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Regional Assessment Report on Disaster Risk Reduction 2023 Europe and Central Asia

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UN Office for Disaster Risk Reduction

Citation: United Nations Office for Disaster Risk Reduction (2023). *Regional Assessment Report on Disaster Risk Reduction 2023: Europe and Central Asia.* Geneva.

For additional information, please contact:

United Nations Office for Disaster Risk Reduction (UNDRR) Regional Office for Europe and Central Asia

37-40 Bvd du Régent Brussels 1000, Belgium

undrr-roeca@un.org

Regional Assessment Report on Disaster Risk Reduction 2023 Europe and Central Asia

SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

Contents

Foreword

The Europe and Central Asia region has witnessed many dramatic events that have challenged our assumptions about the sources of risk, the sources of strength and the limits of what is likely.

Extreme weather events have caused great trauma across the region, as seen for example during the devastating fires in the Mediterranean basin in 2020, the floods affecting Belgium, France, Germany and Luxembourg in 2021, as well as the record heatwaves in 2022 and the tragic earthquake in Türkiye in 2023. The 2021 volcanic eruption affecting the Canary Islands and the knock-on effects to travel, tourism and trade, upon which the islands rely, are another reminder of the complex risk landscape faced by countries across the region, and the extent to which solidarity and cooperation makes the difference.

The nature of risk is changing. This is due to rapid urbanization, increased digitalization, interconnection of economies and dramatic decline in biodiversity. We are learning to recognize how risks that we thought we understood are interlinked and influenced by emerging and new threats. These present compound challenges to our familiar approaches to disaster risk reduction (DRR). Risks are more systemic and more complex than ever before, contributing to greater losses, and an increased number of people displaced and lives lost.

The specific challenges faced by European and Central Asian countries are given special attention in this report. Wildfires are now observed in more countries and with more severe human and economic impacts, and cyber and technological risks have risen to prominence in several countries. This report aims to highlight trends, with a view to improving implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 as a means of managing the deleterious trends and capitalizing on the strengths of the region.

This *Regional Assessment Report 2023* echoes the *Global Assessment Report on Disaster Risk Reduction 2022* in its call to measure what we value. The financial sector needs to account for the real cost of risk and incentivize climate and disaster resilient investment. Governments will need to transform their priorities in investing in disaster resilience, and strengthen national budgets to protect people and critical infrastructure. This is needed to break the costly cycle of **disaster** > response > dependency > **repeat**.

Future efforts require improvements to the interface between decision makers and stakeholders. This will enable scientific actors to better support policymakers with reliable and accurate evidence and better include the priorities and values of the societies in which they operate. Societies will be better able to maintain a healthy balance of scepticism and faih in science and government, and decision makers will be able to make real, good faith efforts to ensure their decisions are transparent and the process of governing is inclusive of science and civil society.

This report captures the challenges and opportunities in the Europe and Central Asia region. It highlights the cost of inaction or what happens next if we do no not take urgent action in line with the recommendations for guiding national, subnational and local actors on DRR. At the midpoint of the Sendai Framework period, now is the time to take stock of progress and transform our collective actions to truly reduce risk, save lives, and avoid preventable losses and damage.

Mami Mizutori

Special Representative of the Secretary-General for Disaster Risk Reduction

Acknowledgements

Lead authors

Dilanthi Amaratunga, Global Disaster Resilience Centre, University of Huddersfield; Vicente Anzellini, Internal Displacement Monitoring Centre; Lorenzo Guadagno, International Organization for Migration; Jenny Sjåstad Hagen, Geophysical Institute, University of Bergen and Sunnfjord Geo Center; Blaž Komac, Anton Melik Geographical Institute, Research Centre of the Slovenian Academy of Sciences and Arts; Elisabeth Krausmann, European Commission Joint Research Centre; Max Linsen, Portolan Association; Gianluca Pescaroli, Institute for Risk and Disaster Reduction, University College London; Jean Louis Rossi, Laboratoire Sciences Pour l'Environnement, Université de Corse; Katja Samuel, Global Security and Disaster Management; Josef Schroefl, Hybrid CoE – The European Centre of Excellence for Countering Hybrid Threats; Reimund Schwarze, German Committee for Disaster Risk Reduction; Jörgen Sparf, Mid Sweden University and Norwegian University of Science and Technology Social Research; and Maureen Wood, European Commission Joint Research Centre.

Contributing authors

Kristoffer Albris, University of Copenhagen; Alexander Altshuler, University of Haifa and Israel Ministry of Science and Technology; Elena Arefyeva, Russian Scientific Research Institute of Civil Defence and Disaster Management; Fabrizio Bianchi, Fondazione Toscana Gabriele Monasterio; Nicholas Bishop, International Organization for Migration; Helko Borsdorf, Helmholtz Centre for Environmental Research; Duncan Cass-Beggs, Global AI Risk Initiative at the Centre for International Governance Innovation; François Joseph Chatelon, Laboratoire Sciences Pour l'Environnement, Université de Corse; Mauro Dolce, Italian Civil Protection Department; Ricardo Fal-Dutra Santos, Internal Displacement Monitoring Centre; Elise Filo, Internal Displacement Monitoring Centre; Urbano Fra Paleo, University of Extremadura, School of Social Sciences and Humanities; Lilit Gevorgyan, Institute of Geological Sciences, National Academy of Sciences of Republic of Armenia; Richard Haigh, Global Disaster Resilience Centre, University of Huddersfield; Clare Heaviside, Public Health England; Kinkini Hemachandra, Global Disaster Resilience Centre, University of Huddersfield; Franziska Hirsch, United Nations Economic Commission for Europe; Johannes Kaiser, Max Planck Institute for Chemistry; Claudia Kamke, United Nations Economic Commission for Europe Industrial Accidents Convention Secretariat; Vassilis Karokis-Mavrikos, University of Surrey; Andrey Krasovskii, International Institute for Applied Systems Analysis; Tuula Kekki, Finnish Ministry of Interior and National Rescue Association; Thierry Marcelli, Laboratoire Sciences Pour l'Environnement, Université de Corse; Aleksandrina Mavrodieva, Independent Consultant; José Manuel Mendes, University of Coimbra; Jadranka Mihaljevic, Institute of Hydrometeorology and Seismology; Lacin Idil Oztig, Yildiz Technical University; George C. Pallis, T4i Engineering; Eduard Plana Bach, Forest Science and Technology Centre of Catalonia; Sylvain Ponserre, Internal Displacement Monitoring Centre; Emanuel Raju, University of Copenhagen; Yelyzaveta Rubach, United Nations Economic Commission for Europe Industrial Accidents Convention Secretariat; Jesús San-Miguel-Ayanz, European Commission Joint Research Centre; Reimund Schwarze, Helmholtz Centre for Environmental Research; Zvonko Sigmund, University of Zagreb; Asitha de Silva, Global Disaster Resilience Centre, University of Huddersfield; Jörgen Sparf, Mid Sweden University; Milt Statheropoulos, European Centre for Forest Fires; Kaili Tamm, Estonia Ministry of the Interior; Torill Tandberg, Norwegian Directorate for Civil Protection and United Nations Economic Commission for Europe Industrial Accidents Convention; Audronė Telešienė, Kaunas University of Technology; Stefan Ulrich, Helmholtz Centre for Environmental Research; Sotiris Vardoulakis, Institute of Occupational Medicine, Edinburgh; and Sergiy Zibtsev, Regional Eastern European Fire Monitoring Centre.

The expertise and support of Soenke Ziesche, who coordinated the initial phases of development of this report and contributed to several of its sections, is acknowledged. The United Nations Office for Disaster Risk Reduction Regional Office for Europe and Central Asia acknowledges its major core donors for their support: Finland, Japan, Norway, Sweden and Switzerland, and also its earmarked donor, the United States Agency for International Development.

Executive summary

This *Regional Assessment Report on Disaster Risk Reduction 2023: Europe and Central Asia* proposes that three broad, interconnected risk drivers characterize the complexity of managing risk in the region: climate change and environmental degradation; interconnected and complex economies, societies and infrastructure; and changing demographics. These themes are not isolated. Instead, they are treated throughout the chapters of this report as being recurring and tightly interwoven, with increasing, compounding and cascading effects on one another and beyond.

The report also discusses some of the main challenges in Europe and Central Asia that require concerted efforts to understand and manage. Each challenge area highlights core issues related to policy coherence as well as decision-making with limited information and many complex variables. These challenges are connected, and reflect the overarching risk drivers. They share a common need for systematic evidence-based and multi-stakeholder approaches for policy coherence and investments in resilience. The coronavirus disease (COVID-19) pandemic has demonstrated there is still a great deal of ground to be made up in better connecting decision makers with reliable and accurate scientific evidence and broad-based social support.

This report also identifies good practices in the Europe and Central Asia region that provide a hopeful outlook for risk reduction opportunities in the future. They represent the strengths in the region for addressing the challenges outlined. Recommendations for the region have been formulated from the challenges, and are provided as a conclusion to the report.

Key drivers of risk

Driver 1: Climate change and environmental degradation

Climate change has far-reaching significance and implications worldwide. However, this report focuses on the nuances and intricacies of climate change as experienced within the Europe and Central Asia region. By examining key factors in relation to climate change, the report aims to provide a comprehensive understanding of the state of affairs within the region.

Driver 2: Interconnected and complex economies, societies and infrastructure

Through the lens of heightened interconnectivity of economies and systems and dependencies within the region, this report examines the alterations in infrastructure investment and priorities, with emphasis on the ageing grey infrastructure, as well as the rising popularity of green and blue infrastructure options. The COVID-19 pandemic and the ongoing war in Ukraine have highlighted the fundamental vulnerabilities embedded within the economies, societies and infrastructure of the region. Thus, the report explores the broader ramifications of these events and provides insights into how they have affected the region's economy, infrastructure and trade systems.

Driver 3: Changing demographics

As a major global, geopolitical cross-roads for centuries, this region is no stranger to massive shifts in demographics. Changes propelled by disease, conflict, borders and political boundaries, integration, urbanization, migration and economics have all contributed to alterations in the Europe and Central Asia region's demographic profile. They continue to shape the way disaster risk is understood, created and managed. This report delves into the implications of these demographic shifts on disaster risk, and explores how the changes have affected the creation, management and understanding of disaster risk within the region.

Challenges

Challenge 1: Reducing the risks of extreme wildfires

This challenge demonstrates how climate change, human behaviour and other factors are creating conditions for more frequent, intense and devastating wildfires that affect a growing number of countries, people and sectors during longer seasonal periods. These evolving conditions require a shift from fire suppression to prevention, to better integrate realistic societal behaviour, to improve awareness and to provide risk information. For reducing risks tangibly, it is also critical to tackle the health impacts of wildfires and to improve the role of science and technology in wildfire risk reduction.

Challenge 2: Shifting to resilient infrastructure

This challenge highlights opportunities to prevent risk and build the resilience of new and existing infrastructure challenged by the effects of climate change and obsolescence, as well as by multinational and multisector interdependence. Such resilience will not be obtained without robust and interoperable data and standards, a legislative and regulatory environment adapted to the complexity of infrastructure systems, as well as more systematic investments in prevention and green and blue infrastructure.

Challenge 3: Addressing cyber challenges and opportunities

This challenge outlines emerging risks due to disruptive dual-use developments in cyberspace, while acknowledging the unprecedented range of opportunities of new technologies. The systemic digitalization of economies requires the integration of cyber risk into national risk assessments, strengthened understanding of cyber risk and the development of cyber risk-informed strategies and capabilities to withstand hybrid and cascading risk scenarios.

Challenge 4: Managing technological risks

This challenge focuses on the critical essence of technological hazards and the importance of considering technological risks in disaster risk reduction (DRR) strategies. Prevention of such disasters must be maintained as an objective for decision makers and stakeholders through improved data collection and data sharing, and better consideration of emerging technological risks. This goal is achievable based on cooperation among competent and expertise-rich institutions with social support and good governance. Particular and urgent attention is required to understand and mitigate new rapidly emerging risks made possible by recent developments in artificial intelligence, including potential global extinction risks from uncontrolled artificial superintelligence that may originate from within or outside the Europe and Central Asia region.

Challenge 5: Considering disaster displacement and risks faced by internally displaced people and migrants

This challenge discloses the growing regional challenges posed by disaster displacement and the specific disaster risks faced by displaced people and migrants within the region. Tackling this issue requires mainstreaming indicators related to disaster displacement into disaster damage and loss databases to assess the risk of future disaster displacement regarding scale and locations. A longer-term vision is also needed to strengthen the understanding of how climate change and related hazards could intensify disaster displacement and to develop policies that include migrants in risk reduction efforts.

Good practices

Good practice 1: Inclusion of disaster risk reduction in the policymaking process

Public policies are essential instruments in the governance of any political field. Many factors influence public policy formulation, including expert advice, science, social norms, and priorities, international forces and interest groups. DRR policies face specific challenges in that their cross-sectoral, interdisciplinary and society-complex character makes it difficult to settle on policies that will be unequivocally resilience-enhancing. There is a strong interest in Europe and Central Asia to understand DRR as a policy field better and to learn how formal evaluations and scientific knowledge are used in the formulation and implementation of DRR policies.

Good practice 2: Creation of scientific knowledge on disaster risk reduction

Scientific advice should be based on rigorous studies and solid empirical grounds. It is of utmost importance that sufficient funding is in place to accomplish such research. Examples exist within the region of highly developed schemes for DRR at the national level. These are characterized by funding from, for example, governmental bodies, ministries, science councils and foundations. Efforts to integrate DRR and climate change adaptation research are essential to produce advanced knowledge regarding interrelated complex problems. International funding is a means of channelling funding to countries with a low national research budget for DRR, but it is also a way to establish and foster international and cross-disciplinary collaboration.

Good practice 3: Transfer of scientific knowledge on disaster risk reduction

Scientific knowledge about DRR is of limited use if it is not communicated among relevant stakeholders. Within the region, there are mechanisms for science–policy interaction on the European level. For instance, the Joint Research Centre plays a crucial role in the European Union's policy cycle, particularly in the context of scientific knowledge dissemination and its integration into policymaking. There are many more examples of how the scientific community is engaged in reciprocal knowledge transfer with officials and professionals in the DRR field. Education is also a crucial channel for expert knowledge exchange, as are webinars, conferences and networks for the development of specific topics on integrated themes and in a multi-risk perspective.

Good practice 4: Adoption of a multi-stakeholder approach for disaster risk reduction

The social and environmental consequences of disasters are increasingly complex and intertwined. Multi-stakeholder platforms (MSPs) gather multiple organizations at different scales of governance that strive for more coordinated and integrated DRR actions. International MSPs can play a crucial role in strengthening coordination among stakeholders working at different levels, in implementing activities, and enhancing technical and financial capacities. There are several meaningful MSPs in the region from which this report draws inspiration and best practices. Multi-stakeholder approaches to policy coherence can be a powerful tool to tackle emergent risks. All four priorities of the Sendai Framework for Disaster Risk Reduction 2015–2030 highlight the importance of multi-stakeholder collaboration at all levels in disaster risk management.

Good practice 5: Fostering of policy coherence for disaster risk reduction

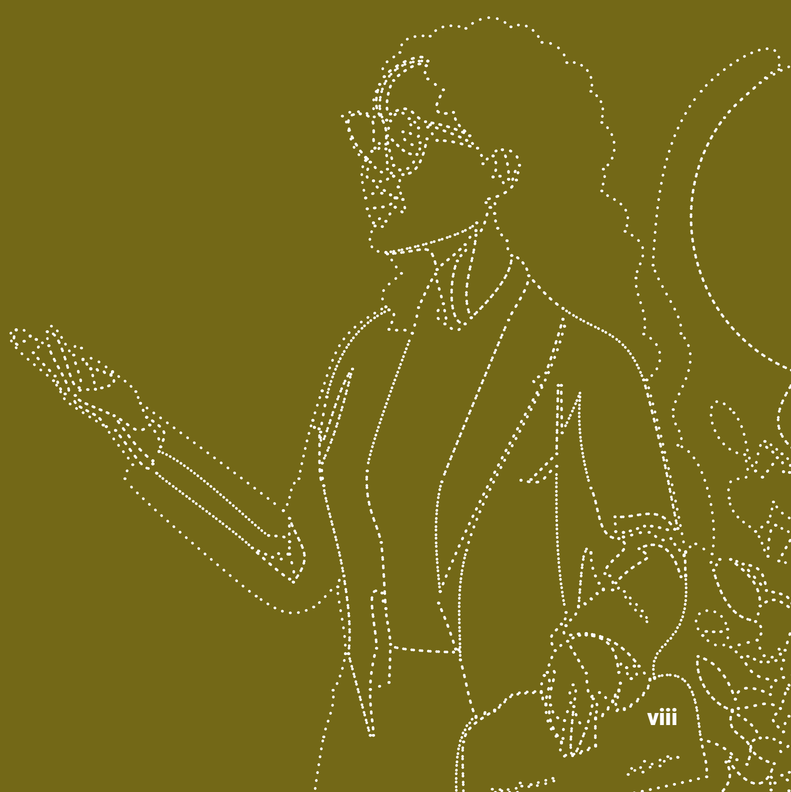
Coherent policy approaches bring greater efficiency and effectiveness, and reduce competition for resources. Disaster policy implementation and the fostering of policy coherence serve as a channel through which DRR influences sustainable development. With the implementation of global agendas like the Sendai Framework and the Transforming our World: the 2030 Agenda for Sustainable Development has come institutionalization of coherent approaches across DRR practices and policies.

Good practice 6: Acceleration of risk-informed investment for resilience

Accelerating risk-informed investment in DRR for resilience means supporting the resilience of the finance sector itself and ensuring investments are resilient. The financial services sector must become more resilient to external shocks and stresses, and disaster risk must be integrated into investment decision-making. The response to COVID-19 in the region has seen strong political leadership for a green and resilient recovery. Europe takes a leading role in driving the international agenda, and aims to showcase positive signs of investment in resilience. Investing in DRR is a precondition for developing sustainably in a changing climate. The benefit of investing in resilience outweighs the cost, with high benefit–cost ratios. Within the region, policies, funds, financial frameworks and other instruments are providing opportunities to prevent creation of new risk and to build resilience of infrastructure.

Good practice 7: Building on a strong foundation of good governance and financial sustainability in cooperation

Faced with an increasingly tight fiscal space and existential dilemmas over whether to allocate scarce public resources to immediate relief or to invest in a more inclusive sustainable recovery, political leaders have recognized the value of investing in risk reduction. It can bridge the short term with the long term, while addressing climate change and ensuring overall sustainability. It requires a shift across the financial system from short-termism to a "think resilience" approach. Political commitment, public buy-in and resources are critical enablers. Policy options should not be perceived as a temporary trend or linked to a particular party or politician but as ways to ensure sustained and sustainable change. Such positive investment developments are being made within the region.



Recommendations and conclusions

Recommendation 1: Develop better ways of understanding, interpreting and communicating systemic risk

Collective comprehension, interpretation and dissemination of systemic risk need to be enhanced, by developing stronger disaster loss tracking systems, in which data are disaggregated and used to inform the analysis and development of policy. Disaster loss data can be used in development planning to guarantee the creation of resilient, sustainable and inclusive policies. Wisdom acquired and lessons learned from previous disasters can be utilized to better understand risk creation and vulnerability, to inform future policymaking.

Recommendation 2: Foster more resilient societies through the development of financial, regulatory and behavioural tools reflecting shared priorities among risk science, policymakers and communities

It is imperative to invest in different ways of understanding and attributing the creation of risk while acknowledging and addressing any recognized biases. Many sociological blind spots are widely acknowledged, and concerted efforts should be made to minimize their impact on risk reduction. The utilization of standards and regulations should be judicious and based on robust evidence of efficacy, they should be transparently applied and their impact publicly evaluated.

Recommendation 3: Focus on attenuating impact, reducing vulnerability and building preparedness

Most actors should focus on reducing vulnerability and building preparedness. Some types of hazards can and must be prevented, especially those that have potentially catastrophic and existential impacts from which recovery is impossible. These will require concerted prevention efforts involving actors from across society, with tight coordination across the international community. For other types of hazards that are unavoidable, the emphasis must be on minimizing their potential to become disasters, by focusing on attenuating impact, reducing vulnerability and building preparedness.

Probabilistic hazard assessments have limited utility, but with better integration of other hazard types and other dynamics of risk through scenarios, decision makers can plan for more realistic outcomes. Inclusive, all-of-society participation along with deployment of green and blue investments as starting points, rather than as nice-to-have processes, will ensure risk reduction works for the long term.

Recommendation 4: Underpin integrated policies to manage risk by a commitment to broad-based, inclusive and multisectoral participation of all interested stakeholders

Oversimplifying disaster impact by accounting only for direct and economically measurable loss causes good faith risk reduction to fail. Exposure changes in every context and every day. The changes that new private and public investments, as well as new green and grey infrastructure, imply to the overall risk profile must be accounted for. The complexity implied by this exercise will require more detailed communication and cooperation among local, subnational, national, regional and global processes.

Recommendation 5: Use smart investments in resilience and better monitoring to make finance work for resilience

Investment in new systems, structures and assets necessarily implies the creation of new risk. To manage this, inclusive and equitable participation in discussions about public investment and private regulation can help make development more resilient. Part of this requires more transparent risk disclosure and the use of evidence and mainstreamed prevention financing (use of evidence and mainstreamed prevention) as a matter of course.


RAR

Chapter 1: Introduction

"The era of global warming has ended; the era of global boiling has arrived. Leaders must lead. No more hesitancy. No more excuses. No more waiting for others to move first. There is simply no more time for that. It is still possible to limit global temperature rise to 1.5 degrees Celsius and avoid the very worst of climate change. But only with dramatic, immediate climate action."

António Guterres (United Nations, Secretary-General, 2023)

In his 2021 report on the implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 (United Nations, General Assembly, 2015a), the Secretary-General also underscored that "Decades of risk creation can be reversed through immediate action to implement the Sendai Framework and its prospective, preventive and inclusive approach to disaster risk reduction" (United Nations, General Assembly, 2021). However, in his 2022 report, he concluded that "no country is on track to achieve the seven global targets of the Framework by 2030" (United Nations, General Assembly, 2022).

The global risk landscape is dynamic and evolving. Over recent years, this dynamism has accelerated as the drivers of risk combine and feed back into one another. To stay abreast of the challenges, the international community must anticipate shocks. It must also develop capacities to identify the true sources of risk and adapt quickly to non-linear changes. Past approaches to compartmentalize risk and design interventions for distinct areas of risk reduction have proven ineffective when tested against real events.

Geographic boundaries are meaningless to hazards such as air pollution or wildfires. The lag effect of desertification or glacial melt means they defy most risk assessment timescales. And epidemics and industrial accidents give lie to the fallacy of managing risk within one discipline or sector. Simplification of the looming challenges can be dangerous. The *Global Assessment Report on Disaster Risk Reduction 2019* (GAR2019) insists that by "incentivizing transdisciplinary integrated, multisectoral research, risk assessment and decision-making efficiency can be improved, duplication of effort reduced, and connected collective action facilitated" (UNDRR, 2019a).

Hazards will happen but they do not have to become disasters.

In 2020, the coronavirus disease (COVID-19) pandemic added to the complex landscape of systemic risk, and demonstrated a global lack of preparedness. A year later, COVID-19 recovery packages presented opportunities to align development, climate and environmental policies and investments in new ways, to prevent new and reduce existing risks. Since then, the systemic effects of shocks such as the war in Ukraine have reverberated around the world, and the interconnected systems that prioritize efficiency and economy have demonstrated that they also put the poorer, weaker and economically disenfranchised communities last.

GAR2022 emphasizes three key actions to accelerate risk reduction in the face of the climate emergency and its interconnected risks (UNDRR, 2022a). First, policymakers should measure what they value by accounting for the real costs of risk, reworking financial systems and adapting national fiscal planning. Second, systems should be designed to factor in how human minds make decisions about risk, recognizing the role of risk perceptions and biases. Third, governance and financial systems must be reconfigured to work across silos and involve affected people through a new "risk language", increased transparency and citizen dialogue. By embracing these actions, the necessary transformations can be catalysed to effectively address systemic risk and protect vulnerable populations from disasters.

The Sendai Framework calls for effective DRR and resilience strategies to be in place at national and local levels and for investment to be risk informed and focused on resilience needs.

At the midterm of the Sendai Framework period, *The Report of the Midterm Review of the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030* highlights that although progress has been made towards achieving the Sendai Framework priorities,[1] challenges persist (UNDRR, 2023a). Priority 1 has seen significant improvements in risk understanding and assessment, but methodologies for cascading risks need development. Priority 2 has shown progress in DRR governance, with established platforms and local actors playing crucial roles, but marginalized perspectives remain underrepresented. Priority 3 has seen the least progress, as dedicated budgets for risk management are inadequate and private sector partnerships are limited. Progress on Priority 4 varies, with advancements in preparedness and technology-driven early warning systems, but transboundary systems require urgent attention. Despite the challenges, capacities for sustainable recovery and inclusive approaches are slowly developing. Continued urgency and coordinated efforts are essential to bolster resilience.

This *Regional Assessment Report on Disaster Risk Reduction 2023* focuses on the key drivers of risk, and associated challenges, good practices and recommendations in the Europe and Central Asia region. It is aimed at Member States, decision makers, policymakers, scientists and researchers, among others.

1 Priority 1: "Understanding disaster risk"; Priority 2: "Strengthening disaster risk governance to manage disaster risk"; Priority 3: "Investing in disaster risk reduction for resilience"; and Priority 4: "Enhancing disaster preparedness for effective response and to 'Build Back Better' in recovery, rehabilitation and reconstruction" (United Nations, General Assembly, 2015a).

Regional profile and recent developments

The Europe and Central Asia region[2] faces a diverse array of hazards, posing significant threats to lives, livelihoods, infrastructure and the environment, and leading to severe economic losses. In response, efforts have been made to align with the Sendai Framework priorities for disaster risk reduction (DRR).

In 2021, the *European Forum for Disaster Risk Reduction: Roadmap 2021-2030* was launched to provide a concise and action-oriented framework for DRR in the region. Based on consultation and lessons learned from the COVID-19 pandemic, it identifies shared priorities and common action areas to achieve the goals of the Sendai Framework. It supports regional, national and local DRR strategies by identifying gaps and opportunities for enhancing resilience. Moreover, it promotes the sharing of good practices, risk-informed policies and inclusive approaches (UNDRR, 2021a).

The road map encourages collaboration and shared learning among countries in the region. Through this comprehensive road map, the region can work together to build resilience and effectively address the priorities of the Sendai Framework. The road map also identifies that a changing climate, shifting demographics, new technologies, and the transition towards digital and green economies requires a paradigm shift in the region's understanding and communication of existing, emerging and future systemic risks.

The 2022 *Regional Synthesis Report – Europe & Central Asia: Sendai Framework Midterm Review Process* takes advantage of the midterm review of the Sendai Framework to provide an overview of trends and activities in risk management at the national level. It describes the state of play of existing practices of risk management within the region (UNDRR, 2022b).

In 2023, the European Commission adopted a recommendation to establish common goals to boost disaster resilience in the areas of civil protection. It includes ways to better prepare European countries for natural hazards such as earthquakes, floods and wildfires. The following five goals aim to improve the capacity of countries to withstand the effects of disasters and emergencies: anticipate, prepare, alert, respond and secure (European Commission, 2023a).

The World Meteorological Organization (WMO) *State of the Global Climate 2022* report emphasizes the significant changes occurring in Europe's land, ocean and atmosphere due to the high concentrations of greenhouse gases (WMO, 2023a). Despite the cooling influence of La Niña, the years 2015–2022 ranked among the warmest on record globally. Indeed, the global average temperature for July 2023 has recently been confirmed as the highest on record for any month (WMO, 2023b). Glacial melting and rising sea levels, which reached record highs in 2022, will continue to have long-term consequences lasting thousands of years. The melting of European glaciers has reached unprecedented levels and the extent of Antarctic sea ice has hit a record low.

In the European Union, the COVID-19 pandemic, infectious diseases and heatwaves have caused high death tolls, while storms, floods and earthquakes have created high economic losses (European Commission, 2020a). This demonstrates again how the Europe and Central Asia region is not spared from disasters and remains vulnerable across various dimensions.

For example, in July 2021, several European countries were affected by severe flooding, particularly in Western and Central Europe. Heavy rainfall caused rivers to swell and burst their banks. Apart from the immense losses, the death toll of over 200 people was unprecedented. At least 189 people died in Germany (Tagesspiegel, 2021) and at least 42 people in Belgium (HLN, n.d.).

Also during 2021, several European countries, Israel and the Russian Federation's Karelia and Siberia regions were affected by severe wildfires, triggered by prolonged droughts and unprecedented heatwaves. Wildfires in Albania, Bulgaria, Cyprus, Finland, France, Greece, Israel, Italy (including Sardinia and Sicily), North Macedonia, the Russian Federation, Spain and Türkiye often caused deaths, displacement and large-scale destruction (IFRC, 2021). The European Commission highlighted that extensive wildfires in Europe in recent years have killed more people and burned more land than ever before (European Commission, 2020a). Wildfires have evolved, and their causes are increasingly linked to climate change.

2 The countries in the Europe and Central Asia region are listed at: https://www.undrr.org/implementing-sendai-framework/sendai-focal-points-and-national-platforms#europe.

