the US, section 5.3, p.114). Care should be taken to ensure that the advisory bodies have a truly interdisciplinary and transdisciplinary nature, representing a mix of relevant disciplines instead of focusing on a single domain (e.g. health experts for pandemics). Given the need for continuous exchange and dialogue between science and policy by which to formulate advice, and the challenges to rapid transdisciplinary collaboration, such advisory systems need to be established before a crisis occurs and should monitor the ever-changing (risk) landscape. Since crisis response is highly contextual, the role of this body would also be to establish and liaise with a network of national and regional risk and crisis advisory systems. Such a reform could be initiated top-down by the EU and national governments, or bottom-up by regional initiatives for building crisis response networks. The process would certainly speed up if bottom-up and top-down approaches were launched simultaneously.

Resilience, preparedness and capacity-building

The need for resilience is uncontested. Resilience is deeply embedded in European policy and strategy, such as in the European Critical Infrastructure Directive. This report has provided further evidence for the need to invest in resilience across critical infrastructures and societal functions, notably via enhancing response diversity and strategic autonomy (see, for example, section 2.5, p.52).

Over recent decades, great gains in organisational efficiency and economic return have resulted in a lack of resilience in critical systems, such as healthcare and supply chains. Investing in resilience needs to focus on five elements: redundancy and buffer capacity, response diversity, flexibility, adaptive management, multi-scalarity and self-organisation (see section 2.5, p.52). Strategic autonomy on key products needs to be strengthened, along with a diversity of response options (e.g. suppliers, markets) and full visibility along critical supply chains. The world has witnessed the spread and effects of COVID-19, exacerbated by supply shortages (for example, for protective clothing and facemasks, 80% of which is manufactured in China), while the Ukraine war is giving concern about energy, food and other shortages. Similarly, relying on only one line of product or service can lead to collapse if no alternatives are readily available. This leads us to the following option:

Option 4: Develop cross-sectoral protocols for dealing with transboundary and systemic risks

In conventional sectoral risk management approaches — for instance, in flood risk management — there is a focus on events that are of a sufficiently high likelihood of occurrence. This is also represented in the risk indices that were reviewed in 7, such as the JRC's Risk Data Hub.[151] However, this approach discards events that have a high impact but very low likelihood. This report highlights the fact that events such as Hurricane Sandy (2012), Hurricane Harvey (2017), and the 2021 floods in the Netherlands, Germany and Belgium can and should be prepared for.

Throughout the report, evidence has been provided that stresses the importance of cascading effects and feedbacks. Aspects such as the duration and distribution of impacts, their indirect and long-term effects, welfare and wellbeing are conventionally not considered but are of critical importance, as section 6.1, p.129, also demonstrates. We argue for the development of new risk assessment protocols and standards that meet the following objectives:

- Integrate distributive impacts (across communities, geographical regions/countries, and over time).
- Integrate beyond-design events (i.e. those that were considered unlikely and therefore not part of the design process) and extreme scenarios.
- Model and simulate the cascading impacts of such events, including the many feedback loops and human behaviour.

151 https://drmkc.jrc.ec.europa.eu/risk-data-hub/

- Consider the (long-term) impact on welfare and wellbeing, instead of focusing on physical indicators only (e.g. such as flood depths, spread of infectious diseases, or direct damage to the built environment).

Learning and training are vital for crisis preparedness. In this report, we have provided evidence about a range of training options. At the European level, large-scale exercises such as ModEx[152] or Triplex[153] are organised to strengthen the Civil Protection Mechanism and practice interoperability, standard procedures and coordination. These large-scale, field-based simulation exercises are extremely valuable, yet also heavy and costly on the organisation. Furthermore, they focus exclusively on professional crisis responders or NGOs that conventionally respond on an operational or tactical level. Our evidence shows that there is much less in place to support strategic crisis management and rapid decision-making in times of crises. This leads to the following option:

Option 5A: Improve decision-support capabilities and train all decision-makers, not just professional crisis management authorities

Decisions in crises need to be made under high time pressure and, despite best efforts, on the basis of limited, uncertain or conflicting information. Decision authority in crises is often delegated to policymakers that have no prior experience of crisis management, yet need to respond rapidly. Furthermore, the evidence shows that the character of crises induce a range of cognitive biases that hamper the quality of decisions made. Here, literature suggests investing in dedicated education and training for decision-makers and embedding debiasing mechanisms in the design of information and decision-support tools (see 7).