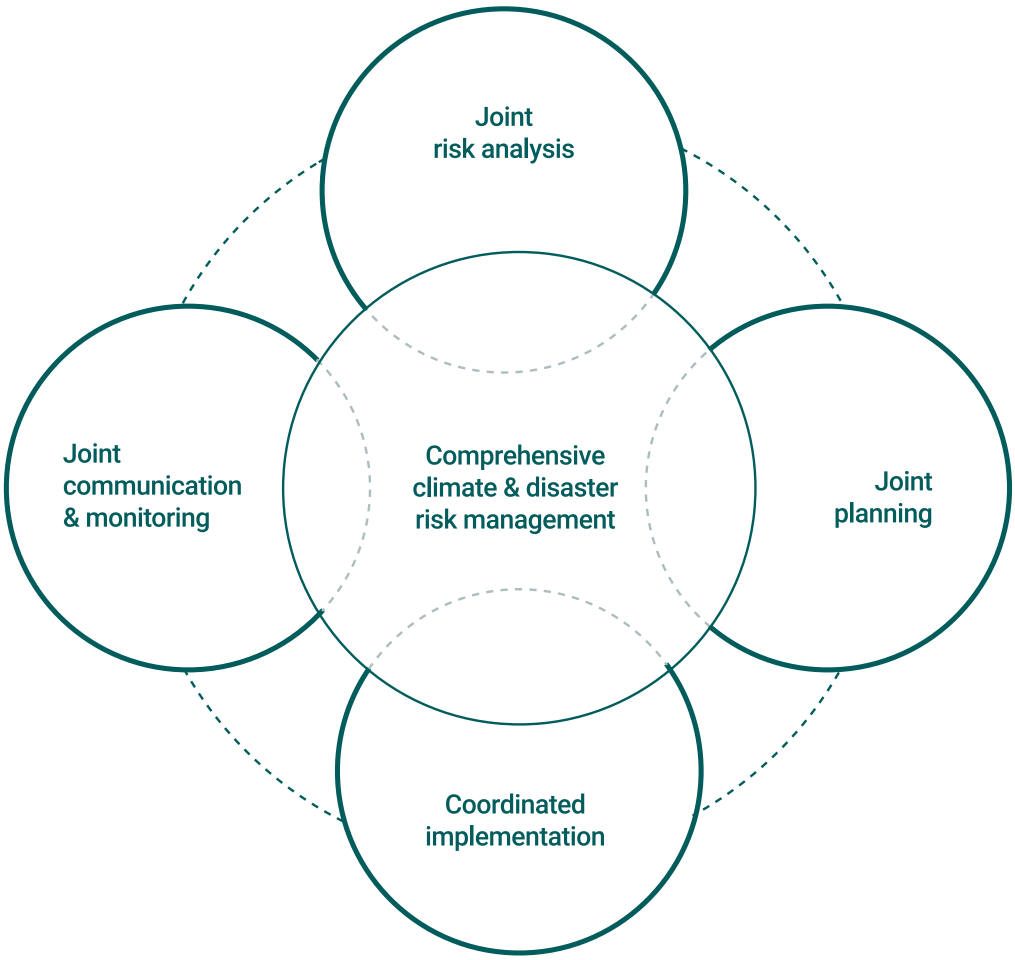
In 2023, Europe has faced an unprecedented heatwave and wildfire crisis, with devastating consequences for people and the environment. Countries such as Greece, Italy and Spain have been particularly affected, experiencing scorching temperatures above 40°C. The island of Rhodes experienced one of the largest wildfire evacuations in Greek history, with more than 20,000 people forced to leave their homes and hotels (Euronews, 2023). Other parts of Europe have also been grappling with extreme temperatures and wildfires. The Italian island of Sardinia saw temperatures soar to 48.2°C (Weather&radar, 2023), prompting a red alert in major Italian cities. In Sicily, Palermo airport had to close due to wildfires encircling the area. Croatia and Portugal also faced wildfires (BritishRedCross, 2023).

The impacts of these extreme temperatures on human health have been severe. People have collapsed in the sweltering heat, and sleeping has been difficult even during the night. Heatstroke has become a significant concern as maintaining a safe body temperature becomes increasingly challenging. The situation is particularly perilous for vulnerable populations, including children, older adults and individuals with pre-existing health conditions.

Climate scientists have warned that extreme weather events like heatwaves, wildfires and floods will become more frequent and more intense as the human-caused climate crisis accelerates (PBS NewsHour, 2023). Global temperatures have already risen significantly due to human activities; unless immediate and substantial action is taken to reduce carbon emissions and combat climate change, temperatures will continue to rise.

Such extreme weather events have led to food insecurity, mass migration and substantial economic losses. Nevertheless, collaboration among United Nations agencies has been effective in addressing the humanitarian impacts of extreme weather events and reducing associated mortality and economic losses (WMO, 2023c). There is therefore a critical need to address climate change and DRR in a way where systematic collaboration and coherence building are ensured at all stages (Figure 1).

Figure 1. Fostering systematic collaboration for climate change and DRR integration



The United Nations Early Warnings for All initiative serves as a crucial mechanism to achieve this objective. The initiative is a global effort to ensure universal protection through early warnings by 2027, launched by the United Nations Secretary-General in 2022, for emphasizing the urgent need to support the most vulnerable populations (UNDRR, n.d.a). Early warning systems have proven to be effective measures for DRR and climate adaptation, offering significant returns on investment and saving lives. However, substantial gaps remain in early warning systems, especially in translating early warnings into risk-informed early action.

The global and interconnected risk landscape demands integrated solutions to address cascading and interrelated risks effectively. A multi-hazard early warning system is therefore a crucial component of a comprehensive DRR strategy. The Words into Action *Guide to Multi-hazard Early Warning Systems* is dedicated to promoting widespread implementation of these vital systems across all sectors, aiming to safeguard the most vulnerable populations from the impacts of disasters (UNDRR, forthcoming).

Objective and structure of this report

This *Regional Assessment Report on Disaster Risk Reduction 2023* aims to provide a comprehensive understanding of three key drivers that are contributing to the evolving risk landscape in the Europe and Central Asia region. It shows how the drivers are interrelated and how they are shaping the risk landscape in the region, providing insights that can inform strategies to effectively manage and mitigate risks. It examines the implications of these drivers, and provides a comprehensive understanding of the multifaceted nature of the risks that are prevalent in this region.

Five major challenges have been identified in the region. This report discusses their background and recent impacts, connected themes, relevance to the risk drivers and associated recommendations to reduce risk in these areas. The report also offers good practices in the region that provide a hopeful outlook for risk reduction.

Finally, the report provides recommendations and conclusions. These take the form of broad principles and good practices that have been extracted from the challenges identified.

Throughout the report, boxes provide real-life examples, case studies and lessons learned from within the Europe and Central Asia region.

Chapter 2: Key drivers of risk

This chapter presents an analysis of three key drivers that are contributing to the evolving risk landscape in the Europe and Central Asia region:

- Driver 1: Climate change and environmental degradation;
- Driver 2: Interconnected and complex economies, societies and infrastructure;
- Driver 3: Changing demographics.

These drivers are not mutually exclusive. Instead, they are interrelated, potentially exacerbating pre-existing risks or leading to the emergence of novel ones.

The three drivers are reflected in all five of the challenges identified in Chapter 3 to varying degrees. It is important to acknowledge that there may be other risk drivers at play, further contributing to the complex risk landscape in the Europe and Central Asia region.

Climate change is undeniably affecting the way societies and economies are structured, while demographic changes are resulting in reprioritized investments and plans in various systems. These two factors are interrelated and exert a significant influence on one another.

Driver 1: Climate change and environmental degradation

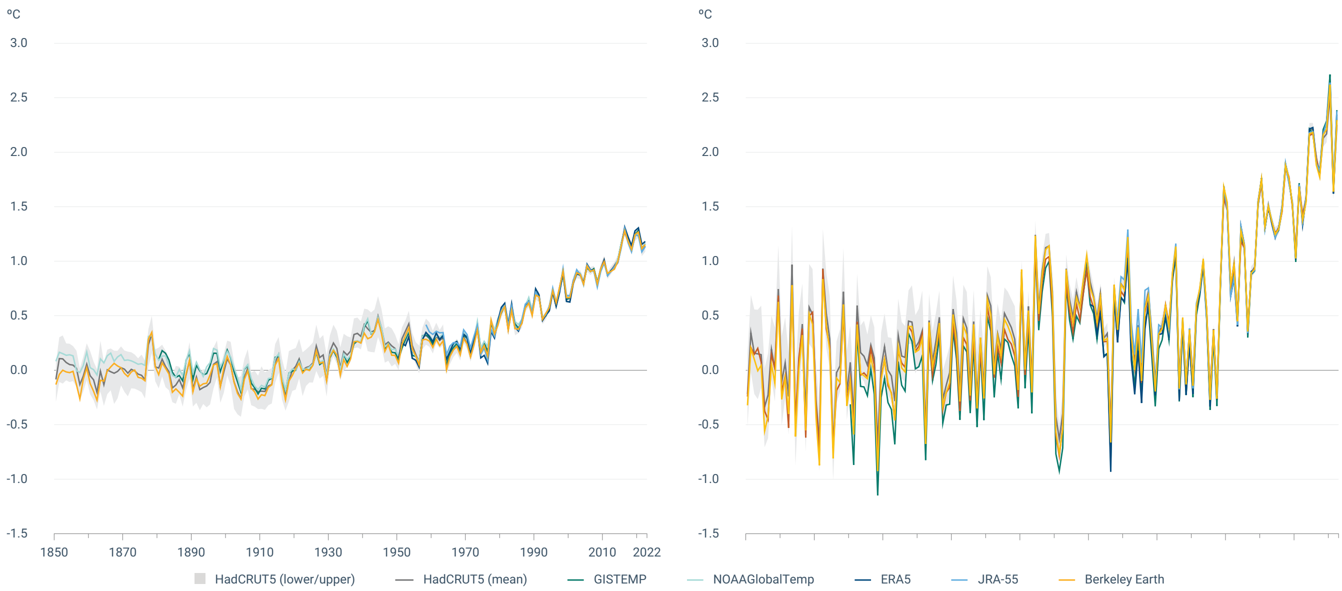
The changing climate is already disrupting and changing the way societies and economies function in Europe and Central Asia. This is confirmed by the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which attributes many of these changes with medium and high confidence to human activities. For example, the report notes there are more frequent rain-related floods in Northern Europe and more frequent hydrological and agricultural/ecological droughts in the Mediterranean area (IPCC, 2021).

If the global temperature rise exceeds 2°C above pre-industrial levels, the consequences for Europe would be even more extreme than they currently are (IPCC, 2021).

Some European and Central Asian countries already score consistently high on the global climate risk index, including France, Germany and Portugal (Eckstein et al., 2021).

Many European countries have recently experienced periods of life-threatening heat, frequently breaking historic temperature records. The period from 2013 to 2022 was the warmest decade on record in Europe, during which land temperatures increased by 2.04–2.10°C compared with pre-industrial levels (EEA, 2023; see also Figure 2). Without massive cuts in global greenhouse gas emissions, the 1.5°C target of the Paris Agreement will be exceeded (UNDRR, 2023b).

Figure 2. Global (left) and European (right) annual average near-surface temperature anomalies relative to the pre-industrial period 1850–1900



Source: EEA (2023)

Temperature changes have complex and far-reaching consequences, such as glacier and sea-ice melting, sea-level rise and altered weather patterns (IPCC, 2018). Longer-term scenarios consider a possible global spiral of runaway climate change with repercussions that are difficult to model because some global tipping points would be exceeded. One such tipping point could be the thawing of Arctic permafrost, which may lead to the release of vast amounts of stored greenhouse gases, thus further exacerbating global warming (European Commission, 2020a).

The European Commission Joint Research Centre Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis (PESETA) IV report assesses the potential impact of a temperature increase of 3°C or more without mitigation measures. It foresees severe ecological and economic consequences for Europe (Feyen et al., 2020).

This eventuality would render current strategies for climate change and DRR virtually obsolete. It also means that it is no longer sufficient to address resilience-building in isolation from development planning and that sustainable socioeconomic development, by definition, must include DRR.

Higher temperatures increase the frequency and intensity of extreme rainfall (Westra et al., 2014). This has caused increased flooding events in recent years in Europe, which could become more intense and less predictable in the future.

Environmental degradation is closely related to and induced by climate change. This implies an increased risks of wildfires and desertification, together with other damaging effects. These are exacerbated by human activities such as unplanned land and sea usage for urban development, agriculture and aquaculture, as well as extraction of resources. The European Commission stresses that environmental degradation is a risk driver since functioning ecosystems are critical for DRR and mitigation as they support "regulation of climate, pests and diseases, water retention and flood control, landslide prevention and coastal protection" (European Commission, 2020a).

Such factors create a rich context in which compound environmental risks, affecting air and water quality and food security, can easily emerge. For example, in 2019, the number of deaths from cardiovascular disease attributed to air pollution in Europe was found to be nearly 800,000 a year (Lelieveld et al., 2019).

A dedicated Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) report focused on Europe and Central Asia highlights that 28% of the assessed species living exclusively in Europe and Central Asia are threatened. Land-use change has been identified as the major direct driver of the loss of biodiversity (IPBES, 2018).

The European Environment Agency (EEA) report, *The European Environment – State and Outlook 2020*, warns that Europe's environmental challenges have reached an unprecedented scale. The alarming rate of biodiversity loss and the overconsumption of natural resources must be addressed, for which only a narrow window of opportunity in the next 10 years exists (EEA, 2020a).

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Driver 2: Interconnected and complex economies, societies and infrastructure

European and Central Asian countries are tightly interconnected – internally as well as among States. This connectedness relies on effective infrastructure of all types. Such infrastructure ensures the provision of services such as energy, transportation, water, food, communications, health and emergency response, as well as financial operations. Significant parts of these systems are developed and are thus of high value. The challenge is that many parts of the infrastructure are ageing and not resilient and thus do not protect against known risks and could pose risks themselves.

The Sendai Framework identifies the resilience of critical infrastructure as a key component for DRR. This is in line with Sustainable Development Goal (SDG) 9 of the Transforming our World: the 2030 Agenda for Sustainable Development, which aims to "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" (United Nations, General Assembly, 2015b).

Critical infrastructure enabling services are increasingly subject to a wide range of hazards, while being interconnected and interdependent in a complex manner that facilitates spreading impact in the case of a disaster. Therefore, damaged or destroyed critical infrastructure triggers cascading effects such as the disruption of further essential services (European Commission, 2020a).

Europe will experience a significant increase in multi-hazard, multisector damage in the next few decades. Damage for European countries is expected to increase from €3.4 billion annually in 2015 to €38 billion by 2080 (Forzieri et al., 2015). The largest increase in damage is expected to occur in the energy sector – from €0.5 billion annually in 2015 to an estimated €8.2 billion by the 2080s – and the transportation sector – from €0.8 billion annually in 2015 to nearly €12 billion by the end of this century.

The Sendai Framework Monitor reports that, in 2018 alone, 1,669 infrastructure assets in 18 countries in Europe and Central Asia were damaged or destroyed due to disasters, amounting to direct economic losses of over $3 billion (UNDRR, 2020a, 2020b).

Many critical infrastructure assets are subject to risk assessments in the construction phase, or an environmental impact assessment. The problem is that most risk assessments and environmental impact assessments consider only potential hazards posed by the new asset to the natural environment – external hazards, interdependencies or creation of new vulnerabilities are not typically captured. As a result, the scale of risk connected to the increasing volume and accelerating decay of infrastructure systems is still not fully integrated into planning or risk assessment processes (UNDRR, 2019a).

While climate-related hazards have an increasing probability, so too do biological hazards such as pandemics, although with lower frequency. Even though their impact does not typically corrode steel or erode concrete, these hazards can have a high impact, even on infrastructure. This highlights the importance of properly

Aerial view of flooded houses with dirty water of Dnister River in Halych town, western Ukraine functioning and fit-for-purpose infrastructure for the provision of essential services and sensible assessments of the potential disruption that could be provoked by failure.

Assets and services that had previously not been considered critical have become paramount in dealing with the public health crisis. Changes in normal habits and the sudden demand for online services have revealed the need for more robust information technology (IT) infrastructure and security (Deloitte, 2020). The shift in demand for health-care services, defined by a decrease in routine and non-urgent medical checks and the increase in the need for specialized acute care services, has caused unexpected costs for hospitals and medical centres (Sharma et al., 2021). The requirements to ensure safe and reliable vaccination infrastructure, which comprises development, production, transport and storage of vaccines, reveal the rich web of dependent systems that must be considered to be critical.

Countries' primary concern should be to strengthen their preventive, preparedness and resilience measures for any future disasters based on the lessons learned from the COVID-19 pandemic. Countries also need to adopt several non-pharmaceutical measures, and a robust, multifaceted approach when returning to normality (Hemachandra et al., 2022).

The world was largely unprepared for the COVID-19 pandemic. Concerted action from international organizations, governments, the private sector and civil society was required. It is essential to learn lessons from the pandemic and to strengthen infrastructure to be better prepared in the future, even for hazards of low probability.

The increasing pace of digitalization, which is transforming European and Central Asian societies, economies and infrastructure, brings a range of opportunities and challenges. Technologies such as the fifth generation of mobile technology, cloud computing, the Internet of Things, blockchain and artificial intelligence (AI) provide numerous opportunities, but could also pose significant threats.

As the European Commission outlines, actors are pursuing increasingly diverse and sophisticated malicious cyber activities, aimed at financial gain, political/social disruption or hacktivism. Two main weaknesses of the existing infrastructure within the European Union have been identified: prevalent ageing and legacy systems can be attacked more easily, and growing digital connectivity with more access facilities provides for increased potential for disruption for malicious individuals or groups (European Commission, 2020a).

Driver 3: Changing demographics

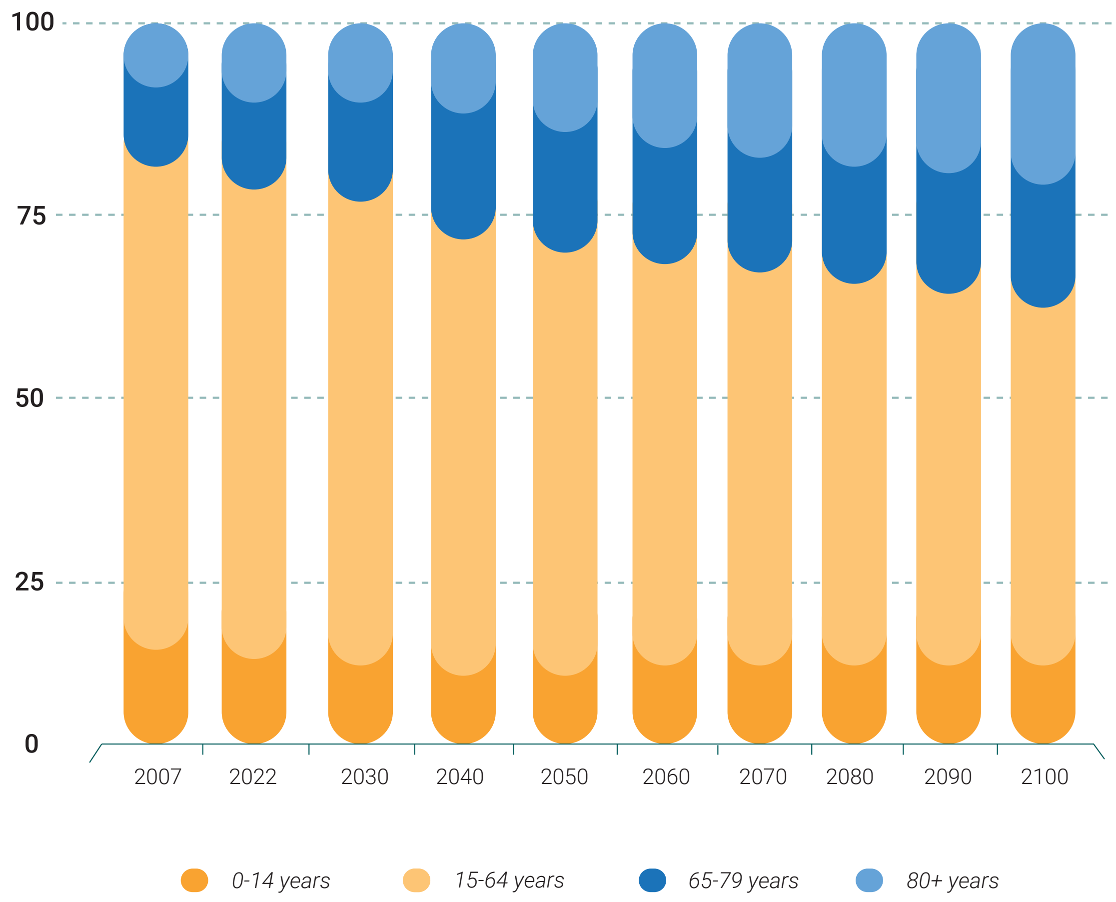
It is estimated that the global population will reach approximately 9.7 billion by 2050, and will grow to 10.4 billion by 2100 (UN DESA, Population Division, 2022). The population of the European Union is projected to increase for the 5 years from 2022, followed by a steady decline until the end of the century, while net migration is projected to remain positive at an annual average of 1.2 million throughout the period (Eurostat, 2023). The European Commission projects that the European Union's population is expected to reach its highest point, with approximately 449.3 million people, around the year 2026. After that, it is anticipated to gradually decrease, reaching 416.1 million by the year 2100.

Another noteworthy aspect of population ageing is the continuous ageing of the elderly population. This means that the proportion of very elderly individuals is increasing more rapidly than any other age group within the European Union's population. The projected data indicate that the percentage of individuals aged 80 years or older in the European Union is set to undergo a significant 2.5-fold increase from 6.1% in 2022 to 14.6% by the year 2100 (Eurostat, 2022) (see Figure 3).

The situation in Central Asia is different. The total population of the five countries grew by 36% or almost 20 million people from 2000 to 2020 (World Bank, 2022a). Therefore, the Central Asian population is consequently relatively young – on average only 5% of the people are older than 65 years old (World Bank, 2022b).

By 2050, it has been estimated that 84% of the population o Europe will be living in urban areas, compared to 75% in 2020 and 70% in 1990 (UN DESA, 2018). Population growth and rapid urbanization have links to the above risk driver of climate change and environmental degradation, as well as to interconnected economies, societies and infrastructure.

Figure 3. **Population structure by major age groups, European Union, 2007–2100 (% of total population)**



Note: 2022: provisional / estimated. 2030-2100: projections (EUROPOP 2023).
Source: Eurostat (2022)

Risks and vulnerabilities are changing as Europe continues to age and urbanize, and countries face displacement in addition to migration. Older people as well as displaced people and migrants are disproportionately exposed to risk and disproportionately suffer in disasters. The resilience of societies in Europe is therefore decreased as a whole.

Disasters triggered 101,000 new displacements across the Europe and Central Asia region in 2019, more than double the figure for 2018 (IDMC, 2020). These displaced people, as well as migrants from outside Europe and Central Asia, are vulnerable due to their limited socioeconomic. Their vulnerability, exposure and coping capacities are often influenced by living in or transiting hazardous locations, and by limited access to information they could use to obtain basic services and assistance to reduce their risk.

Many older people are at higher risk due to compromised health conditions, which can exacerbate other social and economic disadvantages. Older women are often even more vulnerable because of additional gendered disadvantages.

Extreme weather also disproportionally affects older people. The 2003 heatwaves led to over 18,000 heat-related deaths in France (Singh et al., 2019). Another study found that "excess deaths during heat waves

1) occur predominantly in older individuals and 2) are overwhelmingly cardiovascular in origin" (Kenney et al., 2014). The United Nations Economic Commission for Europe (UNECE) has proposed measures to address the needs of older people, such as the inclusion and also the engagement of older people in the development of preparedness plans (UNECE, 2020).

In addition, the Sendai Framework explicitly notes that "youth leadership should be promoted". It calls on governments to engage with children and youth in the design and implementation of policies, plans and standards. It also highlights that "children and youth are agents of change and should be given the space and modalities to contribute to disaster risk reduction in accordance with legislation, national practice and education curricula" (United Nations, General Assembly, 2015a).

An increasing number of young people are marching for climate action and social justice. Youths are real agents of change. Their anxiety about how climate change is triggering a growing number of disasters is being leveraged on social media, thus increasing the public pressure on decision makers. Youth groups and representatives should be properly equipped and supported to influence and advocate within their communities to increase efforts in preventing disaster risk and building resilience. Engaging with young people will help Member States to keep the promises they make. By consistently speaking truth to power, young people will energize the multilateral system and foster change.

The drivers described above set the context in which the challenges in the next chapter must be addressed. This is not a matter of fixing the interconnectedness of systems, fixing climate change or fixing demographic changes – but ignoring those drivers while facing the challenges below will result in failure. This raises a new challenge for governments: coming to grips with the drivers above while working against the risks outlined below.

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Young activists marching on streets with banners at youth strike for climate in protest of climate change policy, Warsaw, September 2022

Chapter 3: Challenges

This chapter outlines some of the major challenges affecting Europe and Central Asia. They are not exhaustive and are not exclusive, but represent important challenges with which policymakers, risk scientists and societies will have to grapple in the coming years to ensure resilient, risk-informed development.

Each of the challenges refers to the three key risk drivers and concludes with recommendations specific to the challenge area and which can be generalized to broader risk reduction practices.

Challenge 1: Reducing the risks of extreme wildfires

This challenge is based on *Evolving Risk of Wildfires in Europe* (E-STAG, 2020). It addresses the evolution of risks of wildfires[3] in general without targeting a specific country or subregion. The evolving and exacerbating factors, the risks and the proposed solutions apply to the whole of the Europe and Central Asia region.

Ververidis Vasilis / Shutterstock.com

Forest fire in the prefecture of Evros in northern Greece, 21 August 2023

3 The term "wildfires" – also known as "forest fires", "bush-fires" or "wildland fires" – is commonly used to refer to unwanted fires that burn forests and wildlands (Balbi et al., 2007; Castro Rego et al., 2018; Tedim et al., 2018).

Background

Climate change, human behaviour and several other underlying factors are creating the conditions for more frequent, intense and devastating wildfires. Alongside efforts to combat climate change, this new context requires adapted policies to shift the focus from suppression to prevention, as called for by the Sendai Framework. In addition, more productive relationships between science and governance mechanisms, a better use of risk knowledge and greater awareness among populations on the need to change behaviour are needed.

For example, the wildfire season of 2022 was the second worst since the Copernicus European Forest Fire Information System (EFFIS) records started in 2000, with 2017 being the worst to date. In 2022, EFFIS observed 45 countries, where 16,941 fires burned a total of 1,624,381 ha (an area approximately the size of Montenegro). Spain, Romania, Portugal, Bosnia and Herzegovina, and France were the top five countries affected, excluding Ukraine (European Commission, 2023b).While final figures for 2023 are yet to be revealed, EFFIS data on 22 July 2023 already noted the burned area as more than 40% above the average recorded over the period from 2003 to 2022 (Copernicus, 2023a).

Available fuel, ignition sources, weather and people are factors affecting wildfire activity (Ganteaume and Jappiot, 2013). For instance, Koutsias et al. (2012) demonstrated that the synergistic effect of fuel and weather can explain the occurrence of large and catastrophic wildfires around the world, such as those in Greece. Other studies have shown that the likelihood of extreme seasonal mean temperatures has significantly increased in the past few decades and suggest that extreme wildfire activity around the world is associated with periods of extreme temperatures (Flannigan et al., 2009, 2013). An analysis of the devastating wildfires of 2022 in Southwest Europe (European Commission, 2023b), including in France, Portugal and Spain, noted that the earlier occurrence of the fire season was associated with "record-breaking values of fuel dryness, atmospheric water demand and pyrometeorological conditions" (Rodrigues et al., 2023).

An increase in droughts has also been observed, and projections suggest more severe and widespread droughts in the future under global warming (Dai, 2013; UNDRR, 2021b). Droughts can be a contributing factor to wildfires due to their influence on the environment and the increased availability of fuel. During droughts, fuels have a reduced moisture content and become more flammable. Droughts can also increase the probability of ignition and the rate at which a wildfire spreads (NIDIS, n.d.).

The properties of vegetation influence how a wildfire burns. For instance, some vegetal species are more flammable than others. The thickness[4] of the fuel is also an important factor. Studies have emphasized the major role played by fine fuel[5] in the propagation of a fire through vegetation. In addition, fuel moisture content is one of the most critical parameters (Awad et al., 2020). It conditions the ability of a fire to spread and its rate of spread (Chatelon et al., 2017; Balbi et al., 2020).

At a larger scale, the spatial distribution of the fuel can greatly influence fire spread. There are two types of spatial distributions: vertical and horizontal. Vertical distribution is related to fuel layers (from duff to tree canopies). If these layers get close to each other or overlap, a "fuel ladder" exists that may create intense fires involving all vegetation at once. The horizontal distribution represents the fuel layout on the ground and has a strong influence on fire spread. They affect the occurrence of crown fires and can create heterogeneous fire patterns (Rossi et al., 2019). Therefore, the fire risk for abandoned land with an accumulation of dead fine fuel is higher than that for managed land.

Climate change and land-use change are projected to make wildfires more frequent and intense (UNEP, 2022). A global increase of extreme wildfires of up to 14% by 2030, 30% by the end of 2050 and 50% by the end of 2100 is expected. Although the occurrence and behaviour of wildfires are driven by complex processes, the bottom line is that a warmer world will have more wildfires.

4 "Thickness" refers to the density or volume of the vegetation that can potentially serve as fuel for a wildfire. It is important to understand how densely packed or thick the vegetation is because it directly affects the intensity and spread of a wildfire.

5 "Fine fuel" is the smaller and more easily combustible materials within a vegetation environment. Fine fuel typically includes dry leaves, twigs, grasses and other small plant materials that ignite quickly and can help a wildfire spread rapidly. A fine fuel can ignite easily and act as a bridge, allowing the fire to move through the vegetation more readily. Its presence or absence can significantly affect the behaviour and progression of a wildfire.

Recent impacts

Many countries in Europe and Central Asia continue to experience severe wildfire events, despite an increase in fire suppression budgets. Examples illustrate how forest fires can quickly become out of control (Greenpeace France, 2020; Zong et al., 2020). Despite the increased level of preparedness about 340,000 ha were burned in the European Union in 2020 – an area exceeding the size of Luxembourg by 30% (European Commission, 2021)). In 2020, experts noted that "forest fires across eastern Siberia have increased in number and intensity in a way that is very similar to the same period last year" (Levresse, 2020).

In 2021, devastating wildfires ravaged large areas of South and South-eastern Europe, Finland, Israel, Türkiye and the Karelia and Siberia regions in the Russian Federation – this pattern is becoming increasingly familiar as similar events happen every year. For example, in 2023, heatwaves and wildfires have marked a summer of extremes, with thousands of people evacuated in parts of the Mediterranean due to fires (WMO, 2023d).

In Europe, approximately 85% of the total burned area of land is due to wildfires in France, Greece, Italy, Portugal and Spain (European Commission, 2020b). Most of the damage caused by forest fires is due to a few large wildfire events, which represent less than 2% of the total number of wildfires. Studies have shown that by the end of the century, the likelihood of catastrophic wildfire events will increase by a factor of 1.31 to 1.57 (UNEP, 2022).

Juan Garcia Hinojosa / Shutterstock.com

Wildfire in a steep and rocky area in the Tagus river valley during an extreme heat emergency day, Spain, July 2023

Connected themes

Changes in climatic and weather conditions are one of the major reasons for the increase in wildfire hazard and risk (Benson et al., 2008; Sommers et al., 2011). As global temperatures increase, and droughts become more frequent, wildfire seasons will be prolonged in many ecosystems. Thus, new areas formerly not at high risk of wildfires will be affected in the future (Jolly et al., 2015).

It is generally recognized that anthropogenic factors have also contributed to increased wildfire risk globally (Rossi et al., 2019). These include the modification of land use, rural exodus and the abandonment of previously cultivated land. This context is exacerbated by rapid, unplanned urbanization in wildland urban interfaces (WUIs), fire exclusion policies[6] that contribute to fuel accumulation, and a focus on wildfire extinction, rather than an effective prevention strategy. A combination of all these factors means that the risk of wildfire is likely to increase substantially in the future, and that extreme catastrophic wildfire events could occur more frequently.

EEA and IPCC reports (Handmer et al., 2012; Smith et al., 2014; EEA, 2017) briefly address the health impacts of wildfires, although the health impacts associated with other extreme weather events, such as floods or storms, are given more prominence (Kovats et al., 2014). This reflects a need for a coherent global understanding on the topic, particularly as projections of more intense wildfires put many urban communities at greater risk. Pollution and health impacts are also recognized by the Sendai Framework as cascading effects that need to be considered in improving risk reduction and sustainable development.

Wildfires can have negative impacts on human health across a large range of scales, and are likely to contribute to human health impacts across the region. People directly affected by wildfires, such as civilians in the immediate vicinity or first responders, can suffer a broad range of physical and mental health impacts related to heat, stress and emissions. And just as wildfires can cross borders, so can the health impacts related to air quality. A country downwind from a wildfire may suffer health effects without any primary damage on its own territory. Indirect effects such as illnesses related to respiratory stress can vary in scale and can affect human health, especially over larger and more densely populated urban areas.

Wildfire emissions contain a dangerous mixture of components that can affect air quality and thus human health over a range of spatiotemporal scales. Many of the emitted components, such as carbon monoxide (CO), are an immediate health risk to those in close proximity to the fire (Miranda et al., 2012). Inhaling CO decreases the body's oxygen supply. This can cause headaches, reduce alertness and aggravate a heart condition known as angina. During increased physical exertion, cardiovascular effects can be worsened by exposure to CO and particulate matter.

Due to the scale of emissions, the dispersal of pollutants over thousands of kilometres and the impacts on atmospheric processes, wildfire emissions can affect air quality and human health across regional or even larger scales. Wildfire emissions have contributed to increased levels of pollutants including ozone and particulate matter in regions far from the fire (Hänninen et al., 2009; Martins et al., 2012).

If a wildfire occurs in an area contaminated by radionuclides, the resuspension of radioactive particles in the atmosphere can be transported long distances and can have additional impacts on the health of populations (Ager et al., 2019). The fire observed in the Chernobyl region in April 2020 illustrates that such knock-on impacts are not purely hypothetical and should be of concern to other countries and subregions.

Smouldering fires produce similar carbon dioxide (CO_2) emissions but significantly more CO and methane than flaming fires (Moreno et al., 2011). Peat wildfires, resulting from the conversion of forests for agricultural activities or the domestic use of peat, also constitute a public health problem, largely because of the high volume of carbon particles emitted into the atmosphere by the burning process (Hu et al., 2018) and the long duration of such fire events. As global warming is likely to have a greater impact on boreal regions, the problem of peatland fires could increase significantly during the coming decades, especially in the Russian Federation and Northern Europe.

The increasing frequency of intense fires, WUI expansion, and a growing and ageing population are increasing the number of people at risk from wildfire smoke (Cascio, 2018). This highlights the need for better population exposure tools and for broadening stakeholder cooperation to understand and address the health effects of wildfires.

6 "Fire exclusion" means deliberately excluding or preventing fire in an area (USDA, n.d.).

Air pollution from wildfires has been consistently associated with respiratory outcome (Liu et al., 2015), with less evidence available on cardiovascular effects (Dennekamp et al., 2015) and other health endpoints (e.g. kidney disease). Certain populations are more at risk, such as the elderly, young children and those with pre-existing illness or disabilities. They are likely to be more intensely affected and have less capacity to adapt (Youssouf et al., 2014).

The lack of health cost data for wildfires in European countries is worrying. Several studies from the United States of America have found that smoke health impacts are an important consideration in the overall costs of wildfires (Thomas et al., 2017). In addition to the health effects of smoke, wildfires can cause health risks through damage to infrastructure. Such ripple effects can take the form of contaminated water distribution systems, and pipes, meters, valves and fittings can show levels of volatile organic compounds and benzene above acute and chronic exposure limits. While the multiple health costs from forest fires and the cost of adaptation will rise in the future, adaptation measures such as wildfire smoke forecasting systems hold promise of multiple health co-benefits.

Relevance of the risk drivers

Three underlying factors can trigger destructive wildfires: climatic conditions, fuel availability and human behaviour.

Climate change and environmental degradation

The indirect effects of climate change, such as the creation of heavy loads of dead or dry fuel, are often responsible for the increase in extreme wildfire events. Fire exclusion over long periods also allows for increased fuel density and creates conditions for extreme wildfires. In a mixed conifer forest, natural wildfires occur every 5–15 years and tend to be of lower intensity. Although the existence of abundant dead vegetation is climate related, it is also linked to land management practices.

Temperature, precipitation, wind and atmospheric moisture are major drivers of wildfire activity. The influences of weather and climate – along with variations in terrain and fuel – are therefore important for understanding the scale of wildfire events (Cary et al., 2006).

Climate change and exceptional weather conditions such as the heatwaves and droughts recorded in Europe in recent years are likely to have a considerable impact on wildfire risk.

From 1979 to 2013, the global area burned by wildfires amounted to 350 million ha per year, and annual pyrogenic CO_2 emissions were equivalent to over 50% of combustion emissions from fossil fuels (Jolly et al., 2015). The findings also indicated a 19% rise in the global average length of wildfire seasons, as well as an increase in the number of fire-prone areas in that period.

During the first half of 2019, severe droughts and heatwaves affected the Western Mediterranean region of Europe, prolonging the wildfire season (Prat-Guitart et al., 2019). In Spain, these conditions led, in June 2019 alone, to five large wildfires that burned over 13,000 ha. The largest of them, known as La Torre de l'Espanyol, affected 6,500 ha in the north-east region and burned for 5 days through shrubs, forest and abandoned agricultural lands, causing roads to be cut off and evacuation of homes.

On 8 January 2021, the Copernicus Climate Change Service and the Copernicus Atmosphere Monitoring Service provided a global picture of 2020 temperatures and CO_2 levels (Copernicus, 2021). Data showed that, globally, 2020 was the warmest year on record for Europe. In January 2022, they reported that Europe experienced its warmest summer on record in 2021, accompanied by severe floods in Western Europe and dry conditions in the Mediterranean (Copernicus, 2022). And January 2023 was the third warmest on record in Europe (Copernicus, 2023a). In addition, it has recently been confirmed that July 2023 was the hottest month on record globally, and that global sea surface temperatures also reached record highs (Copernicus, 2023b).

The evidence indicates that in Europe, all seasons are warmer than they have been historically, and that most subregions are warmer than average, especially in Eastern and Southern Europe. Concentrations of CO_2 in the atmosphere are also on the increase. Such increases in average temperatures have a significant impact on wildfires. The figures recorded during winter are particularly interesting because of the impact on vegetation. In Northern and Southern Europe, ecosystems have become more fragile, the mortality of trees has increased and higher temperatures have prolonged the wildfire season. Several significant wildfires have been observed in the Mediterranean regions, even in the winter months of December and January. Moreover, hot and dry winters create the conditions for high-risk wildfire seasons during the summer. The climate largely determines ecosystem characteristics (Bailey, 2010) and fire regimes (Flannigan et al., 2009).

The influence of climate change on wildfire hazards remains a complex issue. Based on the work undertaken by the Joint Research Centre of the European Commission through the PESETA III project (de Rigo et al., 2017), EEA presented a study on how Europe could be affected by several climate risks (including wildfires) during the twenty-first century (EEA, 2020b).

Substantial warming and an increase in the number of heatwaves, droughts and dry spells across the Mediterranean region provide an important driver of wildfire risk. Climate change could increase the length and severity of wildfire seasons, as well as the size of the area at risk and the probability of extreme wildfires. Models suggest that changes in the length of wildfire seasons will continue, and that they will become the most pronounced at the end of the century and for northern high latitudes where fire seasons could be prolonged by more than 20 days per year.

Interconnected and complex economies, societies and infrastructure

The new context of increased urbanization and inconsistent land use requires new strategies to reduce the risk of wildfires and thereby decrease their economic, environmental and social impacts. Climate change and human behaviour are helping to create the conditions for more frequent, more intense and devastating fires in Europe over the next century. This requires fire management policies that include fuel treatment, prevention measures based on weather forecasts, early warning systems, stronger focus on population awareness, and strategies and techniques that integrate the use of controlled fires, as well as an institutional shift in focus from suppression to prevention (Dunn et al., 2017). It is critical to introduce the fact that, while the multiple health costs from forest fires and the cost of adaptation will rise in the future, proactive adaptation measures may also bring multiple health co-benefits.

There is an increase in the number and frequency of extreme wildfires, for which ecosystems, communities or firefighting methods are not adapted.

As wildfires grow more frequent and intense, their nature is also changing (Attiwill and Binkley, 2013; Ganteaume and Jappiot, 2013). Since the 1980s, there has been a decrease in the total burned area in Europe's most affected countries, apart from in Portugal (Castro Rego et al., 2018). This is reflected in the magnified impact of extreme wildfires. Researchers have shown that destructive wildfires can occur independently of the available fire means in the countries and become under control only when the weather conditions facilitate firefighting (San-Miguel-Ayanz et al., 2013).Therefore, despite a rise in fire suppression budgets, the impacts of climate change may lead to unprecedented risks related to wildfires in many parts of the world.

The increase in highly intense wildfire events appears to be correlated with several factors. In the south of France, between 1997 and 2010, fires that burned more than 100 ha were responsible for 78% of the total burned area (Ganteaume and Jappiot, 2013). These wildfires spread predominantly during periods of drought in densely populated areas characterized by high shrubland cover. This suggests that the size of burned areas was largely dependent on wildland vegetation, long periods of dry weather in summer and wet weather between autumn and spring. These wildfires may also be correlated with pressure from tourism, rural exodus and land abandonment (due to high rates of unemployment) and WUI expansion.

A better understanding of the intimate relationships between ecosystems and wildfires is required. Fires have been an integral part of ecosystems for the past 20 million years (Dubar et al., 1995) and are not uncommon events on a global scale. But land abandonment and fuel accumulation are factors that correlate with the occurrence of extreme wildfires and increase fire risk (Pausas and Paula, 2012).

Changing demographics

In Europe, traditional burning has ceased in many places (Castro Rego et al., 2018), thus creating a paradox around the benefits of managed fires and the impact of wildfires. The role of human behaviour goes beyond the question of fire management. People are abandoning previously cultivated land, thereby extending fire-prone areas (Salis et al., 2022). For instance, in the Western Mediterranean region of Europe, fuel loads are now greater than ever before due to rural abandonment and depopulation resulting from the decline in rural economies (Prat-Guitart et al., 2019).

In other places where wildfires have often occurred, there has been an increase in population density. The expansion of WUIs into fire-prone areas exacerbates exposure and vulnerabilities (Modugno et al., 2016). WUIs are areas where human-made structures are located in or are adjacent to fire-prone areas. These densely populated areas do not have proper wildfire protection measures in place and have an increasing number of citizens who are unaware of the risks (Moritz et al., 2022).

When this complex fire environment is ignited, it often has severe ecological and socioeconomic consequences. Therefore, research on the linkages between extreme wildfire events and human activities is of paramount importance, and requires closer cooperation among scientists, policymakers, local authorities, fire managers and civil society. In addition, strategies and techniques that integrate the use of managed fires, management options for restricting the potential spread of fire, and long-term options that include an increase in the rotation and change of tree species should be promoted (Khabarov et al., 2016). This calls for a strategy for wildfire landscape management to reduce damage and maximize the benefits of fire (Stratton, 2020).

Even though the link between wildfire risk and climate change is complex, it is evident that if trends are confirmed, and if coupled with ignition sources and the availability of fuel, they could have a significant impact on ecosystems and the nature of wildfires, and could also disrupt societies and economies.

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Firefighters and volunteers use water hoses to extinguish a house on fire, Athens, 22 August 2023

Recommendations to reduce risk

Scientific evidence is clear about the role of human activities and climate change in driving and reducing disaster risk – wildfires are no exception. Rapid urbanization and inadequate land-use planning also represent a growing threat. Therefore, in addition to measures to support the global battle against climate change, appropriate risk reduction policies are needed to ensure the risk of wildfires is minimized, and that their potential spread is reduced.

It is time to develop appropriate risk reduction strategies and minimize the impacts of destructive large-scale wildfires.

Integrate realistic social behaviour

Anthropogenic factors contribute to an increase in wildfire risk. The behaviour of people, companies and government entities before, during and immediately after a disaster can notably affect the impact and recovery time. Unfortunately, existing risk assessment methods rarely include these critical factors (Haer et al., 2017; Aerts et al., 2018).

These factors also partly explain the increased fire risk in fire-prone areas or in places where wildfires have already occurred. The same is true of abandoned lands where fire fuel is no longer managed by agricultural workers, and which then become fire-prone areas.

Researchers have claimed that individuals behave according to a threshold of concern decision rule when considering protection against risk. In other words, people ignore the probability of disaster risk if the probability is judged to be below a threshold, and assess the likelihood of an event by how easily similar examples come to mind (Robinson and Botzen, 2018; Robinson, 2019).

In January 2020, many countries believed that a COVID-19 pandemic was highly improbable. This resulted in slow or inadequate adoption of preparedness measures.

Neglecting realistic societal behaviour means that policymakers do not have accurate information upon which to base their strategies. Socioeconomic factors and human behaviour need to be further analysed and included in risk assessments. One way of doing this could be to adapt models applied to floods, such as the agent-based-modelling approach (Haer et al., 2017):

- Policymaking processes, development plans and land-use planning exercises need to more effectively integrate wildfire risk to limit exposure, avoid the creation of new risks and promote sustainable agricultural practices that can help reduce the availability of fuels and improve the management of forests.

- Changing human behaviour requires efforts to disseminate information, raise awareness and educate people about risk. Specific actions aimed at nudging social behaviour such as economic incentives, regulatory changes, advocacy campaigns, the use of social media and on-site information are particularly important for reducing risks associated with tourism, outdoor activities or gardening. The public's understanding of the benefits of reducing wildfire risk and their responsibilities to do so should be improved.

- Socioeconomically vulnerable populations need to be identified. Specific populations are notably vulnerable to the effects of wildfires (Méndez et al., 2020). For example, systemic inequalities, including poverty and overcrowded households, lead to disparities in responses to wildfires (Palaiologou et al., 2019). It is therefore crucial to understand how these events amplify existing inequalities and how to mitigate the resulting damage.

Shift from suppression to prevention of wildfire

Expenditure on fire suppression is increasing. However, this reactive approach is often inefficient and ineffective for extreme wildfires. This is especially true when the costs of fire suppression are compared to the costs of preventive action. For example, evidence in 2015 from National Park Service lands in the United States of America demonstrated that fire suppression cost approximately $2,100 per hectare, while preventive measures such as prescribed burning cost only $200 per hectare (USDA, 2015).

The Food and Agriculture Organization of the United Nations states that "Fire prevention may be the most cost-effective and efficient mitigation programme an agency or community can implement" (FAO, 2006).

In 2016, a study based on the concept of a "fire smart territory" argued that wildfire policies in European Union countries do not adequately address the root of the problem and are unlikely to be effective in the future because they focus predominantly on suppression and/or on preparedness for a wildfire event (Tedim et al., 2016). Many countries therefore still face extreme wildfire risk. In Europe, a transboundary strategy for wildfire landscape management is required to build on existing national plans and measures and move beyond a focus on fire suppression. Zong et al. (2020) analysed fire weather and fire regimes in Central Asia from 2001 to 2015. The study area included five countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. It was shown that the burned areas of this part of the world could increase by 2–8% between 2021 and 2050 and by 3–13% between 2071 and 2099. In conclusion, the researchers claim that it will be necessary to improve and adapt wildfire management to future climate change in the region.

The allocation of resources should build on knowledge of risk to develop efficient fire risk policies (Castro Rego et al., 2018; Rossi et al., 2019); these would include elements such as:

- A legal obligation for homeowners to maintain a standard defensible area around their homes, making properties much easier to defend while protecting surrounding fuels from accidental wildfires.
- Improved regulation of individual prescribed fires and outdoor activities to prevent accidental fires.
- Systematic creation and maintenance of specific roads and tracks with associated fuel breaks in fire-prone areas. As seen in Germany and several other countries, this type of action supports prevention, preparedness and response to fires by breaking up the continuity of fuels, improving access for firefighters and providing shelter.
- Promotion of a strategy for wildfire landscape management to sustainably manage and monitor fuel cover over time, to reduce fire hazard/risk and help decrease intensity in the event of a large wildfire under extreme conditions.
- Improved and more frequent use of prescribed fires as a management tool.
- Consideration of the long-term adaptation of vegetation to climate change and the potential impact on fire risk.
- Increased use of models to anticipate changes in fire risk and to adapt measures and policies and develop innovative legislation in fire-prone regions. There is an interest to institutionalize the use of accurate fire risk maps to support land-use planning, and risk-informed public and private investments.
- Systematic alignment between climate change and DRR efforts focusing on fire risk, including the protection of biodiversity, promotion of green infrastructure and development of long-term weather forecast systems.
- Promotion of incentives to stimulate risk reducing activities. It has been advocated that in the face of climate change, insurance companies are well placed to stimulate risk reduction by providing incentives (Haer et al., 2017).

Improve awareness and risk information

While wildfires cannot be completely avoided, improved warning systems can significantly limit their impact (Moatti and Thiébault, 2016). Public communication must develop to reflect the evolving nature of wildfires in Europe and Central Asia. Populations must learn how to live with wildfire risk, as with other hazards (E-STAG, 2020). Effective risk information should consider differences in education and in social and cultural backgrounds within communities, and develop appropriate channels of communication and messaging. An integrated fire risk policy could include the following awareness-raising steps:

- Develop more specific information about the causes of fires, thus reducing risk through education and knowledge and by creating a fire consciousness.
- Increase government knowledge on how extreme wildfires require different resources, skills, appropriate regulations and prevention policies, in addition to emergency management.
- Improve communication between populations and rescue services.
- Prepare communities for a fire event, as is done for floods or earthquakes.
- Provide methods for analysing fire risk and interdependencies of critical infrastructure systems such as transportation, water, the Internet, electrical power systems and road networks (Hokstad et al., 2012).
- Identify useful fire risk reduction measures by improving understanding on how wildfires can spread through a specific system and affect other infrastructure.

Tackle the health impacts of wildfire emissions

The growing frequency of large wildfires, the expansion of WUIs and an ageing population are increasing the number of people at risk from wildfire smoke. There is therefore an urgent need to address the health effects of wildfires more effectively and consistently. The following actions could address knowledge gaps on the health impacts of wildfires:

- Improve methods to accurately characterize and monitor emissions from wildfires and use monitoring techniques to improve atmospheric modelling. This includes the development of chemical transport models to improve the quantification of air quality impact, and exposure assessments for wildfire smoke exposure response functions for specific pollutants.
- Develop a better understanding of less researched health impacts such as increased cancer risk or mental health effects and other health endpoints related to wildfire smoke.
- Study the toxic impacts of wildfires on public and private water systems.
- Identify populations that are particularly at risk and analyse the different impact chains.
- Examine the long-term health consequences of residing in wildfire-prone regions, including the health effects of different types of fuel.
- Use accurate regional predictions to effectively estimate the health impacts and associated costs under a variety of climate and socioeconomic scenarios.
- Develop recommendations for effective and efficient adaptation strategies for public health and forestry sectors in relation to wildfires, including studies of the co-benefits and co-costs of adaptation.

Give science and technology a core role in wildfire risk reduction

The Sendai Framework specifically stresses the importance of integrating science and technology into DRR efforts. However, operational management or decision-making mechanisms do not always adopt the innovations developed by science. One of the main challenges for the coming years will be to bridge the gap between the needs of stakeholders and the production of scientific knowledge and tools. Challenges to address include:

- Fire behaviour, trends and monitoring. While there are now data available and technology is increasingly accessible, the challenge is to identify the relevant data and use them appropriately to reduce risk. This is particularly important for data and tools used to identify fire-prone areas or to detect the initial signs of a fire and pinpoint its location, as well as to understand fire propagation scenarios (Filkov et al., 2018).
- Ecosystem behaviour. Understanding how ecosystems respond to fire is essential for managing landscapes in fire-prone regions (Blodgett et al., 2010; Ganteaume and Jappiot, 2013; Moatti and Thiébault, 2016). For instance, innovative studies on how an ecosystem would respond after a fire occurs or how to develop adaptation plans to improve the resilience of the vegetation to climate change could be of primary interest to forest managers (Andrews and Queen, 2001; Cannac et al., 2009). The effects of changing climate and fire regimes must be better understood.
- Climate and weather forecasts for prevention and fire management. The scale of fire events is often associated with the El Niño–Southern Oscillation and other atmospheric–oceanic patterns. Weather/climate forecasts should therefore be integrated into fire prevention programmes (Sullivan, 2009; Hoe et al., 2018). Even though the relationship between climate change and the changing patterns of forest fires is complex, there is a critical need to more accurately identify the areas where future wildfires are likely to occur (Bedia et al., 2018; Duane and Brotons, 2018). A combination of improvements in climate forecasts and the quantification of the effects of annual/inter-annual climate variability on wildfires would significantly improve wildfire planning in the decades ahead (Sommers et al., 2011).
- Innovative technologies for detection and prevention. Several areas of further research could be encouraged:

    Video surveillance for fire detection such as terrestrial video surveillance systems and extra-terrestrial surveillance based on analysis of satellite pictures.

    Virtual reality simulations for training operational staff. The capacity to respond to an emergency is based on pre-existing knowledge or ability, and also on the degree of familiarity with potential scenarios staff may have to face. Virtual reality simulations can approximate real contexts and constraints, while maintaining all the advantages of a controlled simulation environment.

Promote good practices

Mitigating the risk of an extreme wildfire is a general conceptualization that can involve many factors. The combination of "when to act", "what to do", "how to do it" and "what tools to use" can generate different lines of action. Wildfire-related good practices can be classified using a three-dimensional matrix based on the following dimensions: (a) the domain (technical, social, economic, political, etc.), (b) the approach (study, operational assessment, action, etc.) and (c) the technologies involved. Box 1 presents examples of wildfire-related good practices in various countries within Europe and Central Asia.

Box 1. **Wildfire management prevention and response strategies**

Croatia: Video surveillance

In recent years, firefighters in Croatia have increased the use of video surveillance as a preventive and operational tool for forest fire control. Such video surveillance offers multiple benefits. In addition to the expected increase in fire detection and more timely interventions, it acts as a psychological deterrent as potential fire-starting offenders are now aware their actions are being monitored and will be sanctioned.

Germany: Effective landscape fires

In Germany, statistical data of landscape fires are available only for lands classified as forests. These statistics reveal that since the mid-1970s, the average total forest area annually affected by fire in Germany has ranged between 200 and 500 ha, with an average size of fire events of around 0.5 ha.

The low occurrence and impacts of forest fires is attributed to the temperate climate characterized by a balanced distribution of precipitation, the healthy conditions of intensively managed forests, the high density of a forest road network (accessible for large logging trucks and thus also for fire service vehicles), the dense array of rural volunteer fire and rescue services, the public observation of legal restrictions and prohibitions on the use of fires in forests and agricultural lands, and disposal of vegetation residues (Goldammer et al., 2012; Goldammer, 2019).

Portugal: Fire legislation

Fuel management laws in Portugal have been amended. The aim of these amendments is to provide guidance on the creation of fuel management bands and to increase the penalties for non-compliance. The Portuguese Government is also investigating other innovative solutions. For example, a pilot programme has been launched to enlist shepherds in fire-prone areas and use goats to clear low-lying fuel.

Slovenia: Forest fire risk forecast system

In Slovenia, an automated daily forest fire risk forecast system with a free web application has been developed using the Canadian meteorological fire hazard indicator (Agee and Skinner, 2005; Stocks et al., 1989; Wotton, 2009). The system uses the ALADIN and INCA meteorological models to provide fire hazard forecasts 3 days in advance. The model is used by different stakeholders in the pre-fire phase, to calculate fire risk and support fire management, before the fire to develop firefighting exercises and for planning during a fire.

Türkiye: Early response

The firefighting policy in Türkiye aims to initiate a first response on wildfires within 15 minutes of detection. Over 40 helicopters are available for the initial sortie and the average time from detection to intervention fell from 40 minutes in 2003 to 14 in 2018. These impressive results were due to an effective fire detection network, extensive road networks and the use of fuel breaks, water impoundments and silvicultural practices in much of the country.

Challenge 2: Shifting to resilient infrastructure

This challenge is based on *Making Critical Infrastructure Resilient: Ensuring Continuity of Service – Policy and Regulations in Europe and Central Asia* (UNDRR, 2020a), with additional contributions from Professor Dilanthi Amaratunga, DRR expert on the European Science & Technology Advisory Group (E-STAG).

Background

Faced with more frequent extreme events, together with increasing population density in cities, the case for more resilient and more reliable infrastructure is compelling. It is critical that the countries of Europe and Central Asia identify and understand the challenges and opportunities for building the resilience of new and existing infrastructure. A crucial factor involves the interconnectedness of infrastructure within the region's emerging green and digital economies. Citizens, policymakers and industry stakeholders must work towards a vision of resilience that ensures critical infrastructure is prepared to absorb and recover from shocks and stresses while maintaining its essential structure, function and identity.

Disasters are predicted for Europe and Central Asia in greater frequency and severity. More rain-related flooding in Northern Europe and more hydrological, agricultural and ecological droughts in the Mediterranean area can be expected (IPCC, 2021). Droughts, floods, storms and rising sea levels could significantly affect the lifespan or operation of critical infrastructure in the energy, transportation and water sectors. In 2019, estimates anticipated a 60% rise in the cost of damages due to extreme weather events in Europe for the 30 year period through to 2049 (EU-CIRCLE, 2019).

Box 2 provides definitions of the types of infrastructure mentioned in this report.

Box 2. Infrastructure terms and definitions

Blue infrastructure	Water bodies, urban wetlands, lakes/ponds, urban rivers/creeks, coastal vegetation, forested wetlands, streams, rain gardens, stormwater ponds, permeable pavement, bioswales, urban drainage and so forth.
Green infrastructure	Urban forests, green spaces, community gardens, urban trees, greenery, green belts, urban agriculture, peri-urban agriculture, nature-based solutions, sponge cities, green roofs, living walls, green buildings and so forth.
Grey infrastructure	Buildings, roads, power supplies, fixed transportation facilities, dams and levees, utilities, public offices, housing and so forth.

The European Union has increasingly recognized the risk to critical assets as well as the need to address interdependencies among sectors. This is reflected in the European Union Civil Protection Mechanism, which extends to partner nations outside the European Union. It states that the protection of critical infrastructure requires the development of mitigation and adaptation measures against risk. The mechanism requires countries to conduct national risk assessments and provide emergency aid and assistance, on request, through the Emergency Response Coordination Centre (European Commission, n.d.a).

The 2008 European Critical Infrastructure Directive established a set of definitions and laid the ground for a common approach in assessing the requirements for protecting critical assets. Even though the Directive was initiated as a response to an evolving terrorist threat across European countries after the 11 September 2001 attacks in the United States, natural and human-made hazards were also included in its scope (Council of the European Union, 2008).

In a subsequent step, a Critical Entities Resilience Directive was proposed. The aim was to establish a framework ensuring that responsible entities can ensure their infrastructure systems can prevent, resist, absorb and recover from disruptive incidents. The causes of such incidents could be natural or anthropogenic hazards, accidents, terrorism or other emergencies (European Commission, 2020c). This Directive was adopted in December 2022 and entered into force in January 2023, with the aim to reduce vulnerabilities and strengthen the resilience of critical entities (Council of the European Union, 2022).The Directive covers 11 sectors providing essential services to uphold societal functions, support the economy, ensure public health and safety, and preserve the environment (European Commission, 2023c).