Many crises evolve within the context of societal change and transformation. What appeared to be reasonable or attentive to public needs in the past may be out of place or disproportionate in the present. For example, if public authorities responding to an economic crisis were to boost the economy without considering the implications for climate change, they may experience public outrage or opposition. It is therefore advisable for EU crisis management agencies to consider the social and cultural contexts in which crisis management is embedded, and provide training to decision-makers that allows them to understand and reflect this embedding.

Option 5B: Develop European standards to evaluate the impact of crisis management training

There is a lack of European standards and evaluations of the impact of training at individual, organisational and inter-organisational levels. As such, it is difficult to judge the effectiveness and efficiency of the very costly large-scale simulation exercises

152 https://www.eu-modex.eu/Red/about/

153 https://www.ihp.nu/training

that are conducted, and how they compare to alternative methods such as learning programmes, virtual reality training, tabletop exercises and so on. One downside of large-scale simulations, documented in the literature, is that they also serve as dissemination events to showcase the capabilities of crisis response, at the risk of not achieving learning objectives and not providing a safe space in which to fail. The development of such a standard could benefit both the effectiveness of the European Civil Protection Mechanism and allow the respective member states to compare and improve their training, facilitating mutual learning.

Throughout the report, evidence shows the benefits of empowering and engaging with local communities, and building participatory resilience. Chapter 6 has presented evidence that trusting citizens are more likely to adjust their behaviour and comply with crisis management and, in turn, participation increases trust. The COVID-19 pandemic has led to enormous backsliding, both threatening and undermining European values, increasing polarisation and the vote share of populist parties.[154] As such, participation can be a powerful instrument, especially given the modern digital infrastructure that provides unprecedented opportunities, to reach and coordinate between many Europeans. Thus far, however, the potential for participation (and thereby increasing trust in European crisis management) is only used in an ad-hoc and not a systematic way. While conventionally, these local efforts are embedded within the context of the national response, a potential role for the EU could be in training and setting standards for participation across the EU.

Option 6. Strengthen participation via dedicated structural capacity

For decades, crisis management has focused on acquiring more or better information, leading to an increasing amount of satellite and drone imagery, social media data analysis, mobile phone tracking, and analysis of video footage from public spaces. Many of the EU's risk analysis and crisis monitoring tools have been set up in this spirit. At the same time, self-organisation, emergence and multi-scalarity of the response are becoming increasingly important means by which to foster resilience (see p.59). Participation and self-organisation are primarily organised through social media and ICT, yet few monitoring efforts are dedicated to these channels (with the exception of misinformation monitoring such as https://euvsdisinfo.eu/; see also 7).

This option therefore suggests expanding the current capacity in the following ways:

- Provide training to crisis management authorities and emergency responders on how to coordinate and manage the interaction with volunteers, especially with those who are not organised within an NGO or formal organisation, but rather come together spontaneously in response to a crisis.

154 https://espas.eu/files/Ideas_Papers_Populism_final.pdf

- Set standards on data sharing and provide guidance for (digital) volunteers to help them understand the sometimes difficult context, and make clear which information can and cannot be shared publicly (e.g. locations of unaccompanied minors in a refugee crisis must not be shared).
- Spearhead privacy efforts to respond to increasing concerns about the use of private company data (such as Facebook's movement data to track the movement of Ukrainian refugees)[155] by developing and setting standards to ensure compliance with the General Data Protection Regulation that include the right to be forgotten (especially for the most vulnerable people), and addressing the question of data ownership.
- Monitor and engage with social media to understand public sentiment, trust and risk perception, going beyond the mere 'counting' of tweets that is currently presented on the Global Disaster Alert and Coordination System. For options related to continuous factchecking, debunking and communication, see p.244.
- Establish formal or informal consultation mechanisms to foster participation in the preparedness and recovery phases of transboundary crises to promote trust, equality and empowerment (see section 6.5, p.153, for a discussion on formal and informal procedures).

Intelligence, technology and data

The COVID-19 pandemic has brought about a plethora of dashboards and information streams by which to track the state of the public health system, the spread of the epidemic, economic consequences and the spread of rumours. 7 presents the many mechanisms and tools that the EU has developed to monitor risks and establish situational awareness in response to crises. These are mostly designed for specific types of crises (e.g. GDACS) or mechanisms for remote sensing and direct damage assessment (e.g. Copernicus, covered on p.192, or in the case-study on wildfires in section 8.2, p.209). The remote sensing tools focus by design on the physical environment and provide, quite literally, snapshots (images) of the situation. However, this report has provided evidence that argues for the need to continuously track the dynamic evolution of a situation and integrate the potential cascading effects across different sectors or geographic regions. These include critical aspects that cannot be monitored by focusing on the physical environment alone, such as health, access to food and clean water, economic, and financial aspects, cyber security, mental health, as well as inequality, polarisation or fragmentation.