Awareness of emerging risks has increased, and governments have developed and updated their national legislation and policies. Of the countries participating in the European Union Civil Protection Mechanism, most have integrated floods in their national risk assessments. In addition, some of them have designated floods as a risk to critical infrastructure.

In Central Asia, approaches like Sustainable Infrastructure for Low-Carbon Development (OECD, 2019a) and Regional Economic Cooperation and Integration in Asia and the Pacific (ESCAP, 2020) are examples that focus on developing quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being. These initiatives underscore the importance of collaborative efforts and forward-thinking strategies to address the region's infrastructure needs, ultimately contributing to its long-term prosperity and environmental sustainability.

Some countries have acknowledged and incorporated the use of green and blue infrastructure in their national policies. For example, in Kazakhstan, environmental legislation stresses improvements to ecology to adopt with the new environmental code, providing pathways towards greening the economy and promoting biodiversity, establishing tariffs to encourage renewable energy source development, and implementing emissions caps for the top 50 carbon emitters in Kazakhstan (Cohen, 2021).

A 2008 study by the Swiss Crisis and Risk Network on the development of critical infrastructure protection policies in 25 countries noted the emergence of three trends (CRN, 2009):

- Countries are increasingly investing in integrating resilience measures and adopting all-hazard approaches, taking stock of interdependencies and cascading risk. This is based on the understanding that the comprehensive protection of all assets is extremely difficult, and that prioritization is necessary.
- There has been a shift towards the centralization of responsibility to protect critical infrastructure in some countries, such as Switzerland and the United Kingdom of Great Britain and Northern Ireland.
- Growing concerns around digitization and the dependence on IT infrastructure have led countries to pay more attention to cybersecurity

In many countries, risk assessment of infrastructure considers only the most obvious hazards, and fails to consider non-probabilistic hazards or systemic interdependencies. Scenarios exploring a range of possible threats of varying likelihood and magnitude are rarely considered (OECD, 2019b; UNDRR, 2020a).

Applications of ecosystems or nature-based solutions still seem inadequate, in particular, green and blue infrastructure as a nature-based solution for better preparedness in DRR (De Silva et al., 2022).

Box 3 demonstrates the legislative and regulatory environment for infrastructure.

Box 3. Legislative and regulatory environment for infrastructure

The responsibility for ensuring the resilience of critical assets lies, to a large extent, with the owners and operators of infrastructure – public bodies and private companies. That said, the nature of critical infrastructure as a public good, and its importance for the safety of residents and the continuity of vital services, gives governments and public authorities an inherent and, in most cases, legally defined role in infrastructure protection.

National and local authorities are responsible for establishing legislation and standards, allocating public funds, providing oversight and regulation alongside designated regulators, and fostering cooperation among sectors (Keele and Coenen, 2019; NIC, 2019a; UNDRR, 2020a). Governments are also responsible for creating the environment and the legal framework for the regulation of infrastructure investments and for streamlining sustainability policies in infrastructure projects. National and local resilience strategies and robust national regulatory mechanisms can, therefore, be a powerful tool for influencing the way financial investments are made (NIC, 2019a).

In the case of critical assets, several actors are involved in their design, planning, construction, operation, maintenance and ownership. Traditionally, such infrastructure has been owned and managed by public bodies. However, in recent years, semi-private and private companies have become increasingly involved in these processes. In some countries, public control over critical infrastructure has diminished because of private companies taking over services. Increased private participation can drive necessary innovation and improve flexibility, as well as increase funding opportunities. However, while private owners and/or operators usually recognize the importance of protecting assets, the perception of risk and views on the required level of security, safety and preparedness may differ between public authorities and private businesses.

Recent impacts

Storms are a major cause of disruption to electricity supplies in countries such as Belgium, Croatia, Portugal and Slovenia (Hallegatte et al., 2019). Infrastructure in the Central Asian region is vulnerable to hazards such as spring floods, mudflows, earthquakes and landslides. Central Asian countries also suffer due to extreme weather events such as strong winds, dust storms and sandstorms.

Compared to the European region, Central Asian countries are still developing their critical infrastructure facilities. The areas that require constant attention, investment and management are inter-State systems for seasonal exchange of electric power, development and renewal of power generation capacities and distribution grids. Similarly important is the periodic assessment and constant monitoring of the safety of dams – natural and artificial (e.g. the 2020 failure of Sardoba Dam in Uzbekistan that also affected Kazakhstan and the Lake Sarez natural dam that threatens four countries and about 5 million people). Spring floods and mudflows combined with lack of riverbank reinforcement result in destruction of bridges, roads, villages, agricultural infrastructure and assets. Climate change makes more prominent the danger of sudden floods caused by outbursts of glacier lakes in the mountain areas of Kyrgyzstan and Tajikistan.

Infrastructure resilience strategies and challenges

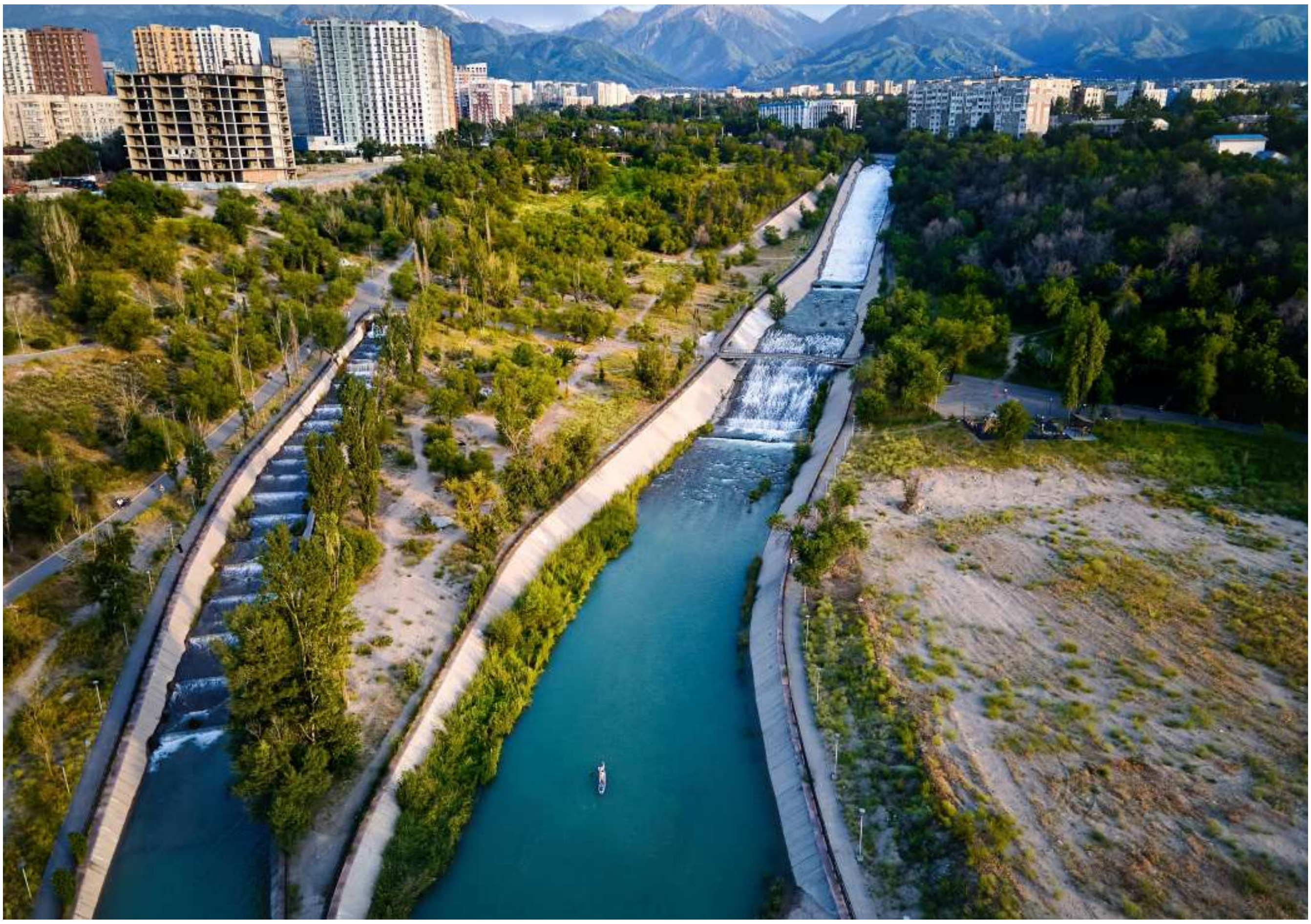
The challenges in understanding impact suffered by infrastructure are exacerbated by shortcomings related to collection of data and reporting on Target D of the Sendai Framework, which calls for “Substantially reduce[ing] disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030” (United Nations, General Assembly, 2015a). According to the United Nations Office for Disaster Risk Reduction (UNDRR) *Sendai Framework Data Readiness Review 2017*, the consecutive monitoring report *Snapshot of Reporting for 2018* on the status of implementation of the Sendai Framework and a report of the ETH Zurich Center for Security Studies (UNISDR, 2017a; Kohler et al., 2020; UNDRR, 2020b):

- There is no commonly agreed definition or understanding of what constitutes critical infrastructure, and especially critical services, resulting in lack of clarity and harmonization of what critical infrastructure includes that needs to be recorded and reported.

- Data quality and data-collection standards and methodologies vary among reporting countries and at times within the different administrative regions of a country. Data are often inconsistent when collected from several sources. Member States face difficulties in identifying all national and local data sources and compiling data in a single format with common definitions.

- Certain data may exist, but they are often “owned” by the private sector, which may not want to share them (e.g. data protection legislation and policies; competition sensitive information) or do not disclose data free of charge.

- The Sendai Framework Monitor requires reporting data disaggregated to type of hazard, geography and socioeconomic status of affected people. It also requires data on Indicators D-4 and D-8 to be provided for each infrastructure and service subsector, but many countries do not have and/or do not provide disaggregated data.



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Aerial view, Almaty, Kazakhstan

In addition, *The Report of the Midterm Review of the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030* finds that the resilience of infrastructure systems has been recognized as a key area of action to support implementation of the Sendai Framework. As such, Member States and stakeholders must place the principles for resilient infrastructure at the heart of developing infrastructure systems, both in upgrading existing systems and integrating risk assessments and data into future projects. This requires assessing the resilience, exposure and performance of existing critical infrastructure (e.g. through stress testing), accompanied by governments integrating resilience as a core value in infrastructure planning and implementation (e.g. building on the principles for resilient infrastructure). The implementation of these measures would contribute to enhancement of the resilience of critical infrastructure systems in Member States by 2030 (UNDRR, 2023a).

Connected themes

An Organisation for Economic Co-operation and Development (OECD) report identified the main challenges for health infrastructure in Europe during the COVID-19 pandemic. These included capacities in hospitals and procurement of necessary equipment and supplies. Delays in cancer diagnoses and treatments may have led to an increase in cancer-related deaths. One lesson relating to health infrastructure can be understood: preparation for biological hazards was insufficient, and as a result, costly containment and mitigation measures were necessary (OECD, 2020).

While it did not cause physical destruction, the pandemic exposed vulnerabilities and limitations of elements of public infrastructure (IRP, 2020). Public transport and public spaces, especially in urban areas, are often crowded and not sufficiently ventilated, which affect sanitation and hygiene conditions, and increase the transmission of COVID-19.

Other aspects of the public health infrastructure include the unprecedented vaccine delivery infrastructure requirement and its supply chain management. This should be kept in place or on standby for other biohazard events.

Green and blue infrastructure bring a variety of benefits for the environment, as well as for human health and well-being. They are therefore important components in building resilience under the sustainable development process. Box 4 presents some examples in the region.

Box 4. **Examples of green and blue infrastructure in Europe and Central Asia**

- Natura 2000 is a network of nature protection areas in Europe (Guerra et al., 2018).
- The Biodiversity Strategy for 2030 by the European Union is a comprehensive long-term plan to protect nature and reverse the degradation of ecosystems (Miu et al., 2020).
- The Business Models Catalogue for urban nature-based solutions that illustrates eight different business models for urban nature-based solutions (Mayor et al., 2021).
- The Sustainable Infrastructure for Low-Carbon Development in Central Asia focusing on integration of climate change and other environmental concerns into infrastructure development decision-making processes (Bekturganova et al., 2019; OECD, 2019a).
- Greening the Belt and Road Projects in Central Asia focusing on ecosystems for functioning landscapes, transboundary water management, and preservation of mountain environments though blue and green infrastructure initiatives (Foggin et al., 2021).
- Bee highways in Oslo to enable bees to rest and find food (Beatley, 2016).

Relevance of the risk drivers

The European Commission defines green infrastructure as a strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation (European Commission, n.d.b). In some literature, green and blue infrastructure refers to a well-planned and sustainably managed network of ecosystems, and water elements of any urban area (Ahern, 2007; Benedict and McMahon, 2006; Wagner et al., 2013). Under sustainable development practices, green and blue infrastructure measures have been successfully integrated as measures of DRR (Depietri and McPhearson, 2017), ecosystem resilience (Maes et al., 2019) and managing the impact from climate change (Mumtaz, 2021).

Climate change and environmental degradation

Developing and protecting green and blue infrastructure ensures environmental processes and anthropogenic activities are sustained through harmonized co-existence. This increases the resilience capacity of a community, and contributes to climate change mitigation and DRR. One of the primary benefits is the preservation and restoration of ecosystems, which provide habitats for native species (Lovell and Taylor, 2013). These habitats aid human health by improving air quality and water quality, and support mental health conditions by providing a stress-free environment (Tzoulas et al., 2007).

The use of green and blue infrastructure supports carbon sequestration, which directly supports climate change mitigation (Chen, 2015). Each ecosystem has the potential for natural carbon sequestration. For example, grassland functions as an air purifier and has the capacity to absorb carbon from the atmosphere. Therefore, incorporating more green infrastructure in urban settings will reduce the levels of carbon in the atmosphere (Ussiri and Lal, 2017). These types of investments reduce energy consumption in buildings for heating and cooling (Foster et al., 2011). They also contribute to reducing energy consumption, providing bioenergy, facilitating carbon uptake and storage, which are also measures of climate change mitigation (Trinomics, 2014). Using green and blue infrastructure also increases infiltration capacities by reducing urban water run-off, which contributes to the reduction of flash floods (Jayasooriya et al., 2020). A sustainable drainage system is created, with high capacities for retaining and draining water especially in urban settings. Natural ecosystems can also remove pollutants from water (Yang and Li, 2013; Liu et al., 2016).

Increasing requirements linked with climate change and other stresses have prompted the need for governments to critically re-evaluate the ability and capacity of public and private partners to manage risk (Hallegatte et al., 2019; Keele and Coenen, 2019).

Interconnected and complex economies, societies and infrastructure

Underinvestment in critical infrastructure resilience could lead to serious socioeconomic disruptions due to the high degree of interconnectedness among sectors and the potentially devastating effects from cascading failures across systems and networks (Drzik, 2019).

In 2019, passenger transport in Europe was expected to increase by 42% by 2050, and freight transport by 60%, placing additional pressure on transport infrastructure and the environment. By 2040, European airports may be unable to accommodate the estimated surplus of 1.5 million flights, as demand continues to rise (European Commission, 2019). In 2012, road congestion in Europe was estimated to cost more than €110 billion annually, and its mitigation has been a priority for many infrastructure measures (Christidis and Rivas, 2012).

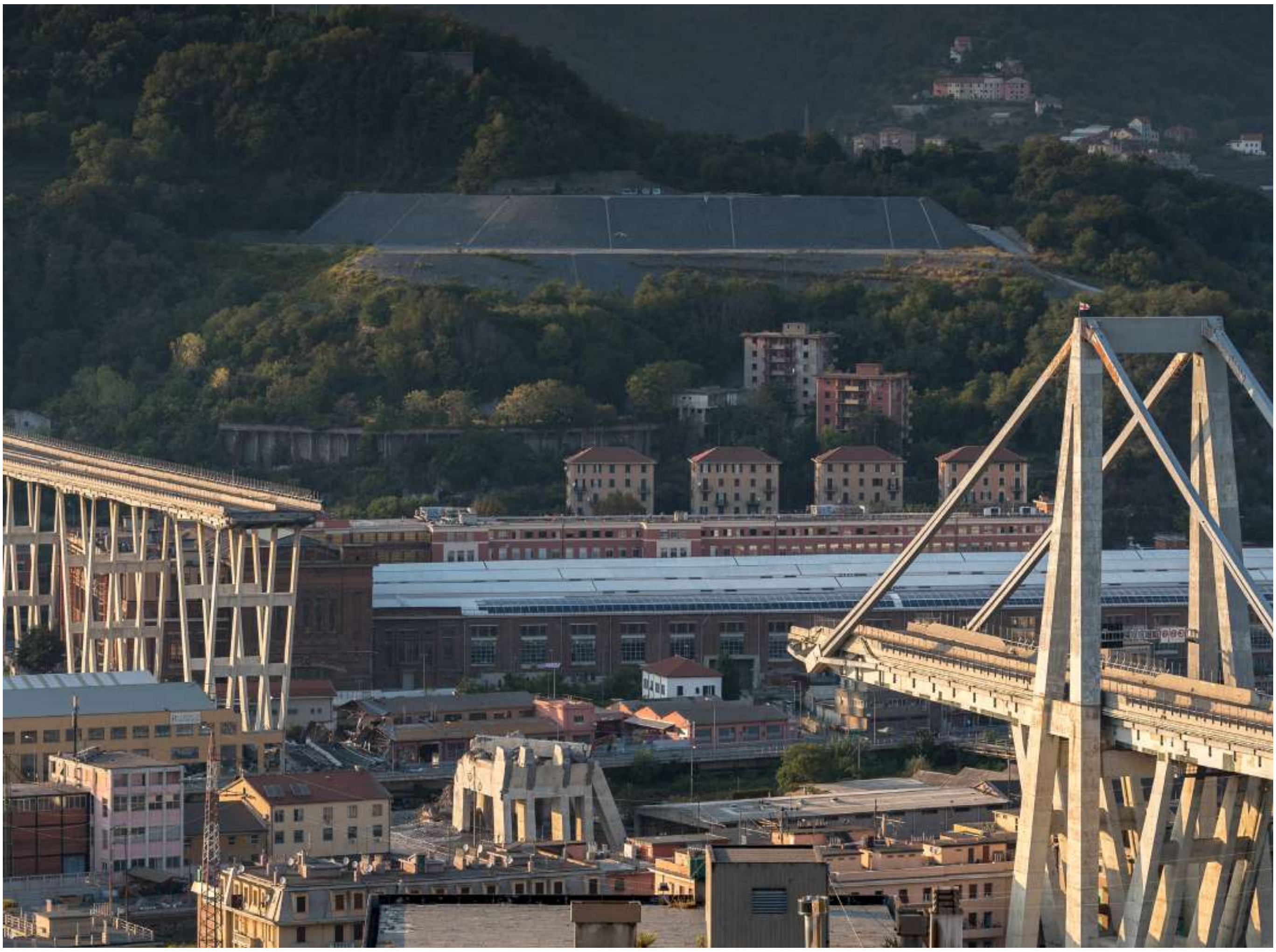
Despite a growing recognition of the consequences of ageing infrastructure, many assets remain undermaintained. In 2019, over 840 bridges were at risk of collapse in France alone (McLellan, 2019). The collapse of the Morandi Bridge in Genoa in 2018 was one of the most startling as well as momentous infrastructure failures in Europe in recent years; it resulted in the death of 43 people. Energy infrastructure is also approaching its designated lifespan, leading to degraded performance and an increased risk of failure in times of disaster (DEFENDER consortium, 2018). Power cuts due to old infrastructure are still common in some countries in Central Asia. While improvements have been made, distribution and transmission losses remain high (Nabiyeva, 2018). In the water sector, European Union programmes have supported the renewal of critical assets, but there are still segments of pipelines that have been operating for more than 100 years. Current levels of investment cannot meet all the challenges presented by increasing urbanization, population growth and climate change (Ramm, 2018).

That there are so many actors and owners involved in the management of critical infrastructure poses challenges for efficient coordination and information exchange, especially given that policies are developed by different authorities at the national, regional and local levels. Often, local authorities do not have adequate awareness of the drivers and composition of risk, the necessary capacities to manage it or the power to develop and enforce risk reduction policies. The very nature of what makes infrastructure critical and thus the subject of resilience planning confounds the public bodies and private companies involved in reducing risk (UNDRR, 2019b, 2020a).

Public authorities and regulators have the important task of overcoming these challenges and closing gaps, by engaging private companies in conversations on resilience and insisting on the benefits of investing in resilience or sanctioning businesses that lack compliance with established rules and standards. Such a responsibility might be new for regulators, which tend to focus on promoting competition and adjusting prices; however, their role in monitoring and approving financial resources puts them in an ideal position to mainstream resilience in infrastructure investments (NIC, 2019b).

Several mechanisms exist for governments to engage with and regulate asset managers and private and semi-private companies. A widespread practice is the use of public–private partnerships, where private sector actors usually provide the service, and public bodies oversee the activities and provide some of the financing or incentives. Other measures include risk disclosure in mandatory financial reporting for asset operators and the use of disaggregated data for understanding risks and needs.

For the understanding of complex risk landscapes, the distinction between compounding, interconnected, interacting, cascading and resulting systemic risks is important. These categories are also relevant for critical infrastructure and for cyberspace in particular.



Luca Rei / Shutterstock.com

Collapsed Morandi Bridge, Genoa, Italy, 30 September 2018

Recommendations to reduce risk

Consider disaster risk in infrastructure investment planning

The indicators for Target D of the Sendai Framework towards reduced disaster damage to critical infrastructure and disruption of basic services were the second least reported in the period from 2015 to 2019 (UNDRR, 2021c). Yet, to increase resilience of infrastructure investments, it is necessary to measure and make judgments about vulnerability, sensitivity, interdependency and exposure to risk. This shift requires investors, operators and decision makers to ensure disaster risks are considered in the location, design, construction and operation of planned infrastructure investments. Equally, infrastructure regulators and operators must develop and make use of indicators that take account of the complexity and interdependencies of global dynamics and patterns of change (Lonsdale et al., 2015).

The combination of increasing demands for new and innovative infrastructure and services, on one hand, and the reality of dangerously outdated assets in Europe and Central Asia, on the other hand, calls for more resilient and more sustainable investment decisions while planning and implementing infrastructure projects. It will take concentrated and continued efforts from all stakeholders to reduce the intensity and frequency of disasters. However, with more resilient infrastructure, it is possible to change the way communities bounce back and recover from cascading disasters and to reduce the likelihood of disaster impact.

The cascading nature of disaster impact, where one event can rapidly lead to another, coupled with insufficient investment in DRR, means that the critical systems relied upon for trade, food, energy, transportation and health are increasingly vulnerable. Alongside COVID-19, the effects of climate change are manifesting more rapidly and intensely than previously predicted. This poses a grave threat to financial and social stability, and has the potential to supersede the immense damage and loss caused by the COVID-19 pandemic.

Improve the resilience of infrastructure

Supported by a robust political will and a meticulous implementation process, the following elements can be part of the way forward to resilient infrastructure in Europe and Central Asia.

- Data and standards:

  Engage the private sector, including the insurance industry, non-governmental organizations and universities in collecting disaster damage and loss data, as well as asset locations and other data to better understand risk.

- Legislative and regulatory environment:

  Incorporate and link infrastructure resilience in national and local DRR strategies and development plans at all levels.

  Mainstream resilience of infrastructure across all national and supranational policies, including in the European Union, and ensure all policies are risk informed.

  Actively engage and create incentives for private sector participation supported by risk-based performance.

- Targeted investment:

  Invest in the prevention of compounding risk for long-term resilient infrastructure through coherent policies and adherence to standards compared to the cost of responding to increasing risk, including systemic risk.

  Invest in green and blue infrastructure to strengthen urban and community resilience against climate change, natural hazards and global pandemics, and to prevent future incurred costs.

To support implementation of the Sendai Framework and SDGs, UNDRR has developed *Principles for Resilient Infrastructure*, endorsed by more than 100 countries, (UNDRR, 2022c). These global principles aim to raise awareness and set an understanding of what “resilient infrastructure” constitutes: to form the basis for planning and implementation of infrastructure projects that take resilience as a core value; to communicate the desired outcomes of national infrastructure systems to establish resilience of critical services; and to assist the public and private sectors in making risk-informed policy and investment decisions.

Challenge 3: Addressing cyber challenges and opportunities

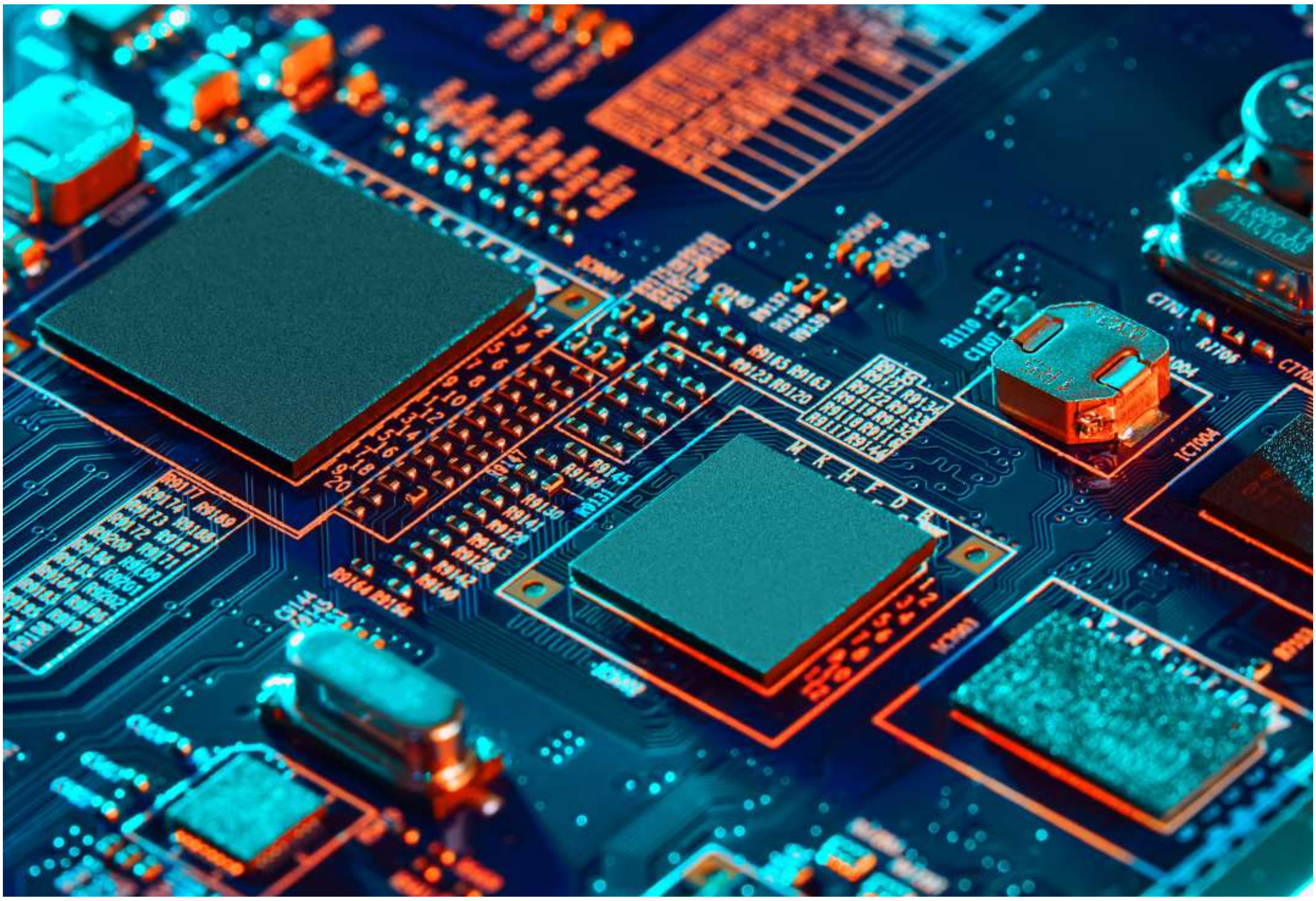
This challenge is based on *Bridging Cybersecurity and Disaster Risk Reduction* (UNDRR, 2020c), with additional contributions from Gianluca Pescaroli (Institute for Risk and Disaster Reduction), Katja Samuel (Global Security and Disaster Management) and Josef Schroefl (Hybrid CoE – The European Centre of Excellence for Countering Hybrid Threats).

Background

IT systems and networks underpin the functioning of much of the critical infrastructure, as well as social, political and economic systems. Investing in the security and resilience of IT systems is as important as investing in the resilience of other types of infrastructure. The globalized and interconnected nature of societies in Europe and Central Asia offers an unprecedented range of opportunities, but it also presents several important risks, marked by the essential role of technology.

The seamless functioning of the digital world has become the most critical prerequisite for operations in almost all global domains. Cyber risks within this space can range from accidental disruptions to technological glitches to malevolent, wilful attacks with destructive consequences. Cyber risks, along with associated innovations to reduce risk, evolve quickly and require risk knowledge, governance and regulatory frameworks – as well as investment – to adapt accordingly (Panda and Bower, 2020).

Box 5 shows some example threats to IT security.



raigvi / Shutterstock.com

Detail of an electronic circuit

Box 5. **Selected threats to IT security**

- Cryptojacking: When computers are used to mine cryptocurrencies while the owners of the computers are unaware. Cryptocurrency mining is a hardware- and energy-intensive activity. Countries in the region most often attacked by cryptojacking include Kyrgyzstan, Tajikistan and Uzbekistan (Bischoff, 2022).

- Cyberespionage: The use of computer networks to gain access to confidential information, conducted for the purpose of information gathering. Targets can include government departments or private sector industries.

- Cyberterrorism: A form of terrorism that attacks computer systems online to conduct violent acts to achieve political or ideological goals through threat or intimidation.