155 See e.g. https://www.crisisready.io/2022/interactive-dashboard-population-density-changes-of-border-countries-to-ukraine/)

Option 7. Develop an EU wide dynamic risk radar methodology and monitoring protocol

A methodology and protocol for a risk radar should be designed to assist the European Commission as well as each member country to address early indicators of crisis and improve overall preparedness for transboundary systemic risks. Since there is no such methodology in place as yet, further research is needed in terms of designing and implementing such a risk radar.

Option 8. Connect strategic foresight and improved intelligence to concrete scenario and contingency planning for decision support

7 outlines the ranges of methods and instruments that research has developed to support decision-making in crises. Broadly speaking, one can distinguish tools for monitoring and crisis prevention or preparedness, from tools that are used during a crisis. For the first category, strategic foresight in Europe has been developed within the European Strategy and Analysis System. However, while the current annual reports[156] are hard to disagree with, they are generic and not tailored to the dynamics and pace of crises that the EU is confronted with.

Strategic foresight exercises are immensely useful in identifying trends and potential crises. However, in a world of scarce resources it is essential to connect such activities with concrete decision support for improved preparedness and better resource allocation processes. The latter includes planning concrete contingencies and scenarios and ensuring that the capacities and resources are in place to respond. This entails, for instance:

- emergency stocks of critical supplies (e.g. health; fresh water & sanitation; food; oil and gas)
- emergency communications and cyber resilience, along with a dedicated monitoring and information management system
- logistics planning (pre-positioning essential goods; location of warehouses or welcome centres; potential locations and distribution of displaced people or refugees; evacuation routes)
- security and safety assessment and planning for how to protect the civilian population or responders against potential violence
- preparing healthcare system to manage a potential surge of patients; preparing field hospitals and resources
- vulnerability analysis for essential goods: how can potentially blocked routes or unavailable suppliers be replaced?

156 https://ec.europa.eu/info/sites/default/files/strategic_foresight_report_2021_en.pdf

- economic preparedness: cost assessment and preparing the availability of (initial) surge funding

Importantly, prevailing methodologies like narrative scenario analyses and risk matrices have a role as initial screening approaches, as relatively simple tools that can be implemented. However, they do not provide the quantitative information that is needed to develop these contingency plans and preparedness steps. Therefore, much is to be gained when developing quantitative optimisation and/or simulation models that allow for better and robust forecasting and planning across a range of scenarios.

To plan and coordinate these and other crisis response activities across member states, especially in transboundary crisis, good data sharing and data preparedness are essential. This leads to the final option:

Option 9: Develop harmonised standards for data preparedness and data sharing

The notion of data preparedness, as introduced in 7, entails four phases:

- An analysis of risk and data requirements in (potential) crises. This includes baseline data (critical infrastructure; population etc.); initial impact data and direct damage assessment; and dynamically-evolving data about the events unfolding during the crisis.
- A review of data sources that can be activated or used to acquire the data needed; the requirements for data storage; sharing and access (e.g. security level; public?); as well as standards for analysis and use.
- Data sharing and storage protocols to ensure that data is shared, stored, accessed and used by authorised individuals or authorities via a secure broker or platform that respects privacy regulations and responsible use principles.
- Ensuring the interoperability and interpretability of the data across emergency services and countries.

There is a clear and uncontested need for harmonised data standards to facilitate policy evaluation and crisis management. This option foresees the expansion of an EU data strategy to include data preparedness to meet the special quality requirements of data-driven, transboundary crisis management. Importantly, investing in data preparedness will require engagement with national and local authorities and crisis managers to facilitate trust, sharing and to adjust standards, as needed. Ideally, the data preparedness process is linked with training and education around coordination and information management (see Option 5A, p.247).

The data spaces by which to share crisis data between the relevant stakeholders must be protected against misuse and provide several levels of security and access. These cross-border EU crisis management platforms should be promoted with very high priority, as they would enable horizon scanning of weak signals and real-time monitoring of crisis development, at European level. Uniform standards for shared data, analysis and (AI) algorithms used in crisis management systems must be specified and qualified for their effective use to manage strategically crises at European level, and monitoring systems need to be in place that ensure the responsible and ethical use of the data.