- Cyberwarfare: Military operations by State or non-State actors conducted in cyberspace; for instance, an attack on critical infrastructure carried out to achieve political and military aims and/or cyber operations during a conventional war. In cyberspace, the attribution of offensive actions can be more easily obscured, while strategic objectives can be achieved with relatively little effort.

- Disinformation: Intentionally wrong information, which is disseminated to confuse, deceive or manipulate target audiences. Fake news has increased significantly in recent years and spread especially on social media. It is expected that the proliferation of availability of text and image-generating AI tools will further exacerbate this problem (Chessen, 2018).

- Distributed denial of service attacks: These send millions of requests towards target webservers, forcing them offline as they strain server resources.

- Impersonation: Targeted attacks where malicious actors impersonate someone with authority or legitimacy to steal sensitive information from workers using social engineering tactics.

- Malware: Software specifically designed to interrupt, damage or access a computer system.

- Phishing: The practice of communications claiming to be reputable to trick people into revealing personal information such as passwords and credit card numbers.

- Ransomware: Malicious software designed to block access to an IT system until a ransom is paid.

The cascading impacts of IT disruptions of national power grids during national or global emergencies, such as the COVID-19 pandemic and/or the war in Ukraine, have an unfathomable reach. This applies particularly when: citizens are required to stay at home with social and business contact being conducted online on a scale that was, until recently, unprecedented; manufacturers are adapting to produce urgently needed medical equipment; global supply (including food) chains are already under immense strain; connectivity is critical for first responders and other essential workers; and many thousands of patients depend on ventilators connected to power grids.

In addressing technological risk, most governments, together with their private sector partners, should emphasize a prevention approach. Although the full potential of the Sendai Framework is not realized in relation to the prevention of risk to IT systems, it offers important principles, with an overarching exhortation to stakeholders to rethink and innovate existing approaches.

Recent impacts

The increase in IT-related risks to societal resilience, including economic security, cannot be overstated. One report estimated that the cost of global cybercrime between 2018 and 2020 reached nearly $1 trillion – an increase of 50% since 2018 (Smith and Lostri, 2020). According to the Cyber Security Breaches Survey 2023 in the United Kingdom, approximately 40% of all United Kingdom businesses experienced some form of cyberattack during 2020. Most common were phishing attacks (83%) and impersonation (27%). Over a third of the affected businesses (35%) were negatively affected through some sort of business disruption, while another fifth (21%) lost money, data or other assets (United Kingdom, Department for Digital, Culture, Media & Sport, 2021).

Box 6 provides an example of a cyberattack on a commercial outsourcing firm.

Box 6. **Cybersecurity incident at Capita, United Kingdom**

In a significant cybersecurity breach, Capita has faced substantial financial repercussions, potentially amounting to £25 million, following a cyberattack that commenced in March 2023. This incident resulted in the outsourcing group incurring a pre-tax loss of nearly £68 million for the first half of 2023.

The assault was orchestrated by the Black Basta ransomware group, which successfully infiltrated Capita's Microsoft Office 365 software, compromising the personal data of company employees and numerous clients.

Capita officially confirmed that a portion of its IT systems had experienced data exfiltration, although the extent of this breach accounted for less than 0.1% of its server estate.

Capita has extracted valuable insights from the ordeal. The financial consequences attributed to this incident are estimated to range between £20 million and £25 million, surpassing previous projections of £15 million to £20 million. This revised figure accounts for the intricacies involved in analysing the exfiltrated data, the costs associated with recovery and remediation efforts, and substantial investments earmarked for enhancing cybersecurity.

Capita's financial report for the first half of 2023 painted a grim picture, with a reported pre-tax loss of £67.9 million, which is a stark contrast to the £100,000 profit recorded over the same period in 2022. This loss is attributed to expenses stemming from the cyberattack, alongside costs associated with divesting from certain business ventures and goodwill impairment.

***Source*: Guardian (2023)**

Connected themes

With supply chains and third-party engagements in cybersecurity risk governance crossing administrative and State borders, local risk reduction measures must inevitably also amount to a global effort – to circumvent deleterious cascading impacts. One specific hazardous event in the cybersphere may lead to unintended damage in highly interconnected global networks, potentially upscaling local disasters to global disasters. Such contrasts call for a revisiting of the four priorities of the Sendai Framework for DRR from a cybersecurity point of view.

In recent years, it has become increasingly relevant to undertake new actions for increasing the resilience of critical infrastructure to cyber risk. Possible infrastructure targets need to consider the physical delivery of essential services and sensitive data from government bodies, exploiting technological and human factors within organizations (Giacomello and Pescaroli, 2019).

Research and existing practices tend to emphasize sectors such as electricity and communications, as they are the ones upon which everything else relies. However, there are also wider challenges to address. Some jurisdictions have carried out exercises to understand the risks posed by "black sky hazards", which are catastrophic events that severely disrupt the normal functioning of critical infrastructure in multiple regions for long durations (EIS Council, 2019). This is associated with scenarios of partial or national shutdown of the electricity grid and requires considerations of cross-sectoral dependencies of systems and the cascading effects of disruptions.

Despite the existence of common points of failures and vulnerabilities, the hidden linkages among sectors are often poorly understood. It is not just a matter of understanding the direct cyber risks – the indirect risks are also important (e.g. the critical infrastructure located in outer space, upon which financial services rely for time accuracy).

The interlinkages between cybersecurity and physical security are still subject to "silo" planning, which overlooks the systemic vulnerabilities of infrastructure and its interconnections with daily life (Cambridge Centre for Risk Studies, 2016).

The European Union's response to the ever-increasing number of cyberattacks against financial institutions is the Digital Operational Resilience Act (European Parliament and Council of the European Union, 2022a). The Act entered into force on 16 January 2023 and will apply from 17 January 2025. It is designed to strengthen the security of financial entities, such as banks, insurance companies, payment and e-money institutions, investment firms and more, by imposing resilience requirements and regulating the supply chain. It is also designed to ensure the services these entities provide are not disrupted by cyberattacks, outages or other risks to the integrity and continuity of those services.

Relevance of the risk drivers

Climate change and environmental degradation

Natural hazard-driven scenarios may coincide with technologically driven cascading effects. Targeted cyberattacks may increase their activity during moments of stress, hamper operations or increase societal pressure on emergency services during a crisis (Pescaroli and Alexander, 2018).

Different attacks can occur simultaneously, or they can be targeted in concurrence with other crises to exploit the existing burden on operational response capacity, as has already happened during the ongoing COVID-19 pandemic. Infrastructure resilience to cyber risk should not be seen as a stand-alone necessity. It requires assessment in terms of the common points of failure between cyber and other threats, moving gradually towards a hazard agnostic approach. This can be interpreted as the need to maintain resilience thinking beyond the single threat, thus adopting a systemic perspective. As argued by Linkov et al. (2019), "the rationale here is that it is often impossible to predict what hits the system, how much of a disruption will ensue, and what the likelihood of a threat scenario is". Stress testing could acquire a new and prominent role in this process, as highlighted below.

While natural hazards – such as floods, earthquakes and wildfires – know no borders, technological hazards – such as cybercrime – can be directed to targeted entities within strictly defined administrative or geographical boundaries. Climate change affects natural hazards in a highly complex and non-linear physical system in which human influence cannot easily be disentangled. In contrast, technological hazards give rise to emerging risks through purely anthropogenically driven technological developments and breakthroughs.

The pace at which events with adverse consequences may inflict damage unnoticed differs in natural and digital systems. In natural systems, undetected events tend to be transient and slow processes with tipping points beyond which grave consequences cannot be prevented (Lenton, 2011). In technological systems, the higher pace at which great damage potentially is inflicted unnoticed is governed by steadily increasing computation power and data availability, which is ever more sophisticated, advanced and efficient.

Interconnected and complex economies, societies and infrastructure

The Sendai Framework calls for effective DRR strategies to be in place, locally and nationally, with a focus on an all-hazards and all-of-society approach, and for investments to be risk informed and better target resilience needs. At the same time, cybersecurity is a cross-cutting theme connecting industries and sectors globally, to which countries are strongly committed. Looking at the global cybersecurity index, which indicates the relative commitment of various countries to cybersecurity, each country's level of development or engagement can be assessed along five pillars (ITU, 2021):

- Legal: Consisting of institutions and frameworks dealing with cybersecurity and cybercrime.
- Technical: Covering the existence of technical institutions and frameworks dealing with cybersecurity.
- Organizational: Covering policy coordination institutions and strategies for cybersecurity development at the national level.
- Capacity development: Based on research and development, education and training programmes, certified professionals and public sector agencies fostering capacity-building.
- Cooperation: Including partnerships, cooperative frameworks and information-sharing networks.

The International Telecommunication Union framework reveals large variations across the world, as well as important differences at the regional level. Moreover, industry-driven work on standardization within cybersecurity risk management is important. For instance, the International Organization for Standardization has developed a series of standards covering numerous topics on cybersecurity. Also worth mentioning is the international police collaboration of the International Criminal Police Organization and the European Union Agency for Law Enforcement Cooperation, as well as the trust-based collaboration among computer security incident response teams that facilitates the sharing of information on cyberattacks, digital vulnerabilities and mitigating measures with business partners. Milestones include the Network and Information Security (NIS) Directive (European Parliament and Council of the European Union, 2016), which was the first piece of European Union wide cybersecurity legislation (subsequently followed by the second NIS Directive (NIS 2; European Parliament and Council of the European Union, 2022b)), as well as the European Union Cyber Security Act from 2019, with a proposed amendment in 2023 (European Commission, 2023d), which further regulates the European Union Agency for Cybersecurity (ENISA, 2023).

However, there is inconsistent practice among States regarding the extent to which cybersecurity and cyber risk are reflected within their national DRR strategies. In addressing such risks, whether natural or human made, most governments, together with the multinational institutions within and alongside which they operate, need to give major policy emphasis and substantial weight to the well-versed "prevention is better than cure" approach by focusing on a truly comprehensive and all-hazards approach to disaster risk and resilience-building.

By definition, cyberspace is highly interconnected – a feature responsible for the tremendous benefits and further potential of cyberspace. However, the interconnectedness has reached such a degree that the functioning of economies and societies fully depends on it. Therefore, vulnerabilities within this interconnectedness contribute to risks, which could lead to cascading effects and thus disasters (Pescaroli and Alexander, 2018). GAR2019 frames the resulting task as: "Understanding the degree of cascading risk and developing ways to isolate, measure and manage or prevent risk is a new challenge in today's environment of computer systems and computer actions that dominate economic, social and even environmental systems management" (UNDRR, 2019a).

Recommendations to reduce risk

Build human capacity and knowledge

To strengthen cyber disaster preparedness, human capacity and knowledge are needed, in addition to procedures and tools. There is a need for research that generates new knowledge on mitigation and reduction of the steadily evolving cybersecurity risk, as is there a need for educating the public and raising cybersecurity risk awareness.

While digitalization and automation have reduced the need for human resources in many industries, enhanced the situational awareness and provided more efficient business processes, human resources are still needed to develop the software code and software patches to reduce known vulnerabilities. Infected systems must be quickly restored – and rebuilt back better.

Enhancing preparedness is a shared responsibility. Contingency plans are needed, with offline backup, necessary operating procedures and human resources. Furthermore, contingency plans should be exercised, tested and updated, preferably with the involvement of stakeholders like vendors and computer security incident response teams. Lessons learned should be shared and embedded in the organizations. If this is done on a regular basis, it is possible to learn and adjust to the continuously changing cyberthreats and be prepared to respond to the next cyberattack by capitalizing on lessons learned from the past.

Build resilience

Regulation of transnational emergency preparedness and risk management that is relevant for all kind of incidents with cross-border impact is on the agenda of numerous public authorities. Efforts are also directed to building resilient systems within the European Union. The European Commission has adopted a Critical Entities Resilience Directive (complementary to NIS 2), targeting all “critical entities” with the aim of reducing vulnerabilities and strengthening the resilience of critical entities (Council of the European Union, 2022).

However, building resilience is challenging. The rise of transnational enterprises with dominating market positions and budgets greater than nation State budgets represents standardization and dissemination of technology that give few alternative choices in the short run if systems fail. Furthermore, the commercial economic power of such enterprises is bigger than that of nation States. Often, software problems (vulnerabilities) are solved with more software (patches and new software tools, thus introducing new problems). In addition, dual-use security measures reduce and increase risk. Encryption is used to protect sensitive data, but the same algorithms are also used by criminals to take data hostages and blackmail data owners. Similarly, surveillance tools are in high demand to detect and attribute attacks, but such tools could become dangerous in the hands of adversaries. Hence, balancing surveillance and privacy is an intricate matter of great importance.

Society’s dependency on the resilience of information and communications technologies, within what is being called the fourth industrial revolution, cannot be understated. As they increasingly underpin the operation of all critical infrastructure and other essential services, and as technology advances rapidly and the barriers to entry for cybercriminality lower, so does digital integrity need to be rethought.

In seeking to make systems, including critical infrastructure sites, more resilient to prevent or at least mitigate potential loss and damage when these risks manifest, it is essential that steps are built into organizational processes. There are five essential elements. The first is to undertake intelligence-led assessments of the primary threats, risks and vulnerabilities. The next steps are then to plan and prepare carefully to ensure the organization is adequately resourced and equipped (e.g. in terms of infrastructure, people and equipment) to respond effectively to the identified most likely threats and risks. It is essential to ensure the ongoing validation of such plans and preparations, at the time of their implementation as well as when the threat landscape and/or organizational mitigation measures change. Finally, it is important that a dynamic resilient culture is nurtured. The resultant agility, adaptiveness and flexibility of the organization, including in terms of leadership, systems and response, are likely to result in a more effective response.

Foster cooperation and collaboration

While mitigation measures are effective, they must be regularly tested and updated in the ever-evolving cyber risk landscape. Continuous success in cybersecurity risk management requires swift, collaborative efforts, with a focus on transnational and regional partnerships. Addressing the ripple effects of cyberattacks in regional collaboration is crucial.

Initiatives like the CyberSmart project, which educates Norwegian teachers and students about cybersecurity (Hagen, 2019), can bridge the gap between experts and the public, fostering long-term preparedness. Scaling up such projects across borders could create a new regional awareness of cybersecurity risk, potentially reducing variation in cybersecurity readiness among countries according to global indices.

The Sendai Framework emphasizes multi-hazard risk management across sectors. Integrating cyber risk into national disaster assessments and risk management is therefore essential for comprehensive disaster planning, investment and response strategies.

These variations in practice do not stem from the Sendai Framework provisions, which adequately cover DRR in the context of natural and technological risks, including cyber and hybrid scenarios. Instead, they arise from different factors, such as varying national priorities and capabilities, a historical emphasis on quantifiable insurance losses from natural hazards, a traditional approach to cyber risk as a security issue rather than a risk mitigation one, and sometimes an overemphasis on the benefits of technological innovation without fully considering potential risks.

This disconnect exists, even though the language of the cybersecurity community is commonly framed in DRR terms – such as prevent, protect, detect and respond – including to protect critical national infrastructure. This presents a challenge in that for national disaster plans and responses to be most effective to realize optimal resilience, they need to be comprehensive and joined up, especially in terms of identifying and integrating all potential sources of threat, risk and vulnerability. If the fundamental risk analysis and planning assumptions are flawed through incomplete identification of potential sources of risk, then everything else that follows could be significantly flawed too. This could result in reduced resilience with potentially (more) catastrophic effects, including the occurrence of associated cascading disasters that might otherwise have been prevented or at least mitigated against.

Regulate cyber risk

At the level of cyberwarfare, the world is at a cross-roads when it comes to determining whether cyberthreats should be compared with strategic weapons, and the destruction cyberwarfare causes, compared with conventional war. If so, cyber risks should be tightly controlled, international law should take a stand on it such as a United Nations Security Council confirmation, and cyber diplomacy should be added to the diplomacy domain. However, should cyber be viewed as an operational or tactical capability available to all commanders? In both cases, the question is how to build a credible deterrence strategy to convince potential attackers that any attack would indeed be comparable to a declaration of war, even if cyberweapons are not viewed as weapons of mass destruction but largely as weapons of mass disruption (to use a phrase from the early days of cyberwarfare theory).

Integrate cyber risk in national risk assessment

Consideration should be given to "the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors" exhorted by the Sendai Framework (United Nations, General Assembly, 2015a). This includes a focus on increased integration of cyber risk within national disaster assessments and planning, not least due to its nature as a hybrid threat, directly affecting critical national infrastructure.

Implement risk-informed strategies

The Sendai Framework calls for effective risk reduction strategies to be in place, locally and nationally, and for investments to be risk informed and to better target resilience needs. As highlighted in the UNDRR guidelines on the development of national DRR strategies (UNDRR, 2019c), strategies should be geared to respond to potential cascading effects, which will involve a complex tapestry of more interconnected security threats. A comprehensive and all-hazards approach to risk reduction should integrate technological risks, notably here cybersecurity, in the strategic planning and decision-making of DRR actions and investments.

Increase accountability

In addition to the associated resilience benefits of more integrated approaches, it is important for stakeholders to fully understand the potential legal and ethical implications of failing to strengthen known gaps and vulnerabilities. Under the doctrine of due diligence (comprising three branches: to protect the population, to prevent harm, and to ensure the availability of appropriate remedies should harm occur), those governmental and quasi-governmental actors involved with the protection of critical national infrastructure especially are required to take all reasonable and appropriate measures to reduce reasonably foreseeable vulnerability related to cyber risk.

Stress test capability to withstand hybrid and cascading risk scenarios

To better understand gaps in addressing cyberthreats, stress testing existing risk management capabilities would support greater understanding of current capacities and improvements that may be required, cognizant of the fact that an event of great magnitude or multiple failures at the same time could exceed all capacity. Pescaroli and Needham-Bennett (2021) proposed an approach for benchmarking stress testing in five steps. It aims to provide replicable tools to stakeholders to prepare for complex situations assuming limited resources available. The final goal of this approach is to support the understanding that hybrid and cascading risk cannot be seen as self-standing criticalities and present some common point of failures with other threats affecting organizations or networks.

Challenge 4: Managing technological risks

This challenge was prepared by Franziska Hirsch (UNECE), Elisabeth Krausmann (European Commission Joint Research Centre), Max Linsen (Portolan Association) and Maureen Wood (European Commission Joint Research Centre).

Background

The risks of technological accidents include various contexts and landscapes in the Europe and Central Asia region. These require robust risk management practices and demonstrate that technological risk reduction plays a vital role in overall disaster risk management (DRM) and resilience-building in the region.

By learning from good practice examples in technological risk management, DRR strategies can be enabled to strive for the highest attainable extent of accident prevention. While prevention is key – and should be the objective of technological risk managers, be it policymakers, public or private sector stakeholders – preparedness and response strategies remain important.

Various sources list different types of events that can be categorized as manifestation of "technological risk" (e.g. UNISDR, 2018; EEA, 2003; European Commission, 2020a; UNDRR, 2020d). For the purposes of this challenge, technological risks include:

- Industrial and chemical accidents (including mine tailings dam failures)
- Oil spills
- Transport (e.g. pipeline) accidents
- Nuclear hazards and radioactive waste

Excluded from the scope of this challenge are accidents related to:

- Acts of terrorism
- Technological risks in political conflicts
- (Critical) infrastructure collapse
- Aviation

Technological hazards are hazards that "originate from technological or industrial conditions, dangerous procedures, infrastructure failures or specific human activities. Examples include industrial pollution, nuclear radiation, toxic wastes, dam failures, transport accidents, factory explosions, fires and chemical spills. Technological hazards also may arise directly as a result of the impacts of a natural hazard event." (UNDRR, n.d.b).

The benefits of technology are so abundantly present in everyday life that they are easily taken for granted. While the current state of technology is an achievement, it cannot be separated from the negative consequences, including pollution and accidents, and their impacts on humans and the environment, in combination with a potential increase in social inequalities (Mirza et al., 2019). Risks related to technology have been and will always be present if technological solutions are being used and developed (Baum et al., 1983).

The extent to which technological accidents have significant impact depends on the amount of damage that such accidents may cause. In this respect, prevention of accidents and their impacts can be achieved where innovations steer the energy, industrial and chemical sectors (e.g. towards the use of less and less harmful chemical substances and processes), thereby increasing inherent safety.

The catastrophic potential of technological accidents can be as great as or greater than that of natural events, for example due to their far-reaching impacts on local communities and the environment (EEA, 2003; Girgin and Krausmann, 2016). The mine tailings accident in Baia Mare in 2000 (OCHA, 2000), the Fukushima Daiichi nuclear accident in 2011 (IAEA, n.d.a) and more recently the oil spill that happened in Norilsk in 2020 (Rajendran et al., 2021) all demonstrate this. The explosion of ammonium nitrate in Beirut in 2020 (UNDRR, n.d.c) made it tragically clear that technological accidents can also cause large numbers of deaths, injuries, displacements and economic damage.

For those involved in risk management, the line between technological and natural risks may be hard to draw, especially in the case of natural hazards that cascade into technological disaster risk with potentially widespread, transboundary impacts (Krausmann et al., 2016). This observation calls for further integration of technological risk management into policy advocacy, knowledge exchange, capacity development and other activities under the Sendai Framework – at the international, national, regional or local levels.

Natural hazards triggering technological disaster (Natech) risks exist where hazardous industry and infrastructure are located in areas prone to natural hazards. Technological accidents can be triggered by all types of natural hazards, including earthquakes and climate-related weather events such as floods, extreme precipitation, landslides and mudslides, but also by slow-onset events such as sea-level rise and permafrost thaw (Necci et al., 2018).

Natech risks are expected to increase in the future due to climate change and growing human development (industrialization and urbanization), putting natural and technological threats on a collision course.

Recent impacts

Natech events play a significant role in technological and multi-hazard risk management, necessitating the development of related guidance (Necci and Krausmann, 2022).[7] In particular, the Norilsk accident (see below) is a harbinger of what the future may bring. Much of the oil and gas infrastructure located in the Arctic is threatened by permafrost thawing, which has already started to undermine the resistance of anthropogenic structures (Hjort et al., 2018).

In the consequences of technological accidents, there may be a geographical distinction of sectors at risk. EEA reported a relatively small number of casualties related to industrial and chemical accidents between 1998 and 2009 in the European Union (169 casualties over 352 events) (EEA, 2010). Wood and Fabbri (2019) reported a calculated 66 deaths based on 501 events in OECD countries reported in the media. The study noted that, while the European Union had a high number of minor chemical incidents, the likelihood of major industrial events with a high impact remains low in the European Union, given the strict controls of chemical accident risk in these countries. However, the study also indicated that non-OECD countries have fewer minor chemical incidents but far more incidents with severe impacts according to media reports.

As they are emerging industrial economies, some South-eastern Europe (SEE) and Eastern Europe, Caucasus and Central Asia (EECCA) countries may face challenges related to technological risk governance. These include access to resources and competences, and a robust legal framework for risk control accompanied by a well-functioning judicial system. Coordination among authorities (national and regional), and with industry and communities may also be insufficient to close gaps in monitoring and oversight of technical risk sources. Moreover, EECCA countries bear the former Soviet Union's legacy of ageing, abandoned and orphaned industrial installations, which have become more vulnerable to failure over time, with insufficient human and financial resources to repair and maintain them.

A wide range of national databases (e.g. the UNDRR DesInventar Sendai system; UNDRR, n.d.d) and a variety of online platforms provide data on past technological accidents. Examples of disaster databases with global coverage include the EM-DAT database hosted by the University of Louvain (CRED, 2023), the NatCatSERVICE database governed by Munich Re (Munich RE, n.d.), and (with a European Union focus) the Risk Data Hub operated by the European Commission's Disaster Risk Management Knowledge Centre (European Commission, n.d.c). Databases with a defined focus on technological risks include the European Union eMARS database of chemical accidents established by the European Union Seveso Directive (European Commission, 2020d), the French ARIA (Analyse, Recherche et Information sur les Accidents) database (ARIA, n.d.) and the European Union eNATECH database for Natech accidents (European Commission Joint Research Centre, n.d.).

Private organizations may also collect data on various types of technological risk, for example the nuclear, chemical, aviation, and oil and gas industries all collect data on their accidents. The European Union Minerva Portal is an initiative that aims to work in all phases of the knowledge management cycle: knowledge gathering, knowledge organization, knowledge analysis, knowledge production and knowledge visualization. It contains an interactive dashboard and also gives links to many other chemical accident information sources (European Commission, n.d.d, n.d.e).

However, there are several challenges related to data collection and interpretation (see Box 7).

7 OECD has also published an addendum on Natech risk management to its guiding principles for chemical accident prevention, preparedness and response (OECD, 2015).

Box 7. **Data collection and understanding of technological risk**

An overview of human-made and natural risks that the European Union may face states that "Data collection on industrial accidents faces particular challenges due to the decentralized nature of this process, private ownership, and different requirements applicable to different types of [hazardous] establishments" (European Commission, 2020a).

The challenges mentioned pertain to:

- A lack of agreement at international level on what constitutes a technological risk, or how to classify different types of disasters.
- The variety of purposes for which data are being collected, for example, legal requirements or policy implementation, research objectives, business needs or lesson learning.

These observations may explain why a harmonized classification of which events fall under technological disasters is not applied throughout databases.

A good example of a database applying a harmonized definition of technological risk to a large extent, is the French ARIA database.

The impacts of technological accidents listed in the various databases include damage costs (e.g. loss of production or clean-up costs), economic damage (related to gross domestic product or otherwise expressed), damage to (critical) infrastructure, environmental damage and loss of lives/human health.

However, overall, long-term impacts, such as environmental impacts, economic costs and community disruption, are hard to measure in consistent ways, especially in the case of technological accidents with limited visibility on the national/transboundary level. An exception may be mortality or indicators related to human health, which are more reliably quantified across incidents.

Connected themes

Since high-income European countries reap substantial benefits from the industrial economies of the EECCA and SEE regions, there is strong justification for European economies to support these countries in their efforts to control and reduce technological risks. In 2019, the material footprint (which attributes the total amount of resources used in a product supply chain to the final consumer) of inhabitants of high-income countries was estimated to be two to five times as high as the per capita material footprint of middle- to low-income countries (IRP, 2019). Consumers and businesses in the European Union buy and use many materials and products generated or extracted[8] in countries outside of the European Union, including from EECCA and SEE countries. Taking a perspective in which users and providers of services and goods supplied by hazardous activities are connected in the same system, such as a supply chain perspective, could potentially be more adequate.

8 This includes extracted uranium, with Kazakhstan and Uzbekistan holding large uranium reserves.

Relevance of the risk drivers

Climate change and environmental degradation

Adaptation to and mitigation of climate change both relate to technological risks, most notably through Natech. Natural hazards that can potentially trigger technological accidents include geological and hydrometeorological hazards. For the latter, climate change may, for example, increase their severity, making it an important Natech risk driver. As such, adaptation to climate change and Natech risk reduction are intricately linked. Adaptation efforts are necessary to consider Natech risk in policy and governance, risk assessment, land-use planning/siting and contingency planning, among others.

In terms of mitigation, there is also an important connection: mitigation of climate change translates into the just and inclusive transition towards a low-emission and climate-resilient development on a global level. Extraction of minerals and metals to facilitate the transition is increasing, alongside an expected increment of industrial and chemical processing activities, including the potential revival of legacy sites. The higher demand for raw materials for the low-carbon transition may therefore increase the exposure of industry to natural hazards and worsen Natech risk. This increased pressure may cause challenges in terms of the prevention of, preparedness for and response to technological disasters, as well as a structural need for broader governance and risk management.

Interconnected and complex economies, societies and infrastructure

Data on past accidents can contribute to a better understanding of technological risks, if considered carefully and due consideration is also given to the context in which data were collected. Well-analysed data can also help prevent future accidents, through enhanced risk diagnostics (Wood and Fabbri, 2019), by drafting case studies and lessons learned, and by informing good practice. The UNECE Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention), the European Union Seveso Directives or the OECD Working Party on Chemical Accidents provide platforms to strategically assess and apply data for technological risk management.

A comparison of data available for different countries[9] within and outside of the European Union shows there are inequalities between the availability of consistent and long-term data sets for most types of technological disasters, notably in Central Asia and the Caucasus. Instruments with global coverage such as the World Bank Open Database (World Bank, n.d.) and the SDG implementation tracker cover only part of the larger Europe and Central Asia region, and without including technological risks in the monitoring methodology.[10] While the latest EEA state of the environment report (EEA, 2020a) leaves industrial and chemical accidents out of its scope (whereas it was included in earlier versions), technological risks are mentioned as a priority for the coming years (European Commission, 2020a). Beyond the European Union, the Industrial Accidents Convention collects information on chemical and industrial accidents through Member States' national implementation reports.[11]

Efforts undertaken by Central Asian countries for establishing national disaster loss databases with the financial support of the European Union and the technical support of UNDRR are good examples of risk knowledge efforts that would be supported, accompanied and replicated on a longer term for ensuring regional-scale systematic collection of disaggregated loss data from disasters.

The European Union's Civil Protection Mechanism, its flagship policy on DRM, recommends including all hazards in national risk assessments and has the objective to protect the European Union against all kinds of disasters, including technological ones.

Coordination among (inter)national organizations of certain frameworks (e.g. chemical and industrial risk management through the Inter-Agency Coordination Group on Industrial and Chemical Accidents), countries (e.g. the Center for Emergency Situations and Disaster Risk Reduction, in Central Asia, and the CIS Interstate Council on Industrial Safety) and subregions (e.g. the Industrial Accidents Convention) is also well established. Technological risks are also increasingly present in the wider UNDRR framework, for example through the introduction of chemical/industrial and Natech hazards in GAR2019 (UNDRR, 2019a) and the publication of the Words into Action Guidelines on *National Disaster Risk Assessment* (UNISDR, 2017b) and *Implementation Guide for Man-made and Technological Hazards* (UNISDR, 2018).