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Annex 1. List of working group members

- **Tina Comes**, Maastricht University, Netherlands (Chair)
- **David Alexander**, University College London, UK
- **Arjen Boin**, Leiden University, the Netherlands
- **Claudia Eckert**, Technical University of Munich, Germany
- **Thomas Elmqvist**, Stockholm Resilience Center, Sweden
- **Mattia Fochesato**, Bocconi University, Italy
- **Dirk Helbing**, ETH Zürich, Switzerland
- **Dominika Latusek-Jurczak**, Kozminski University, Poland
- **Kristian Lauta**, University of Copenhagen, Denmark
- **Eija Meriläinen**, Örebro University, Sweden; University College London, UK
- **Simo Nikkari**, Finnish Centre for Military Medicine, Finland
- **Panos Papadimitratos**, KTH, Stockholm, Sweden
- **Ortwin Renn**, Institute for Advanced Sustainability Studies, Germany
- **David Ríos Insua**, Institute of Mathematical Sciences, CSIC, Spain
- **Caroline Rizza**, Institut Polytechnique de Paris, France
- **Enrico Zio**, Mines Paris-PSL, France; Politecnico di Milano, Italy

Academies

The above experts were identified with the support of:

- acatech, the National Academy of Science and Engineering in Germany
- The Council of Finnish Academies
- The Danish Academy of Technical Sciences
- The Polish Young Academy
- The Royal Danish Academy of Sciences and Letters
- The Royal Netherlands Academy of Arts and Sciences
- The Royal Swedish Academy of Sciences
- The Spanish Royal Academy of Sciences
- The Young Academy of Europe

Annex 2. Background and process

In May 2020, the independent Group of Chief Scientific Advisors to the European Commission accepted the mandate to produce a Scientific Opinion that will address the topic of EU strategic resilience to major crises, in collaboration with the with the European Group on Ethics in Science and New Technologies. After a scoping phase in consultation with Commission services, a scoping paper was approved and published in June 2021. The scoping paper formulates the formal request for independent scientific advice by the Mariya Gabriel, European Commissioner for Innovation, Research, Culture, Education and Youth, and Janez Lenarčič, European Commissioner for Civil Protection and Humanitarian Aid, to the European Group of Chief Scientific Advisors.

The main question to be answered by the Scientific Advice Mechanism is:

> Based on a broad and multidisciplinary understanding, how can the EU improve its strategic crisis management?

To inform their Opinion, the Group of Chief Scientific Advisors asked SAPEA to produce an Evidence Review Report.

Working group

SAPEA set up an international and interdisciplinary working group with 16 members and one external contributor from 11 European countries, with Professor Tina Comes as Chair.[1] Members represent a broad range of disciplines required for the review. All working group members were required to fill out the Standard Declaration of Interest Form of the European Commission, in accordance with SAPEA's quality guidelines. Due to the COVID-19 pandemic, all the meetings of the working group took place online, over the period from October 2021 to May 2022. The Evidence Review Report was drafted by the working group in that same period.

1 More information on how experts are found and selected is at https://sapea.info/about-us/how-we-find-our-experts/

Coordination of the review

A Coordination Group was formed at the beginning of the project, composed of four members of the Group of Chief Scientific Advisors:

- Nicole Grober
- Maarja Kruusmaa
- Nebojsa Nakicenovic
- Eric Lambin

Nicole Grobert and Maarja Kruusmaa were appointed as co-lead Scientific Advisors for the crisis management topic and were responsible for chairing the Coordination Group meetings. The Coordination Group asked the Commission (SAM secretariat) to allocate responsibility for the evidence gathering to SAPEA. They invited the chair of the SAPEA working group, the president of the SAPEA network leading on the topic and members of staff supporting the project to join the meetings of the Coordination Group.

The representatives for SAPEA were Antonio Loprieno (ALLEA), supported by Céline Tschirhart (SAPEA, Scientific Policy Officer for ALLEA), who coordinated the development of the Evidence Review Report. The SAPEA working group chair, Tina Comes, and Louise Edwards (SAPEA Scientific Policy Officer for Academia Europaea) also participated in the meetings of the Coordination Group. Alessandro Allegra, Piotr Kwiecinski, Nicola Magnani, Scira Menoni, and Ingrid Zegers coordinated the project from the Science Policy, Advice and Ethics unit at DG RTD.