9 This comparison extends to the scope of this Regional Assessment Report, that is, databases covering countries in Europe and Central Asia.

10 The data used to track implementation of SDG 1 focus largely on natural hazards only (see sources listed at Our World in Data (2023a)). The indicators related to disaster risk under SDGs 11 and 13 focus solely on natural hazards (Our World in Data, 2023b, 2023c). SDGs 3 and 6 include indicators on chemicals and hazardous waste, without specifically indicating waste management in relation to disasters. SDG 12 on sustainable consumption and production patterns includes a targeted indicator on meeting commitments of multilateral environmental agreements.

11 While these reports are not publicly available, overview reports are given by UNECE (n.d.a).

The most important legal instruments addressing technological risks (see Box 8 for examples) have similar risk approaches, often including risk assessment and mitigation steps (e.g. through land-use planning, siting, and accident prevention policies and measures), risk preparedness (through contingency planning and early warning) and response (including mutual assistance, ideally in a coordinated manner involving civil protection, inspection authorities, environment and public health disciplines). Integrating natural DRM and technological risk management is one of the objectives of many of these frameworks. Smooth cooperation among responsible agencies at national and regional levels is a major step towards coherent and complete risk management within and across country borders.

Box 8. **Examples of legal instruments addressing aspects of technological risk management**

- UNECE Convention on the Transboundary Effects of Industrial Accidents
- OECD Council acts:
    - Decision on the Exchange of Information concerning Accidents Capable of Causing Transfrontier Damage
    - Decision-Recommendation concerning Chemical Accident Prevention, Preparedness and Response
    - Decision-Recommendation concerning Provision of Information to the Public and Public Participation in Decision-making Processes related to the Prevention of, and Response to, Accidents Involving Hazardous Substances
    - Recommendation concerning the Application of the Polluter-Pays Principle to Accidental Pollution
- European Union Seveso Directives
- International Labour Organization (ILO) conventions:
    - Prevention of Major Industrial Accidents Convention, 1993
    - Chemicals Convention, 1990
    - World Health Organization International Health Regulations
- International Atomic Energy Agency (IAEA) conventions:
    - Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
    - Convention on Nuclear Safety
    - Convention on Early Notification of a Nuclear Accident
    - Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

A report on the implementation of the Industrial Accidents Convention (United Nations, Economic and Social Council, 2020) lists good practice examples of countries having established working groups or national platforms for the implementation of the Sendai Framework through strengthened cooperation among the different authorities, including on technological accidents triggered by natural hazards. OECD published a useful analysis of lessons learned across hazards, showing how emergency preparedness and response in the nuclear sector can benefit from experience in other sectors (OECD, 2018a).

While many technological accidents have only local effects, small- and large-scale accidents with transboundary effects also happen, notably in cases of accidental water pollution,[12] adding a cross-border dimension to risk management. For these large-scale, cross-border events, transboundary cooperation is crucial for limiting potential consequences.

International and regional legal instruments focusing on technological risk management often address issues related to prevention (risk identification, notification/information-sharing,[13] land-use planning and siting), preparedness (contingency planning and early warning) and response (accident notification, emergency response and mutual assistance). To a varying extent, they stipulate public information and participation, involving the public of countries potentially affected by a technological disaster (the ILO and UNECE conventions, as well as the European Union Seveso Directives include specific stipulations in this regard). Most of these instruments aim at enhancing policy and governance nationally, with a dedicated emphasis (e.g. health-related impacts in the case of the World Health Organization International Health Regulations or occupational health and safety in the ILO conventions). The Industrial Accidents Convention predominantly addresses transboundary cooperation and governance in prevention, preparedness and response of industrial and chemical risks, and the IAEA conventions take into account the impacts on any States physically affected by a nuclear or radioactive waste accident.

From a legal perspective, "early warning systems and other risk-reduction and adaptation measures to address transboundary risks [...] do not on their own provide a clear pathway for requiring another state to take action to reduce the transboundary risk being generated" (Wilkinson et al., 2019). For this, awareness of the potential transboundary impacts of accidents is needed, combined with a willingness to take measures to reduce risks through transboundary cooperation among competent authorities. The Industrial Accidents Convention provides a good example of how these mechanisms apply in chemical and industrial risk management at the transboundary level. The European Union Civil Protection Mechanism also includes risk assessment, early warning and alert systems, and cooperation across borders.

Changing demographics

Population growth and projected trends of urbanization of the population occur coincidentally with an increasing encroachment of urban areas on industrial sites. This is witnessed in Europe and Central Asia (European Commission, 2020a). Combined, these trends may increase the exposure of populations to industrial and chemical risks. Natech risks add to the complexity of managing and reducing these risks.

> **The world will unfortunately continue to face a large number of ongoing risks in the years ahead, of natural origin and human-made origin (see Box 9 for examples of emerging technological risks). However, it seems increasingly likely that the most severe risks facing citizens globally may originate from technologies they have played no part in creating and of which they have little awareness. The Sendai Framework provides the mandate and the responsibility to Members to help mitigate such risks on behalf of their citizens and for the benefit of all of humanity. The next step is to rapidly develop the will and the means to do so.**

12 In addition to the Baia Mare accident mentioned above, accidental water pollution with significant transboundary effects occurred in 2016 in the town of Ridder, Kazakhstan (Rysaliev, 2016).

13 "Notification" represents different actions in DRM, depending on the policy instrument. In the Industrial Accidents Convention, it refers to information-sharing with neighbouring or riparian countries. In the European Union Seveso context, it refers to information-sharing between authorities and operators of hazardous installations.

Box 9. **Emerging technology risks**

In addition to the risks discussed above, some new, rapidly emerging technology risks are gaining the attention of risk experts and policymakers globally. These novel risks could potentially result in hazards of an unprecedented severity and scale, and will likely require increasingly urgent attention and action in the coming months and years. These risks originate primarily from recent progress in various areas of scientific and technological development including biotechnology and particularly AI. While such areas of development bring significant potential benefits and opportunities to humanity, they are also creating new risks that are not yet widely recognized or well understood.

The primary technological risk related to biotechnology is the potential intentional development of a synthetically engineered pathogen and pandemic. Such a pathogen could theoretically be engineered to have properties that make it much more infectious and lethal than naturally occurring pathogens, and with a longer asymptomatic incubation period, thus making it more difficult to detect and contain. The development and coordinated distribution of such a latent "flubola"-type pathogen could result in globally catastrophic casualties, which could provoke further cascading impacts through a breakdown in food systems, health, security, governance and other core functions of society. It is estimated that only a few tens of thousands of people currently have the capability to produce and distribute such a pathogen.

However, as information, biotechnology equipment and AI tools become more widely available, it is likely that this number will expand to hundreds of thousands of people in the coming decade. This could potentially include terrorist organizations, rogue States or homicidal individuals. Experts in this field warn that while a variety of promising and workable policy options are available to mitigate this risk, too few of these are being put into practice.

AI is becoming increasingly recognized as potentially posing the most severe and challenging risk to humanity. These risks are particularly striking due to recent rapid acceleration in AI capabilities that have taken even most AI experts by surprise. This includes the success of generative AI models such as GPT-4, as well as the further enhancement of such models through a variety of post-development techniques. AI already poses existing challenges to societies, such as algorithmic bias, automated mis- and disinformation, enhanced privacy infringements, self-programming cyberattacks and a proliferation of autonomous weapons.

However, the primary concern of AI developers and AI safety experts is that humans could soon be able to create an artificial superintelligence that is impossible to control. Such an artificial superintelligence, if not controllable or otherwise aligned with human interests, may eventually have the motivation and capability to destroy humanity and all biological life on Earth. Although such potential outcomes are uncertain, they appear to present a sufficiently credible risk as to warrant urgent attention, particularly given the potential magnitude of the impacts (i.e. human extinction).

Some efforts are under way to better understand and mitigate the potential global existential risks from AI. These include the elaboration of possible licensing requirements and other restrictions on the development of the most dangerous kinds of AI models, as well as an acceleration of research into AI safety, alignment and control techniques. To be effective, such policies will need to be applied urgently in the coming months to all entities with frontier AI capabilities, and shortly after, be adopted by all members of the international community. Achieving success in these efforts will be challenging given current and growing obstacles to effective coordination within and between societies.

The global DRR community can play a key role in these efforts through its expertise in providing rigorous analysis and advice on risk management and prevention and by building global support for the shared humanitarian goal of safeguarding life in the face of existing and newly emerging risks.

Recommendations to reduce risk

Technological accidents can be prevented. Many past accidents could have been avoided, if the risks had been identified and properly controlled and if the organizations involved had been sufficiently attentive to the dangers involved in their operations (Krausmann and Necci, 2021). Still, even in countries where death rates from technological accidents have been successfully reduced for some technological hazard types, the number of incidents has not necessarily dropped significantly (CRED, 2023).

Technological risk must be included, notably in the strategic planning and decision-making of DRR actions and investments. It should be accompanied by a dynamic resilience culture that is agile, adaptive and flexible.

Analysis of technological accidents and their consequences provides valuable insights into potential causes, unfolding of the accident, impacts and response mechanisms, which can help risk managers to prevent similar accidents in the future.

For technological DRR, prevention must be the focus and aim of policymakers, operators and private sector leaders. Addressing the priority areas and actions under the Sendai Framework, such as the establishment of national platforms and the development of national DRR strategies, should support accomplishing this. Risks related to upcoming trends and expected changes that technological risk managers will be faced with in the coming years (e.g. climate change, use of resources and land use) also need to be considered.

The Sendai Framework recommendations need to be applied to support transboundary risk management. National DRR strategies should have a transboundary component, where relevant, starting with risk assessments acknowledging the potential transboundary consequences of a technological accident – and including preparedness and response measures across borders (UNISDR, 2018). The transboundary context also regards cooperation among institutions and authorities that are responsible for risk management and accident prevention, preparedness and response in neighbouring or riparian countries possibly affected by transboundary risks.

To accelerate implementation of Sendai Framework priorities, efforts can build on existing legal instruments, policy frameworks and regional cooperation mechanisms, such as the Industrial Accidents Convention, the OECD Working Party on Chemical Accidents and the European Union Seveso Directives on the control of major accident hazards. Oil spills and pollution in the maritime environment are addressed in the International Convention on Oil Pollution Preparedness, Response and Co-operation, and nuclear risks are managed through various conventions of IAEA,[14] as well as the OECD Nuclear Energy Agency.

Recommendations on how to address these challenges are listed below in the context of the four priorities of the Sendai Framework and their recommendations for action. The below examples of lessons learned from accidents in different technological activities, and with various characteristics, causes, magnitudes and impacts, show how the priority areas of the Sendai Framework can be put into action.

14 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Convention on Nuclear Safety, Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

Understand disaster risk (Sendai Framework Priority 1)

- Work towards obtaining regionally representative information. Even if numbers of casualties and damages in the European Union have stabilized in the last decades (European Commission, 2020a) (an achievement that can be attributed partly to effective implementation of risk management policies), other parts of Europe, SEE and EECCA have made far less progress.

- Increase understanding of issues that affect the status quo of technological risk identification and assessments, including:

  The effects of climate change (also related to Natech risk);

  A projected increase in demand for mineral resources, related to the low-carbon energy transition, switching to new technologies (hydrogen and batteries) and increasing the share of nuclear power in the energy mix;

  Continued acceleration of industrialization;

  Changing technologies, for example, increased automation and advances in chemical engineering;

  Ageing infrastructure (European Commission, 2015) and stranded assets;

  The increasing encroachment of urban areas on industrial sites (European Commission, 2020a);

  Cyberattacks (Wood et al., 2017).

- Improve representation and communication of local, national and transboundary consequences of accidents, also addressing the question of purposeful data collection and use.

- Improve and promote data collection and data sharing. This could provide more insight and understanding with a twofold benefit: to prevent future accidents and to reach a (more) balanced level of technological risks in Europe and Central Asia. For each technological risk type, indicators should be identified. These should be meaningful and feasible in terms of data collection, based on an evaluation of information already available in industry, academia, government and the media for monitoring performance in controlling the risk and identifying emerging risks (see Box 9). Commonalities across technological risks need to be examined to determine what data can be reasonably collected in a harmonized way across diverse technological risks.

Lessons learned

Nuclear accident prevention by peer reviewing nuclear infrastructure

IAEA facilitates missions by international experts to review all factors that may influence safety, security and sustainability of use of nuclear power in an IAEA Member State, upon request of that Member State. The methodology used includes a review of existing legislation and policies, as well as on-site inspections and targeted discussions with operators. Best practices are exchanged, and the country receives recommendations for actions to improve and sustain its safe use of nuclear energy.

The peer review methodology has been picked up by networks outside of nuclear risk management. The international network for storm surge barriers (I-STORM) conducts peer reviews to prevent failure of storm surge barriers, based on the IAEA review missions and following exchanges with IAEA international peer review experts.

***Sources*: IAEA (n.d.b); I-STORM (n.d.)**

Strengthen disaster risk governance to manage disaster risk (Sendai Framework Priority 2)

- Develop competent and expertise-rich institutions to foster inter-institutional cooperation. Experts in several types of risks, whether technological (industrial/chemical and nuclear) or natural, should be involved in the design and use of comprehensive risk management policies at local, national and transboundary levels. Governments should ensure they have access to sufficient competence to use the data available and to foster understanding across risks and inter-institutional cooperation in addressing matters where several risks converge (e.g. Natech). A systems perspective could underpin joint risk management strategies, sharing of knowledge and expertise, and capacity development nationally and across borders.

- Expand the scope of policies and risk management decision-making for emerging risks. The boundaries between disaster risk governance and technological accident risk governance should diminish with the ability to communicate across the different disciplines. Preventing future accidents while addressing the consequences of climate change, increased use of technological processes and encroachment of industrial areas into urban areas requires an approach that:

    Addresses conjoint natural and technological risks through Natech risk management;

    Starts with integrating land-use planning and decision-making on siting and the significant modification of hazardous installations/activities with (strategic) environmental assessments and technological risk assessments;[15]

    Integrates public information and participation in decision-making, whether on land-use planning, siting or contingency planning;

    Uses good practices across sectors, by promoting active communication among all actors, exchanging experience and expert knowledge, technology, and research and development.

- Apply the entire risk management cycle to the transboundary level. From accident prevention (and mitigation of exposure and effects), preparedness and response to reporting and building back better: transboundary risk management must become a reality. Target E[16] of the Sendai Framework is a crucial vehicle in this respect: national DRR plans and strategies should take into account the potential impacts of natural and technological hazards cross-border or in transboundary water courses, and foster information-sharing and cooperation. Such transboundary cooperation should extend from information-sharing to risk assessment, including improved access to risk assessment knowledge and tools. Examples are transboundary hazard and risk maps, joint contingency planning, transboundary response exercises and mutual assistance in the case of an accident. National DRR strategies and plans should be aligned with existing legal instruments that support countries in addressing transboundary hazards and risks, such as the Industrial Accidents Convention in the case of industrial/chemical hazards and risks.

Chemical worker carrying canisters with hazardous materials
Aleksandar Malivuk/ Shutterstock.com

15 See UNECE (2017) for guidance on how to integrate these elements.

16 “Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020”. See UNDRR (2023c) for a recent report on Target E implementation.

Lessons learned

Land-use planning for prevention of and preparedness for industrial accidents in Portugal

Portugal applies licensing procedures for new hazardous establishments (or for modifications of existing establishments) listed as establishments under the European Union Seveso Directives. These procedures are embedded in legal environmental impact assessment and strategic environmental impact provisions. Land-use plans are used by comparing maps of areas prone to natural hazards with siting of establishments, before deciding which areas can be licensed for use.

Through risk assessments and land-use-planning, deployment of hazardous activities in sensitive areas can be prevented and potential consequences of chemical accidents limited.

This example and many others, including transboundary examples, are available in the Information Repository of Good Practices and Lessons Learned in Land-Use Planning and Industrial Safety (UNECE, n.d.b), led by UNECE and the European Investment Bank.

Source: UNECE (2016)

Invest in disaster risk reduction for resilience (Sendai Framework Priority 3)

- Invest to increase understanding of risk, including data collection and use. This requires human and organizational infrastructure and resources, including research and development, training and communication.
- Improve the availability of time, resources and competences for disaster risk governance, with national, local and regional authorities, industry, international organizations (e.g. OECD, UNDRR and UNECE) and development banks (e.g. European Investment Bank) supporting these efforts.
- Focus investments on prevention to save lives and limit damage. Continuously building prevention into technological activities may come at higher initial capital expenditure, which can be justified by limited damage and impacts on human lives.

Enhance disaster preparedness for effective response and "Build Back Better" in recovery, rehabilitation and reconstruction (Sendai Framework Priority 4)

- Integrate and implement lessons learned throughout the DRM cycle. This can be done through structural and non-structural measures (peer reviews, policy reviews, capacity-building and training) and requires funding from the public and private sectors alike. Efforts to understand technological risks should contribute to the prevention of accidents as well as to preparedness strategies, including contingency plans, early warning systems and response mechanisms, in addition to building back better strategies.
- Use understanding of risks to justify building back better investments. If risks are better understood after an accident, this could justify building back infrastructure in a different way and against higher financial costs to prevent future economic damage.

Lessons learned

Diesel spill at a Russian power plant

On 29 May 2020, a diesel tank at a power plant in Norilsk, Russian Federation, ruptured and released over 21,000 t of diesel into the region's surface water network. The accident causes were a combination of foundation failure due to permafrost thawing, design deficiencies and underestimation of the tank collapse risk. The accident's investigation concluded that the failure would have been avoidable had the tank support piles been designed and installed properly, thus highlighting the importance of respecting design requirements. It also recommended the management of climate change risks via implementation of a permafrost monitoring system for all tanks at the site, the strengthening of safety management systems and updating of emergency response plans for major spill events

Source: ERM (2020)

Challenge 5: Considering disaster displacement and risks faced by internally displaced people and migrants

This challenge is based on contributions developed by the Internal Displacement Monitoring Centre (IDMC) and the International Organization for Migration (IOM).

Floods, earthquakes and wildfires triggered most displacement due to disasters during 2008–2021. As climate change may render some hazards more frequent and intense, it is likely that the Europe and Central Asia region will experience higher disaster displacement if climate change adaptation and mitigation measures are not put in place. This challenge provides figures and analysis to help understand the scope and scale of disaster displacement in the region. It also provides recommendations on the way forward.

Background

Between 2008 and 2021, more than 1.9 million internal displacements due to disasters were recorded in Europe and Central Asia (IDMC, 2021). Most were as a result of the impacts of floods, earthquakes and wildfires. This value should be considered an underestimate since there is no comprehensive monitoring of disaster displacement in the region. Some reporting on disaster displacement is partially covered by local, national and regional authorities, but around half of the figures come from local and national media outlets, which are generally less comprehensive and reliable sources of information.

In general, internal displacement estimates are extrapolated from proxy indicators such as evacuation orders and destroyed housing, which may not fully capture the scale or duration of disaster displacement. Reporting also covers only some natural hazards, which means that figures could be just a fraction of true totals.

Emergency responses support the immediate needs of displaced people. However, the lack of a solid evidence base about displaced people hampers the design and implementation of policies that adequately respond to challenges inclusive of the identification of durable solutions, resolution of documentation and legal status issues, and other formative obstacles.

In recent years, many countries in the region have aligned their DRR policies and strategies with the Sendai Framework (UNDRR, 2020b)[17]. This holds the promise for more and better data on migrants and internally displaced persons. These data could guide policy and action for DRR and durable solutions to internal displacement, including under the United Nations Secretary-General's Action Agenda on Internal Displacement (United Nations, n.d.).

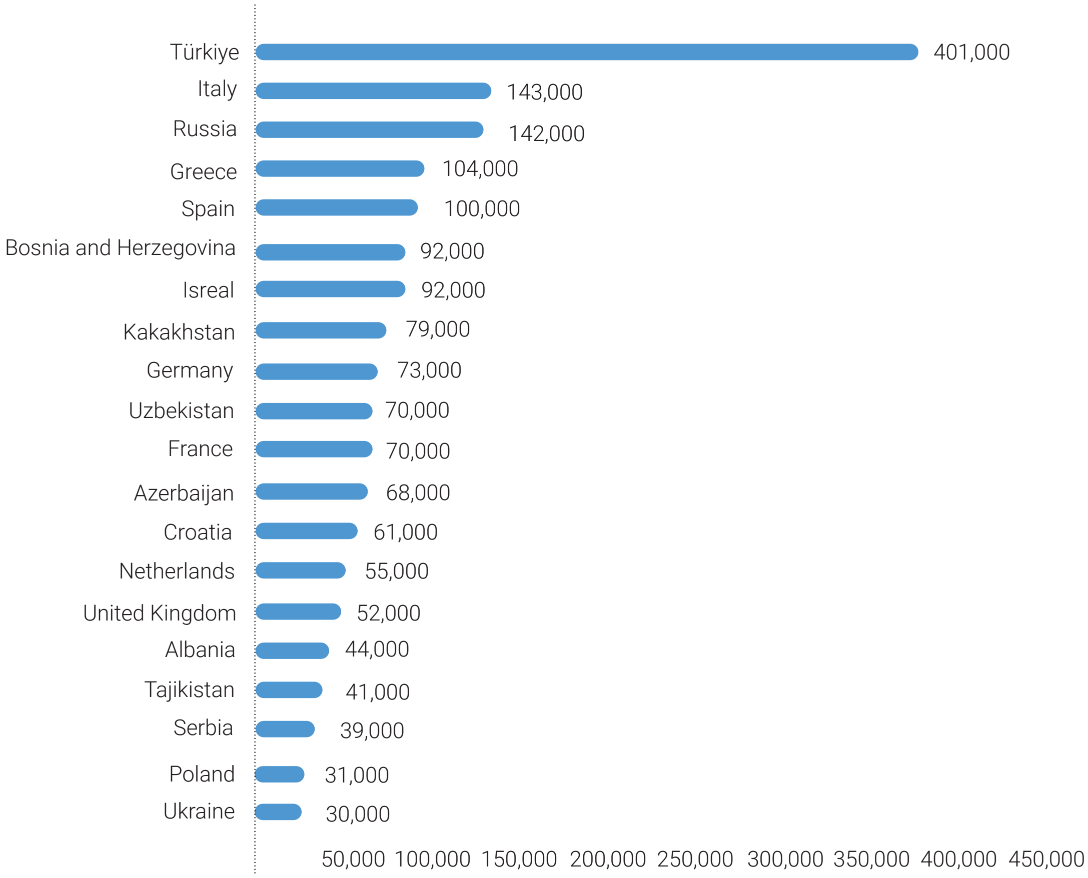
Recent impacts

Within Europe and Central Asia, in 2008–2021, the countries with the highest numbers of internal displacements triggered by disasters were Türkiye (401,000), Italy (143,000) and the Russian Federation (142,000) (see Figure 4).

In 2021 alone, 109 disaster events triggered 280,000 displacements, the highest figure since 2008 (IDMC, n.d.a).

17 See, for example, the European Union Civil Protection Mechanism (European Commission, n.d.a) and the Central Asia and Caucasus Disaster Risk Management Initiative (World Bank, UNISDR and CAREC, n.d.).

Figure 4. Twenty countries in Europe and Central Asia with the highest number of internal displacements triggered by disasters (2008–2021)

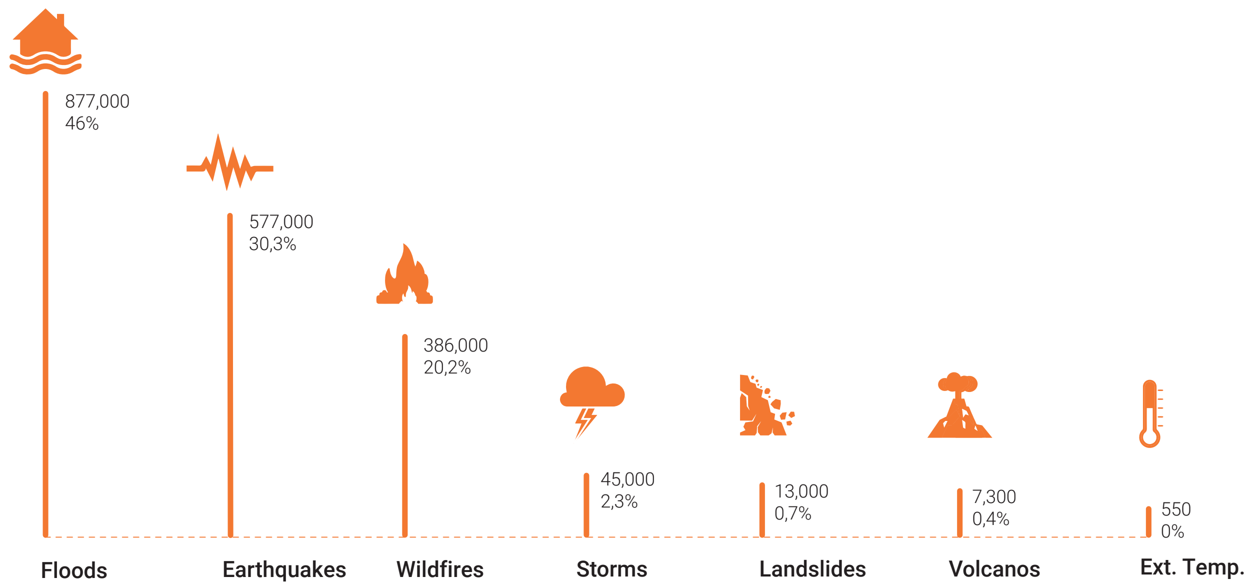


Note: No data for this reporting period have been obtained for Andorra, Armenia, Belarus, Denmark, Estonia, Holy See (Vatican City State), Liechtenstein, Lithuania, Malta, Monaco, San Marino and Turkmenistan.

Source: IDMC (n.d.a)

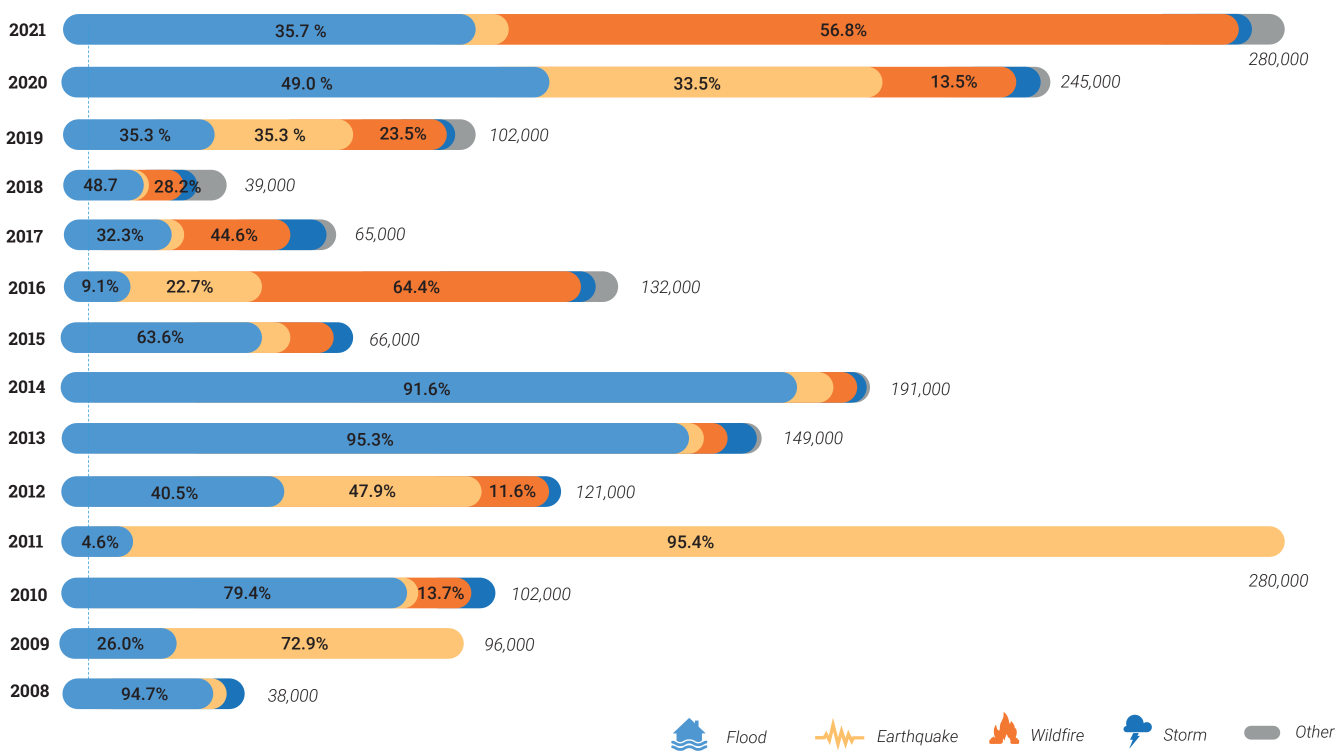
Over the same period, floods were the most frequent hazard and triggered the highest number of internal displacements. Earthquakes, although less frequent than floods and wildfires, also triggered a high number of internal displacements (see Figures 5 and 6).

Figure 5. Internal disaster displacements in Europe and Central Asia, by hazard type (2008–2021)



Source: IDMC (n.d.a)

Figure 6. Historical overview of internal disaster displacements in Europe and Central Asia (2008–2021)



Source: IDMC (n.d.a)

More than three quarters of the total disaster displacements recorded in the region in 2021 were triggered by just five events. However, small-scale displacement events are far more frequent, and they can undermine development gains and compromise the well-being of individuals and communities. Even though small-scale displacements tend to be underreported, around half of the disaster events that triggered displacement in 2021 caused fewer than 100 displacements each. Many were the result of consecutive disasters that pushed the same communities to flee more than once.

This happened for instance in the United Kingdom during the spring floods in 2020: some of the 40 people evacuated in the county of Kent in March were fleeing flooding for the second time in a few weeks. Some had to evacuate in December 2019 and again during Storm *Dennis* in February 2020. Since hazard intensity plays a lesser role in such events, their scale and impact can be significantly reduced by measures aimed at reducing people's exposure and vulnerability, for example by improving land-use regulations, social protection and insurance coverage.

Floods

Floods have been the hazard triggering most displacement in the region, with more than 870,000, or 46%, of the total disaster displacement between 2008 and 2021.

The countries with the highest number of flood events triggering displacement are France, Italy and the Russian Federation. It is worth noting that this may be partly due to more comprehensive and accessible information on disasters in these countries.[18] While all of France is subject to heavy precipitation, the county's Alpine and Mediterranean regions are more frequently affected, and intense rainfall often results in flash flooding.

The Russian Federation experiences yearly flooding due to snow and ice melt, and heavy precipitation during the summer months. Floods have triggered an average of 8,400 displacements per year in the country. In June 2021, over 2,700 people were evacuated in the Amur region due to heavy rains and flooding (Russian Federation, 2021).

The same disaster event may have a displacement impact in several countries. This is particularly the case with floods. For instance, on 1 May 2020, following a week of heavy rain, the Sardoba Reservoir Dam on the Uzbek side of the Syr Darya River collapsed, leading to massive flooding in Kazakhstan and Uzbekistan (UNOOSA, 2020). About 70,000 people were evacuated from 22 villages in Uzbekistan, and around 32,000 from 14 villages in Kazakhstan (FloodList, 2020).

Another noteworthy example is the Western European floods of 2021, which triggered at least 83,000 displacements across three countries. Heavy rains from a low-pressure system that developed in July triggered severe floods that caused around 51,000 displacements in the Netherlands, 16,000 in Belgium and over 16,000 in Germany (IDMC, n.d.a).

The high damage and destruction to houses and the economic losses that floods cause leave many of those displaced facing long-term displacement and challenges in sustaining their livelihoods. This was the case with the 2010 flooding in the French town of La Faute-sur-Mer, where the French Government deemed it unsafe to rebuild homes in flooded areas. This measure was positive in the sense that it prevented future displacement, but it left those displaced with no other option but to move to a different location (Martinez and Monella, 2022).

Earthquakes

Displacement associated with earthquakes is less frequent and occurs at a lower yearly average than many other hazards, but earthquakes remain the hazard with the highest displacement impact per event (BDTiM, 2023).Fifty earthquakes triggered about 577,000 displacements in the Europe and Central Asia region between 2008 and 2021, which shows how mass displacement can be triggered in just a few disaster events.

Given its location in the Anatolian tectonic plate, Türkiye is in a distinctive setting, effectively positioned amidst the Eurasian, African and Arabian plates (DownToEarth, 2023). As the larger plates shift, Türkiye is squeezed and sits on several fault lines, with the North Anatolian fault line being the most seismically active regions in the world (Abraham et al., 2023). The East Anatolian fault line and the Aegean Sea Plate also affect different parts of the country, makingTürkiye prone to thousands of tremors each year (Federal, 2023), with four of the deadliest earthquakes occurring in 2020 and 2023.

18 The countries for which 15 or more flood events were recorded from 2008 to 2021 were: Albania, France, Italy, Romania, Russian Federation, Serbia, Spain, Türkiye and United Kingdom.

In 2023 the 7.8 magnitude earthquake that hit Türkiye displaced 3 million people (OCHA, 2023).

During 2008 to 2021, 11 earthquake events triggered 292,000 displacements. One large event was a 7.2 magnitude earthquake that struck Van Province on 23 October 2011. It is estimated to have displaced 252,000 people (IFRC, 2011a). This was followed by a 5.7 magnitude aftershock 50 hours later, hundreds of smaller aftershocks, and a 5.6 earthquake south of Van on 9 November that year (Mehdi and Nazmazar, 2013). In addition to the people displaced, hundreds were killed and approximately 4,000 buildings were destroyed or seriously damaged. The earthquake on 9 November caused the destruction of more buildings than the initial earthquake on 23 October, as previously weakened buildings were unable to withstand the further shock. The quality of construction of the buildings played a role in the breadth of the damage, and thus displacement. On 6 February 2023, a 7.8 magnitude earthquake occurred in southern and central Türkiye and northern and western Syrian Arab Republic. The earthquake had a maximum Mercalli intensity of XII and was followed on 20 February by a 7.7 magnitude earthquake, resulting in widespread damage affecting an estimated 14 million people and leaving around 3 million people homeless (OCHA, 2023).

Wildfires

Wildfires are the hazard causing extensive displacement in Europe and Central Asia, with 174 events that triggered 386,000 displacements during 2008 to 2021 (see also Challenge 1 above).

The increase in displacement associated with wildfires is largely the result of an improvement in quality and access to data. Across the region, around 155,000 displacements due to wildfires were recorded in 2021, predominantly in France, Greece, Spain and Türkiye. Almost 300 wildfires burned 126,000 ha of land within a span of less than 3 weeks in Türkiye in July and August 2021. Prolonged drought, record-breaking heat and strong winds contributed to the spread of the fires, which triggered almost 81,000 evacuations. Similar conditions in Greece provoked more than 58,000 displacements.

Connected themes

Challenges faced by migrants: Vulnerability, disasters and socioeconomic impacts

European and Central Asian countries are places of transit and destinations of diverse, significant international migration flows, originating from within the region, as well as from all other regions in the world. In 2020, the region was estimated to host over 100 million migrants, or 35% of the world's total stock (United Nations, Population Division, 2020). Immigration is an influential factor shaping demographic trends in the region, including overall population, and its distribution and characteristics (Lutz et al., 2019).

The impacts that migrants suffered due to the COVID-19 pandemic and other disasters are felt directly and through psychological and economic impacts to distant family members and communities of origin. Their capacities, knowledge and networks underpin their resilience in the face of shocks. While migrants across Europe and Central Asia are a heterogeneous population, they fare consistently worse than native-born individuals on most socioeconomic metrics, including poverty, access to employment and residence in substandard housing. These issues are particularly acute for migrants in transit, irregular migrant workers and migrants from discriminated minorities. They manifest in a variety of day-to-day challenges, but also influence their specific patterns of disaster risk.

The locations in which many migrants live and transit through are often particularly hazardous. Since 2019, many migrant settlements have become risk hotspots, due to the concentrations of people living on marginal land in inadequate conditions. This has translated into disasters such as the 2020 fires in the Moria refugee camp on the Greek island of Lesvos, which left 13,000 migrants and asylum-seekers without shelter (BBC News, 2020). Similar conditions drive risk in other migration settings. Migrant farmworkers' accommodation, for instance, has been affected by fires, including in Nea Manolada, Greece (ekathimerini, 2018), the Campania region, Italy (Corriere, 2021) and southwest Spain (Bathke, 2020). In Europe and Central Asia, migrant workers are also vulnerable to the effects of heatwaves and cold waves in the construction and agricultural sectors through their employment conditions (ILO, 2019; Messeri et al., 2019).

Past disasters show the specific challenges migrants face in a disaster, which are rarely accounted for by DRM and DRR efforts. Limited proficiency in the local language reduces their ability to access information, while limited local knowledge hinders their ability to obtain basic services and assistance, as was the case for foreign-born residents affected by the 2017 Grenfell fire in London (Brooks, 2017). Undocumented migrants may refuse to come forward to seek help, due to fear of arrest and deportation, or may have limited resources to cope with and recover from disasters.

All these challenges were on full display throughout the COVID-19 pandemic, shaping migrants' vulnerability to the different components of this crisis (Guadagno, 2020). Migrant reception centres and migrant workers' accommodation were identified as some of the most hazardous living arrangements for the transmission of the virus, requiring widespread decongestion and monitoring efforts (Costanzo et al., 2020; EASO, 2020).

Unsafe living conditions translated into increased likelihood of contracting COVID-19 for migrants. Migrants are overrepresented in the workforce most exposed to the risk of contracting the disease, such as in the health-care and food production sectors, and more in general in employment sectors where distancing or remote working was not possible (IOM, 2023a). Limited access to health care, whether due to economic, administrative or communications barriers, lack of knowledge or mistrust towards service providers have resulted in consistently worse health outcomes for migrants relative to natives – a fact that has been verified in Germany, Greece, Italy, the Netherlands, the Scandinavian countries, Spain and the United Kingdom (Hayward et al., 2021).

Migrants have, in general, suffered worse socioeconomic impacts due to the pandemic and related lockdowns, business closures and the economic crisis. Migrants in the region were found to be disproportionately likely to become unemployed due to the pandemic, with up to 40% of the total migrant workforce facing the prospect of being laid off in countries such as Austria, Germany, Italy, Portugal and Spain in 2020 (Fasani and Mazza, 2020). This was due to the relative lack of protection of many migrants' jobs, especially those who were employed in the informal labour market, meaning they were often among the first to be let go. Many migrants, especially the undocumented ones and those working informally, lacked access to welfare assistance to cope with these impacts.

Lastly, COVID-19 resulted in unprecedented closure of borders and obstacles to international mobility (IOM, 2021). Throughout Europe and Central Asia, COVID-19 resulted in migrants becoming stranded in host and transit countries. This created specific impacts for migrants, including loss of legal status and destitution (Najbullah and Akimbek-uulu, 2021).

The Ukraine situation

The full-scale war in Ukraine entered its second year in 2023, with continued destruction across the country and fighting particularly concentrated in the east and south. As of early June 2023, large-scale displacement persisted, with over 13.5 million people affected by displacement within and beyond the country's borders. Some 5.6 million people have returned to their place of habitual residence, primarily following displacement within Ukraine, despite critical challenges such as persistent instability, damage to housing and civilian infrastructure, and limited services. People's movements and intentions continue to be dynamic, and humanitarian needs remain high. The humanitarian community estimates that 17.6 million people in Ukraine – 40% of the country's total population – and 4.2 million in refugee hosting countries continue to need multisectoral humanitarian assistance (IOM, 2023b).

According to Ukraine's Environment Minister, as of February 2023, the country had suffered over $51 billion in environmental damage because of the war (Guillot, Zimmermann and Coi, 2023). Numerous pieces of military equipment and expended ammunition, as well as exploded missiles and aerial bombs, have polluted soil and groundwater with chemicals, including heavy metals. The numerous attacks will lead to potentially devastating environmental consequences at more than 200 industrial facilities in Ukraine, including nuclear power plants, often located near populated areas, posing serious health-related risks for the population and representing significant sources of environmental degradation.

Large-scale displacement and changing cross-border mobility dynamics have significantly challenged the capacities of border management, law enforcement and protection systems to ensure safe cross-border pathways and service delivery for increased numbers of people, often at sudden rates. This creates the need for national migration and border authorities to adapt their approaches and build institutional and preparedness capacities in line with European Union standards and international good practices.

Relevance of the risk drivers

Climate change and environmental degradation

Climate change, in combination with other factors, is likely to increase future displacement. If the world's population were to remain at its 2021 level, the risk of flood-related displacement globally would increase by more than 50% with each degree of global warming (Kam et al., 2021). In the region, the Russian Federation would be the country most affected by such an increase, as floods exceeding 1 m in depth are projected to occur more frequently, especially in Siberia (Kam et al., 2021). However, all of Europe and Central Asia must be prepared to cope with unprecedented extreme weather events, whose probability has been substantially increased by global warming (Diffenbaugh, 2020).

Extended wildfire seasons, increasing drought, sea-level rise, and glacier and permafrost melting are among the hazards that may affect the region due to climate variability and change as a result of global warming and the concentration of greenhouse gases (Kovats et al., 2014). But so far, understanding of how these hazards could intensify and displace more people remains limited.

Climate projections suggest that extreme temperatures and shifting rainfall patterns could increase the number of and intensify heatwaves and severe droughts across Europe. This would increase the frequency, length and severity of wildfire seasons and extend the areas at risk, which could drive desertification and degradation across most of the Mediterranean region and southern Europe, thus affecting displacement (EEA, 2021a).

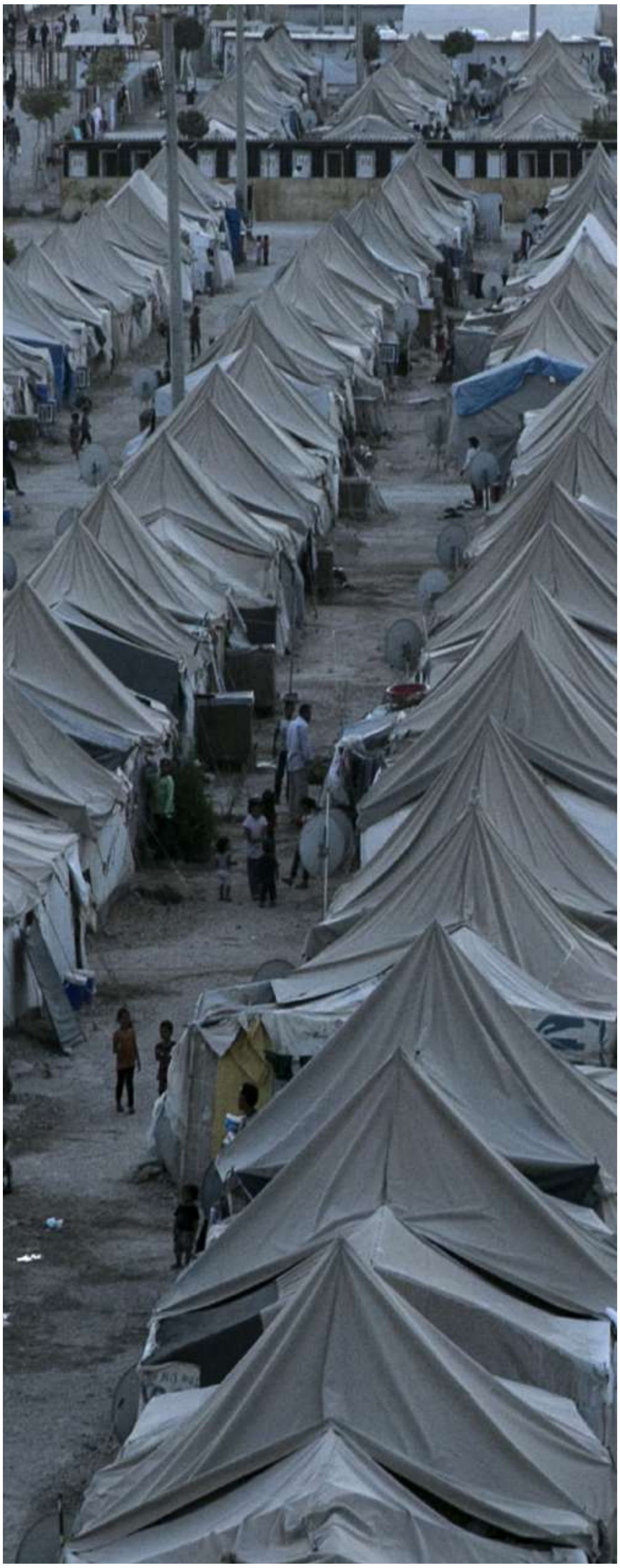
The observed trend towards warmer and drier conditions in southern Europe is projected to continue in the next decades, which could lead to a substantial expansion of the fire-prone area. These changes can lead to changes in the ecosystem, which also reduce protection against fires, storms and other sudden-onset events, leaving people more vulnerable and increasing their risk of displacement. As countries often face multiple hazards, their impacts on disaster risk displacement are interwoven and heightened.

Improving data on population exposure and rethinking how to assess vulnerability will allow understanding how "riskscapes" evolve, and how social and economic patterns come about in the face of a changing climate[19]. By looking at the likelihood of displacement, local and national governments will be better equipped to understand the consequences of (in)action.

Interconnected and complex economies, societies and infrastructure

Disasters, including floods, earthquakes and wildfires, are a reality of life for people in Europe and Central Asia. They are anticipated to increase in severity as the climate changes and as different hazards compound the risks created by one another. In disaster-affected countries and communities worldwide, displacement is a strong people-centred marker of where increased efforts are needed to reduce exposure and vulnerability. Integrating displacement risk and impacts into national DRR policies and measures promotes coherence across the mandates of multiple ministries and/or agencies, as it spans emergency and longer-term actions needed to avoid and reduce further risk creation and enable sustainable solutions.

As highlighted in GAR2015: "While historical losses can explain the past, they do not necessarily provide a good guide to the future. Most disasters that could happen have not happened yet" (UNISDR, 2015).



Aerial view of Akcakale Refugee Camp, Sanliurfa Türkiye

Tolga Sezgin / Shutterstock.com

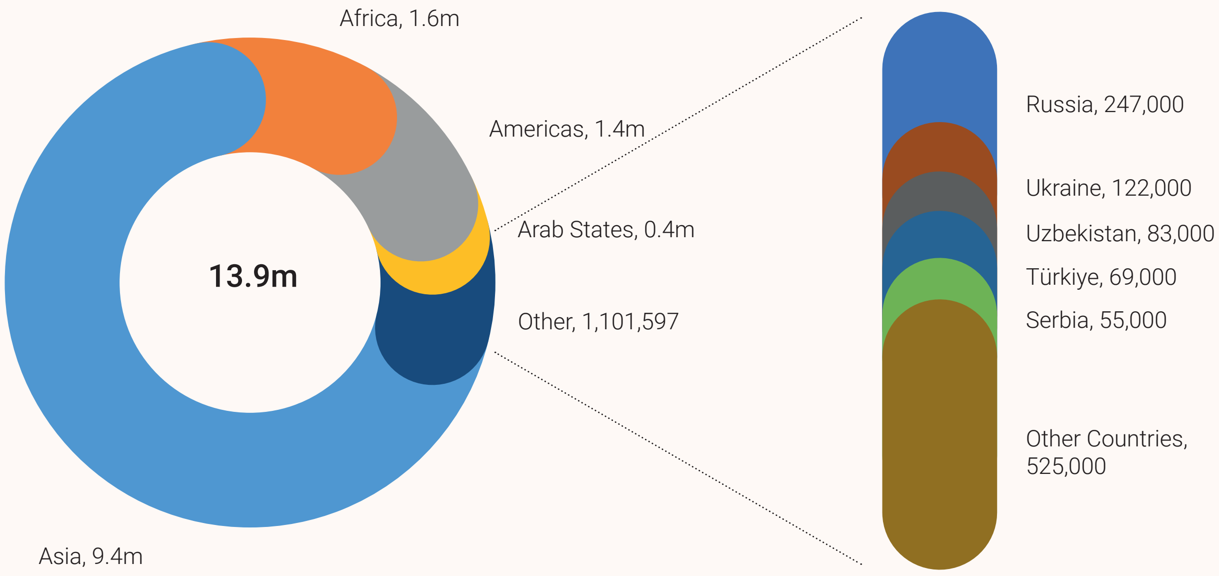
19 "The concept of riskscapes refers to temporal spatial phenomena that relate risk, space and practice. It links the material dimension of potential physical threats, the discursive dimension of how people perceive, communicate and envision risks, and the dimension of agency, i.e., how people produce risks and manage to live with them" (Müller-Mahn et al., 2018).

Assessing the risk of future disaster displacement can help policymakers to understand the potential scale of disaster displacement and the places that are most at risk. They are a useful tool for action to reduce such risk and avert future displacement (see Box 10 for an example).

Box 10. Predicting risk trends

In 2017, disaster impact models suggested that, on average, 13.9 million people were expected to be displaced each year globally by tropical cyclones, including from the winds and storm surges they cause, and by earthquakes, tsunamis and riverine floods. About 8% of them, or 1.1 million, were in Europe and Central Asia (see Figure 7) (IDMC, 2017). About 838,000 of them could be displaced by riverine floods, especially in the Russian Federation, Serbia and Ukraine, where about 50% of the annual displacement risk was related to this hazard alone (see Figure 8). Flood displacement risk is particularly high in the Russian Federation, mostly due to the high population density near major river basins that are prone to flooding.

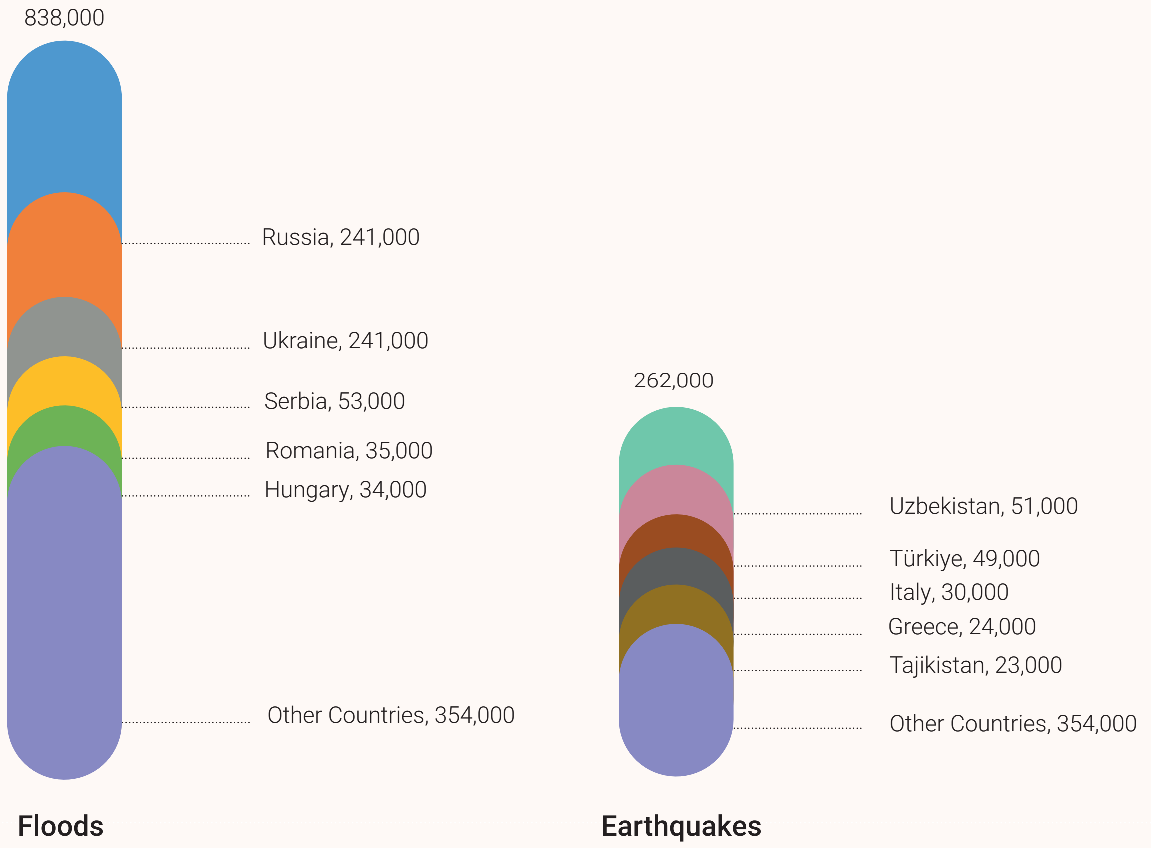
Figure 7. Average risk of annual displacement per region, and top five countries in Europe and Central Asia



Source: IDMC (n.d.b)

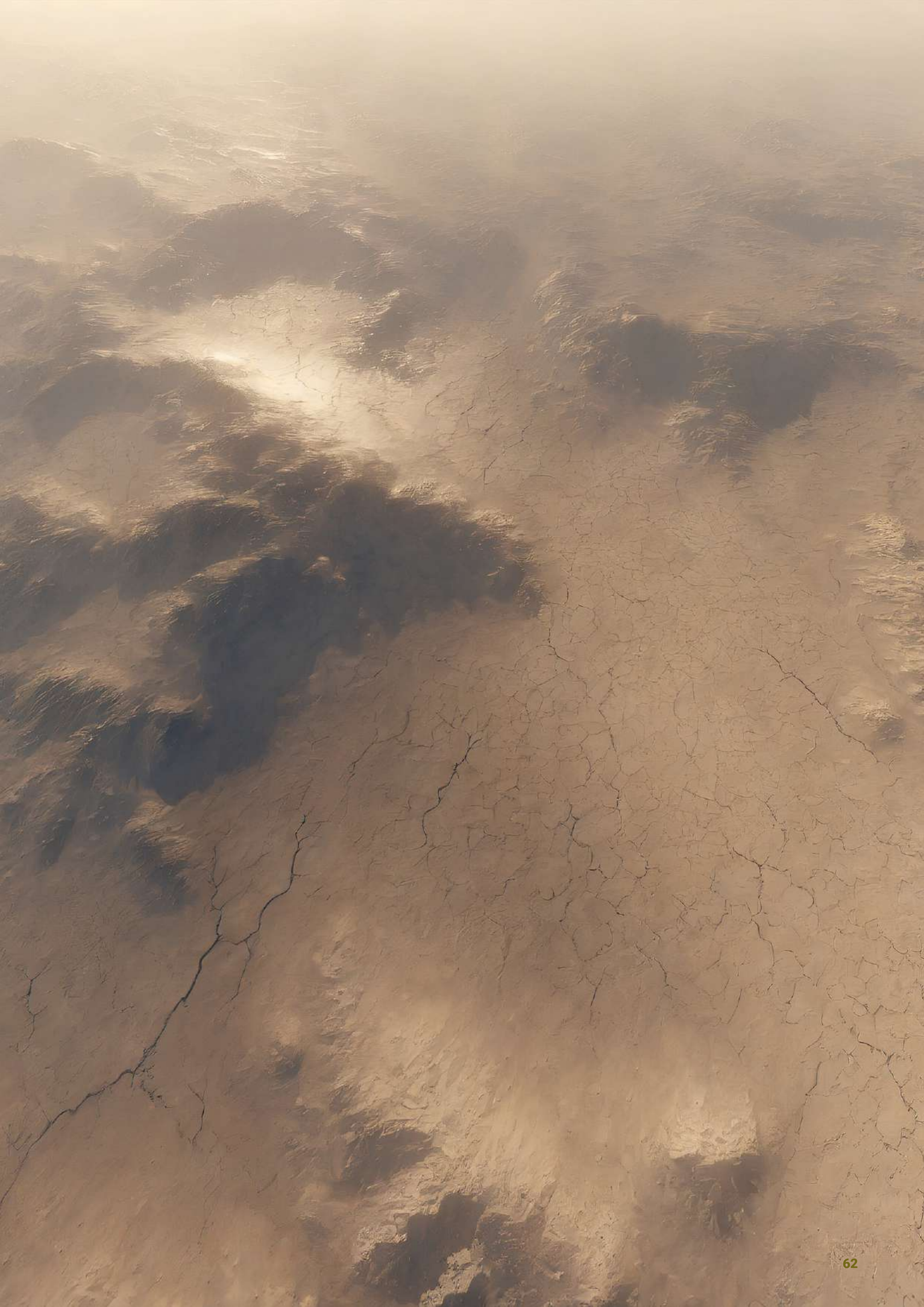
Although less frequent, earthquakes were also expected to trigger a high number of displacements in the future (as recently witnessed with the 2023 Türkiye earthquake), with about 262,000 people at risk of being displaced, which represented about 25% of the regional total displacement risk in the region. Nearly three quarters of those at risk are in Greece, Italy, Tajikistan, Türkiye and Uzbekistan, which are located in fault lines prone to seismic activity (see Figure 8).

Figure 8. Average risk of annual displacement by floods and earthquakes in Europe and Central Asia



Source: IDMC (n.d.b)

It is important to highlight that the statistics provided above are future annual averages, but there may be outlier events that could displace a much higher number of people at any given year in the future. In addition, the analysis is limited in the sense that it is not assessing the risk of displacement due to other hazards that could potentially displace a high number of people. For example, the city of Naples, in Italy, at the foot of Mount Vesuvius, could be affected by a volcanic eruption of massive proportions (Barberi, 2011). No displacement risk assessments exist for this type of event; therefore, the number of people that could be displaced by volcanic eruptions in this and other countries in the region is unknown.



Recommendations to reduce risk

Learn how to live with extreme weather events

Better risk knowledge can shape policy and make a positive difference. In May 2014, an extreme flood event, which affected 1.6 million people and triggered 32,000 displacements, highlighted the need for Serbia to change its approach to flood prevention. The country abandoned the idea that floods can be suppressed or controlled and shifted towards embracing flood risk adjustment or the principle of "living with floods" (Gačić et al., 2015). This policy shift was based on data.

Monitor disaster impacts and disaggregate data

Without improved data on disaster impact, countries lack evidence to amend policy to protect the people who are affected or who are at risk of being affected by future events. Monitoring is a necessary and cost-efficient investment for DRR.

Beyond systematic data collection, good data disaggregation is also useful. High-quality impact data must be prioritized. This includes using data on slow-onset disasters, and understanding the geolocation of displacement (from where to where), as well as its temporal dimension (for how long people are displaced). Disaggregating data by hazard type can allow countries to better plan for risk reduction, preparedness and response. Box 11 shows the different indicators that could be mainstreamed into disaster damage and loss databases, to better account for and understand disaster displacement in Europe and Central Asia.

Box 11. **Examples of legal instruments addressing aspects of technological risk management**

Given the lack of displacement-related metrics among the indicators that countries use to monitor progress of the Sendai Framework, IDMC and IOM launched a joint project to develop a set of indicators inclusive of the elements listed below for monitoring disaster displacement, and the impacts and related risks (IOM, n.d.). Under funding from the German Federal Foreign Office, pilot implementation of the disaster displacement indicators is ongoing in Bangladesh, Indonesia, Mozambique and the Philippines between IOM Displacement Tracking Matrix teams and host government national disaster management authorities and other relevant government counterpart entities. Initial findings should be available later in 2023.