Literature review

A literature review team was formed, which included the working group chair Tina Comes, the director of the Specialist Unit for Review Evidence at Cardiff University Alison Weightman, the manager of the European Documentation Centre at Cardiff University Frederico Rocha, and SAPEA staff. The European Documentation Centre at Cardiff University was also responsible for developing an EU policy mapping to support the work (see separate document on Policy Landscape).

Outputs included a set of factsheets about existing cross-sectoral crisis management mechanisms at the European Commission (see separate document on Policy Landscape); reviews on definitions of terms used in the scoping paper (see Annex 3); and evidence to support the case studies (see 8, p.207).

Rapid reviews of the literature were also carried out on a number of specific, relevant topics, either in response to requests from members of the working group or to support their work.

The reviews were conducted systematically. Protocols were recorded and submitted alongside the screened results, and EndNote files were retained with all the extracted results. Scopus and Web of Science were used in the literature searches, alongside further screening of grey literature and using EUR-LEX, the EU Publications Office catalogue and other databases, such as Overton, Policy Commons and European Sources Online. The inclusion/exclusion criteria were discussed with and endorsed by the Working Group Chair and/or appropriate member of the Working Group, as well as other members of the Literature Review Team.

Literature searches were carried out on the following topics:

- specific cross-sectoral and sectoral eu crisis response mechanisms
- cross-border health threats, including health security
- biological threats
- cybersecurity
- EU response to forest fires and wildfires
- science advice in crisis management
- research & innovation at regional level (in relevant fields)
- socio-economic impacts of crises
- data management for crises

SAPEA expert workshop

The expert workshop on strategic crisis management in the EU was held on 25 March 2022 as an online meeting. Its purpose was to receive feedback from the wider expert community on the draft Evidence Review Report. Eleven experts were invited on the basis of their expertise, applied knowledge and experience, while also observing representation on the basis of gender and geography. Also present were members of the SAPEA working group, SAPEA representatives, members of the Group of Chief Scientific Advisors and staff of the European Commission as observers.

The workshop followed an established format. Participants had received a draft confidential copy of the report in advance of the workshop. After a general introduction to the report, a keynote speaker presented an overall assessment of the report, with initial observations on strengths, possible limitations and gaps. Each of the main chapters was then introduced, followed by feedback from an invited discussant and then an opportunity for open discussion. After the workshop, members of the working group considered the feedback and agreed on the actions that should be taken to address it. The draft Evidence Review Report was then revised, prior to undergoing formal peer review. The report of the workshop is published separately, as a companion document to the Evidence Review Report, and is available on the SAPEA website. Invited experts are listed below:

- Professor Frederick Benaben, Professor, IMT Mines Albi – Industrial Engineering Research Center
- Commander Bert Brugghemans, Chief Fire Officer for the Antwerp Fire Service
- Dimitri De Fré, Disaster Management Coordinator, Leuven University Hospital
- Dr Bernard Guézo, Expert in urban vulnerability and territorial resilience of local areas, French Association for the Prevention of Natural and Technological Disasters
- Dr Igor Linkov, Risk and Decision Science Focus Area Lead with the US Army Engineer Research and Development Center, and Adjunct Professor, Carnegie Mellon University
- Professor Valérie November, Director of Research, CNRS
- Federica Ranghieri, Senior Urban Specialist, World Bank
- Professor Jozef Ristvej, Professor of Crisis Management, University of Zilina
- Professor Amy Verdun, Professor of Political Science, University of Victoria

Peer review

In accordance with the SAPEA quality guidelines, a minimum of three peer reviewers were required to undertake a double-blind peer review process (i.e. peer reviewers do not know the identity of the working group members, and vice versa, during the process). The peer reviewers were identified and chosen by the different SAPEA networks and consideration was given to gender and geographical balance. Following these directions, four peer reviewers accepted the invitation and three responded within the set deadline. The peer reviewers are listed below:

- Professor Sir Ian Boyd, Professor of Biology, University of St Andrews (Scotland, UK) and former Chief Scientific Adviser (UK, nominated by the Royal Society)
- Professor Dariusz Jemielniak, Professor of Organizational Studies at Kozminski University (Poland, nominated by the Polish Young Academy)
- Dr Claudia Morsut, Associate Professor, Department of Safety, Economics and Planning, University of Stavanger (Norway, nominated by Academia Europaea)

SAPEA is grateful for the work of these peer reviewers, who do not necessarily endorse the content of the report as a whole or any specific claims made in it.

Plagiarism check

A plagiarism check on the main report was run by Cardiff University using Turnitin software.

Publication

This Evidence Review Report was handed over to the Group of Chief Scientific Advisors on 28 June 2022. At the time of writing, it is planned to publish in September 2022, along with the Advisors' Scientific Opinion. The main report is accompanied by two parallel documents: one expert workshop summary report, and one Policy Landscape review. All documents can be accessed on the SAPEA website: https://sapea.info/topic/crisis-management.

Annex 3. Literature review on key terms and definitions

In the scoping paper, the Group of Chief Scientific Advisors is asked to provide clear definitions for a defined set of terms ('crises', 'disasters', 'emergencies', 'risks', 'resilience', 'adaptation', 'absorption' and 'recovery'. Against this background, the working group chair asked the literature review team to undertake initial literature reviews for definitions of these terms. The results of this review were presented to the working group for discussion, providing a basis on which to address some of the questions set out in the scoping paper.

Searches were carried out for:

- definitions used by the United Nations Office for Disaster Risk Reduction, OECD, European Commission Joint Research Centre, IPCC and WHO
- academic reviews exploring definitions across a variety of disciplines including: psychology, engineering, social ecological, economics, political science, health
- definitions adopted by the most recent edition of the accepted authority on the English language, the Oxford English Dictionary, and relevant subject dictionaries and handbooks published by Oxford University Press

A summary of the definitions was created, and diagrams or graphics identified that might be adapted to illustrate the interrelationships between the terms was included in the summary. The results can be seen in 2 (for instance, Figure 10, p.53) and in the table below.

Term	Definition
absorption	The ability of a system to keep the same level of performance and service delivery (in terms of quantity, quality and equity) despite a disruptive event, using the same level of resources and capacities.
adaptation	The process of adjustment to changing conditions including risks, crises and disasters.
crisis	Occurs when people perceive a severe threat to the fundamental values or functioning of a society or system, requiring an immediate response that must be delivered under conditions of deep uncertainty.
disaster	A severe disruption of normal functioning of a system, leading to widespread losses and impacts that overwhelm the response capacity of a system or society.
emergency	An imminent, serious situation requiring immediate action. It tends to occur with some sort of regularity, which has allowed professionals to prepare a response to particular sorts of emergencies.
recovery	The restoring or improving of livelihoods, economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected society or system.

Term	Definition
resilience	The ability of a system to sustain or rapidly recover its key functions in response to abrupt shocks or chronic stresses through absorbing, responding to, recovering from, adapting to, or reorganising.
risk	The possibility of undesired effects associated with an event or an activity.
vulnerability	The susceptibility of a system or asset to damage. As such, vulnerability is one of the determinants of risk.

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Absorption

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Annex 4. List of acronyms

- **ARGUS**: a European systems and network monitoring instrument (not an acronym)
- **CBRN:** chemical, biological, radiological and nuclear
- **CCA:** Crisis Coordination Arrangement
- **CECIS:** Common Emergency Communication and Information System
- **CERT:** Computer Emergency Response Team
- **DG ECHO**: Directorate General for European Civil Protection and Humanitarian Aid Operations
- **DIKW**: data, information, knowledge wisdom. See Figure 4, p.35
- **ECDC:** European Centre for Disease Prevention and Control
- **EEA:** European Economic Area
- **EEAS:** European External Action Service
- **EFFIS:** European Forest Fire Information System
- **ENISA:** European Network and Information Security Agency
- **EU**: European Union
- **ERR**: Evidence Review Report
- **FAO:** Food and Agriculture Organisation
- **FP7:** Framework Programme 7
- **GDACS:** Global Disaster Alert and Coordination System
- **GDP:** gross domestic product
- **HERA:** Health Emergency Preparedness and Response Authority
- **ICT**: information and communications technology
- **IHR:** International Health Regulation
- **IPCC**: Intergovernmental Panel on Climate Change
- **IPCR:** Integrated Political Crisis Response
- **JRC:** Joint Research Centre
- **MIC:** Monitoring and Information Centre
- **NIS:** network and information security
- **OECD**: Organisation for Economic Cooperation and Development
- **R&I:** research and innovation
- **UCPM:** Union Civil Protection Mechanism
- **UN**: United Nations
- **UNEP:** United Nations Environment Programme
- **UNHCR:** United Nations High Commission for Refugees
- **WHO:** World Health Organisation

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