Number of people pre-emptively evacuated

Displacement is not always a negative outcome. Pre-emptive evacuation saves lives, and is an effective resilience measure. Governments are encouraged to collect and provide disaggregated information on the number of evacuated people. Keeping track of the number of evacuees will allow countries to measure their success in early warning and evacuation protocols.

Number of people displaced during and after disasters

Information on the number of people displaced during and after disasters should also be collected. The impact of hazards may be worse for those who are forced to flee their homes, and the vulnerabilities of displaced people may be higher than those who are not displaced.

Disaggregated metrics

Metrics on the number of people displaced during and after disasters will allow governments to better understand the situation faced in terms of impacts (e.g. loss of livelihood because of displacement), location (e.g. in shelters or with relatives) and so on. Ideally, information should be disaggregated by sex, age and other relevant characteristics.

Number of houses destroyed

When no data on the number of people displaced by disasters are available, housing destruction could be used as a proxy to measure displacement. Depending on national indicators such as insurance penetration or construction costs, it is also possible to extrapolate the duration and extent of economic disruption linked to the disaster.

Duration of displacement

Understanding how internally displaced persons' vulnerabilities differ from one situation to another, irrespective of scale, is important in painting a comprehensive picture of the severity of their displacement. It is also vital to inform effective and targeted planning and responses to help bring displacement to a sustainable end, and to focus attention, political will and resources where they are most needed.

Assess spatial and temporal changes

Given that people's level of vulnerability and exposure to hazards determines the severity of their impacts, it is important to assess how these aspects will change over space and time, and to unpack the economic, social, environmental and governance factors that affect disaster displacement risk (Field et al., 2012).

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Migrants walk towards Türkiye's Pazarkule border crossing with Greece's Kastanies, Edirne, Türkiye

Chapter 4: Good practices

Just as the Europe and Central Asia region is host to specific risk drivers, as covered earlier in this report, so too is it the home of good practices that provide a hopeful outlook for risk reduction. These are not exhaustive and are clearly interconnected. They represent the great strengths of this region in addressing the challenges outlined in this report and offer levers in achieving some of the recommendations in each of the challenges.

Good practice 1: Inclusion of disaster risk reduction in the policymaking process

Public policies are essential instruments in the governance of any political field. Many factors influence public policy formulation, including expert advice, social norms and priorities, international trends, interest groups and other contextual aspects.

DRR policies face specific challenges in that their cross-sectoral, interdisciplinary and society-complex character makes it difficult to settle on policies that will be unequivocally resilience-enhancing. For these reasons, it would be ideal to:

- Consider specifying policies explicitly related to DRR in comparison to other social welfare, safety or development policies.
- Determine the appropriate scientific knowledge to incorporate into the formulation of DRR policies and establish methods to assess their value.
- Seek clarity on the origins and implementation of DRR policies, including how and where they have been developed and applied.

A survey conducted in 2018 by E-STAG showed there is a strong interest in Europe and Central Asia to understand DRR as a policy field better and to learn how formal evaluations and scientific knowledge are used in the formulation and implementation of DRR policies. A better understanding of the status and processes of DRR policies could improve communication between the scientific community and policy bodies and implementation of the Sendai Framework. Based on that survey, E-STAG decided to conduct a further study to investigate the science–policy–society ecosystem throughout the European region. The study considered three types of policies:

- Formal policies, such as laws and regulations. These are usually in the form of official documents with legally binding rules.
- Normative policies, such as standards, norms and principles. These are typically found in "softer" policy documents targeting actors in the field and campaign and communications material.
- Operative policies. These can take various forms, such as guidelines, instructions and training material.

The study found there is a broad understanding that many, if not all, governmental bodies need to be involved in working towards reduced disaster risks. However, there is a difference in approaches between countries with politico-administrative systems consisting of small governmental departments and large agencies vis-à-vis the other way around. The former tends to have dedicated national agencies for DRR that bring together the relevant authorities and stakeholders. The latter exhibit a more hierarchical organizational structure with substantive involvement by political institutions, such as ministries and civil protection agencies.

Funding is offered for research inputs during windows of opportunity that succeed disasters but usually turns out to be short term, reflecting a narrow scope in inducing change.

Several countries highlight that DRR policies and plans are often, but not always, related to new risks induced by climate change, such as rising sea levels, eroding shorelines, an increase in heatwaves, and more intense storms and precipitation patterns.

While the policymaking process might look different from country to country and from one policy area to another, a set of specific steps and procedures is typical in the policymaking process (Dryzek and Dunleavy, 2009; Hill and Varone, 2021). It is usually conceptualized as cyclical, consisting of sequential parts or stages (Howlett and Giest, 2015). In a simplified, widely recognized format, the six most common phases are: (1) problem emergence, (2) agenda setting, (3) consideration of policy options, (4) decision-making, (5) implementation and (6) evaluation (Jordan and Adelle, 2012).

The initiatives for normative and operative policies often come about through policy learning within the DRR policy domain. Valuable or painful experiences of implementing the DRR policies (failures, implementation dysfunctions and lessons learned) draw attention to the gaps or inadequacies of the legislation, procedures or norms and steer new legislation. DRR policies are therefore driven by individual events that prompt politicians "to do something".

This discussion of what Birkland (1998) calls "focusing events" is well known in disaster research, and is commonly seen as challenging for policymaking around DRR (Albris et al., 2020). Post-event stimuli are reported as decisive moments in DRR agenda setting by several countries, for example Armenia (Spitak earthquake 1988), Italy (L'Aquila earthquake 2009), Portugal (forest fires 2017), Sweden (Boxing Day tsunami 2004) and Türkiye (Marmara earthquake 1999). Several countries also report on lessons learned from the COVID-19 pandemic.

Case study: Croatia

Croatia provides a particularly interesting example of the impact a focusing event can have in producing comprehensive and meaningful change involving several actors. On 22 March 2020, an earthquake struck Zagreb, damaging the city centre and many of its historic buildings (Bogdan, 2020). At the time, Croatia did not have well-developed post-earthquake damage assessment mechanisms.

Immediately following the event, the University of Zagreb initiated a rapid post-earthquake assessment process. Within the next 2 days, the assessment process was established and ready to use on an online platform (Uroš et al., 2020).

Next, the post-disaster recovery legislation was created. The Croatian Chamber of Civil Engineers, the Croatian Chamber of Architects and the University of Zagreb had a crucial role in creating the Law on Reconstruction of Earthquake-damaged Buildings (Official Gazette 102/20, 10/2; Narodne Novine, 2020; Republic of Croatia, 2022). When another earthquake struck 9 months later, in December 2020, members of the Croatian Centre for Earthquake Engineering had become regular members of the Civil Protection Headquarters, advising on better recovery after the earthquake.

International bodies such as the European Union, the United Nations and the World Bank, and also standardization organizations issue legislation, standards, recommendations and practices. This kind of influence can provide support, templates and standardized procedures that render international collaboration more effective. However, there is a risk that DRR policies are not specific enough to accommodate the nuances of national contexts. Furthermore, a culture of DRR policymaking exclusively driven by international norms might limit an inclusive and bottom-up perspective and serve as a quick fix for governments.

Good practice 2: Creation of scientific knowledge on disaster risk reduction

Scientific advice should be based on rigorous studies and solid empirical grounds. It is of utmost importance that sufficient funding is in place to accomplish such research. Country experts have investigated how DRR research is funded nationally and internationally.

Within the region, there are examples of highly developed schemes for DRR on the national level. These are characterized by funding from, for example, governmental bodies, ministries, science councils and foundations. In a few cases, there are strategic investments in individual hazards or hazard families, such as seismological institutes in Greece, Italy and Türkiye, and hydrology and weather institutes in the Central and Northern European countries. A form of strategic funding was reported from Portugal – collaborative laboratories. These are integrated environments that demand specific cooperation among academic, public and private entities for a period of 5 or 10 years. As of July 2023, there were 35 such laboratories active in Portugal, of which one was specifically related to DRR: forestWISE (forestWISE, n.d.; National Innovation Agency, Portugal, n.d.).

In Sweden, the Swedish Civil Contingencies Agency funds most research in the field. A significant restructuring of the national funding for research in safety and security in the late 1990s resulted in an allocation for needs-based (applied) research to the agency. There was an articulated idea to split the funding between basic research – mainly funded by the national science councils –and needs-based studies. All of these are issued with calls for proposals that are reviewed blindly and exhibit high-quality demands. Efforts to integrate DRR and climate change adaptation research are essential to produce advanced knowledge regarding interrelated complex problems, but the heightened focus on climate change threatens to draw the focus from research funding for broader topics.

International funding is a means of channelling funding to countries with a low national research budget for DRR, but it is also a way to establish and foster international and cross-disciplinary collaboration. One of the most important international funding body within the region is the European Commission. Almost all countries reported deep involvement in international programmes and projects funded by the European Commission.

Case study: Montenegro

The BALANCE project (BALANCE, 2023), financed by the European Union, gathers a consortium of academic and civil protection organizations from Albania, Bulgaria, Croatia, Cyprus, Greece, Italy, Montenegro and Spain. The project aims to improve the civil protection preparedness and response capabilities of Montenegro in dealing with disasters that require joint response coordination facilitated via the European Union Civil Protection Mechanism.

Good practice 3: Transfer of scientific knowledge on disaster risk reduction

Scientific knowledge about DRR is of limited use if it is not communicated among relevant stakeholders. There are mechanisms for science–policy interaction on the European level, such as the Science Advice for Policy by European Academies (SAPEA, 2023), All European Academies (allea, n.d.) and Using Science for/In Diplomacy for Addressing Global Challenges (S4D4C, n.d.).

In the DRR field, the UNDRR Regional Office for Europe and Central Asia is driving a wide range of networks and initiatives including E-STAG, which is a voluntary group of experts providing scientific and technical support to European and Central Asian countries on the implementation of the Sendai Framework, and other relevant frameworks in the European Union in close collaboration with the European Commission's Disaster Risk Management Knowledge Centre. Among the scientific products E-STAG has developed, there are studies on wildfires in Europe, green and resilient recovery, resilient infrastructure and the science–policy interface (UNDRR, n.d.e).

The European Commission is a major funder for many collaborative projects, networks and infrastructure for knowledge exchange and brokerage. There are also national examples of mechanisms such as joint conferences for researchers and practitioners, expert networks, seminar and workshop series, knowledge-brokering platforms and scientific advisory boards.

While the inclusion of academia in drafting policy documents is crucial, the focus here is on contexts that foster interaction beyond that. There are many examples of how the scientific community is engaged in reciprocal knowledge transfer with officials and professionals in the DRR field. There are several well-established academic conferences, but they often focus on specific disciplines or hazards. While these topical conferences are undoubtedly vital for knowledge production and the exchange of knowledge within the scientific community, they are not well suited for external knowledge transfer or collaboration. Another type, exemplified by Greece and Türkiye, is commemorative conferences where stakeholders take stock of the developments after a particular event, such as an earthquake. A mechanism reported by Israel is weekly webinars and occasional conferences of the National Knowledge and Research Center for Emergency Readiness. These webinars are recorded and appear on the centre's website and other Internet platforms. Practitioners and researchers lecture in the webinars. Similar series exist in Germany and Sweden.

Case study: Italy

In Italy, an important and continuous mechanism for science–policy interaction in DRR is the collaboration between the Italian Civil Protection Department and competence centres. Emphasis is placed on the possibility of establishing networks of competence centres for the development of specific topics on integrated themes and in a multi-risk perspective.

The Italian Center for Research on Risk Reduction also aims to create a network of multidisciplinary competencies to carry out prevention and preparedness activities for civil protection and, more generally, towards DRR with a multi-risk, multisectoral and systemic approach (Italian Center for Research on Risk Reduction, 2021).

A crucial channel for expert knowledge exchange is education. There are a few examples of engagement at the primary school level in developing teaching material.

Case Study: Türkiye

The Disaster Training Application and Research Center at Istanbul Aydin University in Türkiye offers disaster-related training programmes for adults, children and people living with disabilities, as well as disaster emergency planning training to educational institutions, hospitals and the private sector.

Detailed assessment Making Cities Resilient workshop in Astana, Kazakhstan

Good practice 4: Adoption of a multi-stakeholder approach for disaster risk reduction

The social and environmental consequences of disasters are increasingly complex and intertwined. Innovative strategies are needed to manage risk and attenuate impacts. Multi-stakeholder platforms (MSPs) gather multiple organizations at different scales of governance that strive for more coordinated and integrated DRR actions (Djalante, 2012) and can effectively support complex impact mitigation to foster a more proactive and adaptive risk governance. In particular, international MSPs can play a crucial role in strengthening coordination among stakeholders working at different levels, implement activities, and enhance technical and financial capacities. This MSP mechanism is a useful form of adaptive governance. It facilitates multi-stakeholder approaches involving actors at different levels with different agendas – creating a space for participation and collaboration – ultimately creating a space for learning and sharing. These are contributing factors to building disaster resilience.

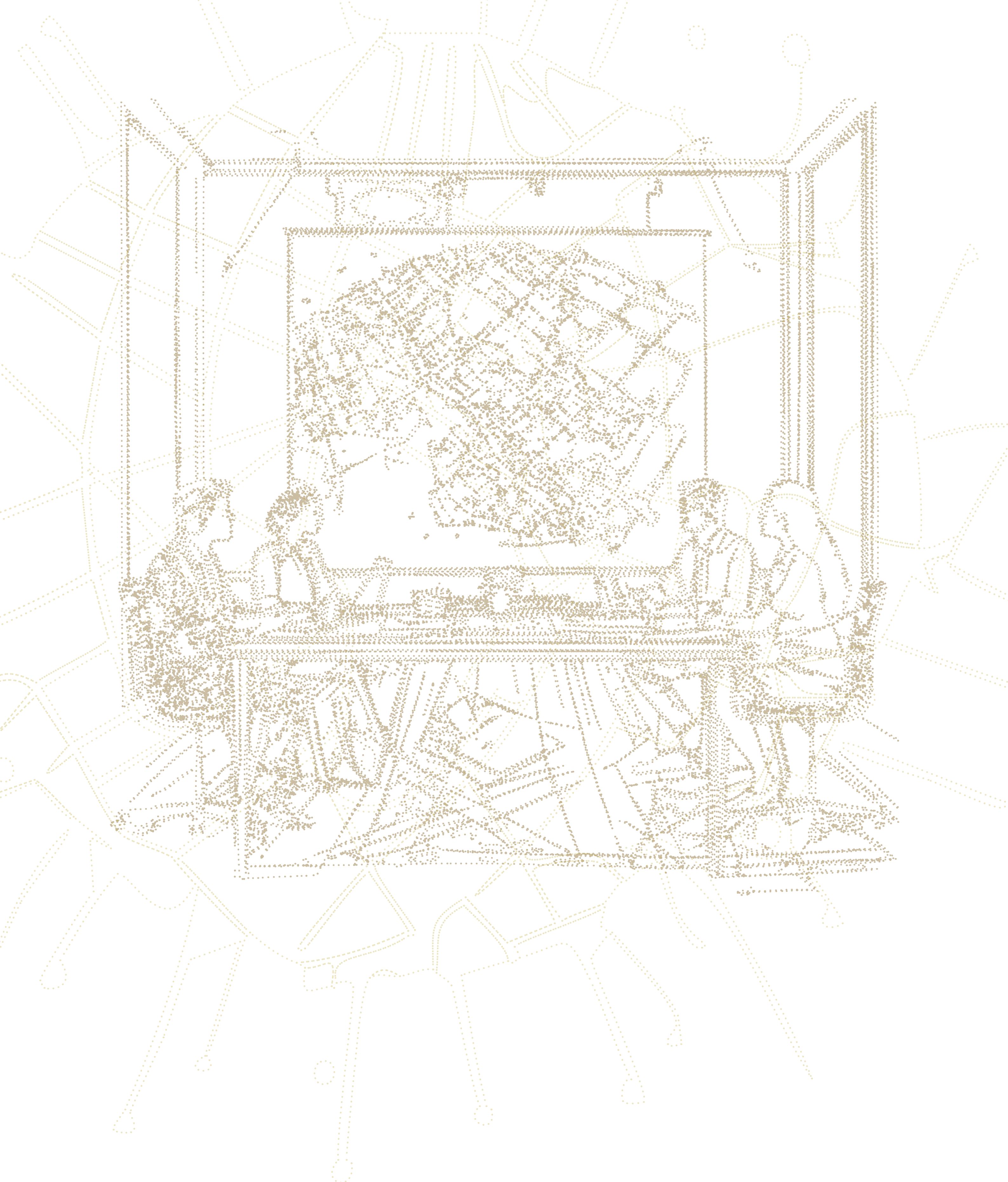
The UNDRR Making Cities Resilient initiative is an example that promotes multi-stakeholder involvement at the subnational level (UNDRR, n.d.f). Through it, many cities have undertaken strategic approaches to integrating DRR in their planning (Amaratunga et al., 2018).

The European Commission's Action Plan on the Sendai Framework outlines the actions needed to achieve the objectives of the Sendai Framework. Actions under Priority 2 (disaster risk governance) include managing multisectoral and multidisciplinary stakeholders to ensure risk awareness (European Commission, 2016). Box 12 provides several meaningful MSPs from the Europe and Central Asia region from which this report draws inspiration and best practices.

Box 12. Examples of MSPs

- Central Asia celebrated the International Day for Disaster Risk Reduction in 2020 and used the occasion to generate risk awareness. It focused directly on developing the potential of youth and engaging them in science and policymaking for DRR (UNESCO, 2020).
- The annual National Disaster Risk Management forum.
- A social media campaign named Stand out in Disasters was launched by EUR-OPA Major Hazards to raise awareness of disaster risks and showcase effective prevention measures all over Europe (Council of Europe, 2020).
- The European Flood Awareness System (EFAS, n.d.) was developed as a Pan-European flood early warning system. It was intended to systematically raise flood risk awareness with preparedness within the community and improve coordination between civil protection authorities at national levels and river basin levels. Raising awareness of and improving societal resilience against the threat that disinformation poses is one of the four pillars of the Action Plan against Disinformation (European Commission, 2018).
- The Making Cities Sustainable and Resilient Action was a joint initiative of UNDRR, the United Nations Human Settlements Programme and the European Commission that aimed to improve the understanding of and increase the capacity to address disaster risks and build resilience at the local level (including in crisis-prone cities) (Urban Resilience Hub, 2016).
- The International Federation of Red Cross and Red Crescent Societies (IFRC) developed a guide for planning public awareness and public education efforts, which has yielded increasingly successful high-impact outcomes (IFRC, 2011b).

Multi-stakeholder approaches to policy coherence can be a powerful tool to tackle emergent risk. However, the inclusion of science and technology in DRR should be utilized to ensure a fundamental understanding of risk is embedded in stakeholder engagement.



Good practice 5: Fostering of policy coherence for disaster risk reduction

The 2030 Agenda embraced universal goals applicable to all countries regardless of their level of development. It moved the focus away from the symptoms only to addressing the underlying causes of economic, social, environmental and governance challenges (OECD, 2016). SDGs and their operational targets are indivisible, universally applicable, and global priorities that incorporate economic, social and environmental aspects and recognize their interlinkages in achieving sustainable development.

Policy coherence for sustainable development (PCSD) means coherence among policies addressing all dimensions of sustainable development. It is important for (OECD, 2019c):

- Fostering synergies and maximizing benefits across economic, social and environmental policy areas such as climate change adaptation and DRR;
- Balancing domestic policy objectives with internationally recognized SDGs;
- Addressing the transboundary and long-term impacts of policies, including those likely to affect developing countries.

SDG Target 17.14 ("Enhance policy coherence for sustainable development") calls on all countries to apply policy coherence as a key means of implementation of all 17 SDGs. However, the 2030 Agenda does not provide guidance on how to ensure an integrated and coherent SDG implementation (Soria Morales, 2018). According to many voluntary national reviews, enhancing policy coherence is one of the most pronounced challenges in implementing SDGs (Soria Morales, 2018). Some countries, such as Iceland, have indicated that the Climate Action Plan is an example of a coordinated policy vehicle. The PCSD framework (OECD, 2016, 2019c) developed by OECD comprises:

- An analytical framework, to help understand trade-offs between SDGs and identify policy coherence;
- An institutional framework, to help align existing institutional mechanisms;
- A monitoring framework, to help trace progress on PCSD.

The European Commission Joint Research Centre has developed a method to identify and address interlinkages among SDGs and a dashboard of policy priority areas in which the European Union added value is maximized and the European Union policy nodes represent levers to exploit synergies for SDG implementation (Miola et al., 2019).

Coherent policy approaches bring greater efficiency and effectiveness and reduce the competition for resources (Akhtar-Schuster et al., 2011). Policy coherence in DRR and risk management can be addressed in two ways:

- Via policy coherence in practice, as similar ideas and objectives overlap. For instance, how integrated water resources management policies (United Nations, 2014) and climate change adaptation policies (UNDRR, 2020e) combine under flood risk management.
- Through comprehensibility, consistency and coherence in the policies at the local level and national level, as well as mutual reinforcement of policy actions (e.g. the alignment of national and local DRR policies with the Sendai Framework). Furthermore, there is horizontal coherence, which refers to coherence among policies at each level (local, national and international), and vertical coherence where instruments, institutions and organizations across scales are integrated.

Given the complexity of DRR policies, closer inspection of macro- and meso-level policies can reveal options to correct community disempowerment (Atkinson and Curnin, 2020). While DRR acts as a mechanism for climate change adaptation, the responsibility of each field lies within two different authorities, and the failure to connect alienates those who suffer first and most (Thomalla et al., 2006).

Disaster policy implementation and the fostering of policy coherence serve as a channel through which DRR influences sustainable development (Sawaneh and Fan, 2021). All four priorities of the Sendai Framework highlight the importance of multi-stakeholder collaboration at all levels in DRM, with a particular focus on policy coherence (UNISDR, 2015).

With the implementation of global agendas such as the Sendai Framework has come the institutionalization of coherent approaches across DRR practices and policies (Mizutori, 2020).

While creating a national DRR strategy involves multiple stakeholders (UNDRR, 2019a), it is important to note that various agencies and ministries at the national level follow distinct policy implementation and planning procedures when executing DRR and sustainable development policies (Mysiak et al., 2018).

On top of the misalignment of policies in different agencies, there is a power disparity in responsibility for DRR action (Dias et al., 2018). Only grass-roots involvement in decision-making will promote real policy integration.

Good practice 6: Acceleration of risk-informed investment for resilience

Accelerating risk-informed investment in DRR for resilience means supporting the resilience of the finance sector itself and ensuring that investments are resilient. The financial services sector must become more resilient to external shocks and stresses. More than 300 hazards have the potential to significantly affect the world's financial services sector (UNDRR, 2020d). Dynamic, non-linear risk will increasingly characterize disasters in the twenty-first century. Disaster risks must therefore be integrated into investment decision-making. To do so, the finance sector should better understand hazards, and their interconnections and possible impacts.

The global shock of COVID-19, initially a public health crisis, also became an unexpected and unprecedented global economic crisis.[20] Pandemic risk has demonstrated that disasters can cause unsustainable losses and require a change in how disaster resilience is addressed and valued by the financial system. In many cases, the financial sector assesses disaster risk based on a small group of well-modelled natural hazards with probabilistic impact curves. But COVID-19, climate change, global tipping points and non-linear, systemic disasters refute the viability of those approaches.

The financial losses from disasters are a systemic financial risk.

The response to COVID-19 in Europe has seen strong political leadership for a green and resilient recovery. Europe takes a leading role in driving the international agenda across forums including through the European Union, the Group of Seven, the Group of Twenty and the twenty-sixth Conference of the Parties (United Nations Climate Change Conference). It aims to showcase positive signs of investment in resilience through, for example, NextGenerationEU (NGEU), which allocates 30% of its funding to tackling climate change (European Commission, n.d.f). Central banks are also breaking new ground by integrating climate risk into stress tests and oversight. While a "green recovery" is popular in generic terms, there is less understanding of what a "disaster resilient" recovery means. DRR is a precondition for a resilient and green recovery. It can be achieved and makes good financial sense to invest in prevention from the outset.

Before the pandemic, the total reported economic losses caused by weather- and climate-related extremes in EEA member States over the period 1980–2021 amounted to €560 billion (EEA, 2021b). In the future, losses and disasters from climate impacts are likely to increase dramatically if adequate investment is not made in resilience to climate change. Cascading risks will create a further compounding effect. This has been confirmed by the IPCC Sixth Assessment Report, which forecasts with high confidence more rain-related flooding in Northern Europe and more hydrological and agricultural/ecological droughts in the Mediterranean area (IPCC, 2021).

In 2017, the expected annual damage of €3.4 billion per year for the European Union countries plus Iceland, Norway and Switzerland was projected to increase almost sixfold to approximately €19.6 billion by the 2050s, as a result of the effects of climate change (Forzieri et al., 2018).

Investing in DRR is a precondition for developing sustainably in a changing climate.

The benefit of investing in resilience outweighs the costs with high benefit–cost ratios. Flexible, adaptive approaches to infrastructure can reduce the costs of building climate resilience given uncertainty about the future. Damage estimates suggest that future infrastructure projects with a long lifespan may require a substantial additional upfront investment to ensure resistance to climate-related hazards (OECD, 2018b).

While the investment required in infrastructure is immense, public sector resources are limited, and the financing gap continues to grow rapidly. In 2016, the European Investment Bank calculated investment needs totalling €688 billion per year for Europe, including energy (€230 billion), transport and logistics (€160 billion), water and waste (€138 billion) and telecoms (€160 billion) (EIB, 2016). In 2017, according to the Asian Development Bank, Central Asia will require on average $33 billion in annual infrastructure spending through to 2030, to meet existing and known development needs (ADB, 2017).

20 As an example, a 2006 analysis by the European Union Directorate-General for Economic and Financial Affairs on pandemic risk concluded "although a pandemic would take a huge toll in human suffering, it would most likely not be a severe threat to the European macroeconomy" (Jonung and Roeger, 2006).

Public funds are already stretched to meet basic public and social services requirements. The European Green Deal, InvestEU, the European Union's Cohesion Policy, structural funds, the multiannual financial framework and other instruments, such as public–private partnerships, provide opportunities to prevent creation of new risk and build resilience of infrastructure.

Good practice 7: Building on a strong foundation of good governance and financial sustainability in cooperation

Disaster resilience is often not prioritized because it is wrongly perceived as being politically risky. It is an upfront cost for an outcome that might never come to pass within a political term, in most cases driven by lack of visible and well-communicated incentives. It is a vicious cycle where the cost of disasters is rapidly rising, hindering governments in their ability to mobilize and provide necessary resources, and trapping them into emergency response. Although there has been progress in upgrading investment into risk reduction, there is still a bias towards reliance on ex post response, reconstruction and rehabilitation, rather than ex ante risk reduction.

Investment tends to flow where there are comparative advantages, including low labour costs, access to markets, infrastructure and stability. From a disaster risk perspective, this results in investment decisions that rarely consider the level of risk exposure in those locations. In addition, opportunities for short-term profits outweigh concerns about future sustainability as opposed to environmental degradation and climate change.

Such "business as usual" planning betrays continuous mispricing (or overlooking) of risk, meaning consequences are rarely attributed to the decisions that generate the risks. Therefore, private capital continues to flow into hazard-prone areas, leading to significant increases in the overall risk. These investments are in essence bankrolling future catastrophes – the cost of which will be borne by public budgets and vulnerable people, communities and systems.

Public actors, such as governments at regional and local levels, and private actors, such as investors, lenders and corporates, face challenges in making investment and finance risk informed:

- Evidence: Many governments, businesses and financial institutions do not regularly incorporate all hazards identified by the Sendai Framework into their financial decision-making. The COVID-19 pandemic revealed that many are unprepared particularly for the systemic nature of risk, for which no assessment or planning has been undertaken. There are no metrics to measure a disaster resilient future, thus disaster resilient investment.

- Rationale: While the Sendai Framework states that governments are primarily responsible for risk reduction, it insists upon an all-of-society approach, including in the private sector, along with regulators, to engage. Private sector actors (corporate and financial) can have expectations that governments will take sole responsibility for risk and certainly for managing impact. This moral hazard has built-in disincentives to action because risk creators know the negative consequences for their actions will be handled by public authorities.

- Oversight: Oversight or governance initiatives, which seek to facilitate and enforce risk-informed investment, are generally limited (e.g. mandates for multi-hazard risk analyses or disclosures). This could be due to a lack of awareness of the need to anticipate a wider range of risks and their interconnections. It is essential that actions be taken to improve oversight of risk-informed investment, including actions that highlight regulatory barriers and work to remove disincentives to resilience.

- Advocacy: A short-term outlook is a challenge to risk-informed investment. Political short-termism hampers public sector investment, as risk reduction benefits typically accrue over the middle to long term, and so are thought to provide limited financial value or political reward. There is a critical role for organizations with influence (and for individuals) to play in advocating for the inclusion of the hazards outlined in the Sendai Framework and a systemic approach to investment decisions.

Case study: European Union

In reaction to the unprecedented economic fallout precipitated by the COVID-19 pandemic, the European Commission agreed on a Recovery and Resilience Facility as its economic stimulus package. It was focused on reviving and modernizing the European Union economies in the spirit of "building back better" (European Commission, n.d.g). NGEU is an expenditure programme of €750 billion that is structurally embedded into the European Union multiannual budget for 2021–2027. The total amount of European Union spending for building back better and the European Union Green Deal amounts to more than €1.8 trillion.

In May 2021, the European Commission announced a package of measures on sustainable finance. These included new implementing rules (delegated acts) on climate change adaptation taxonomy, which covered DRR. The regulation established technical screening criteria for determining whether an economic activity contributes substantially to climate change mitigation or climate change adaptation and does no significant harm to any environmental objectives. The rules are detailed technical criteria that companies need to comply with to win a green investment label in Europe. They consider the need to prevent climate- and weather-related disasters and manage risk of such disasters. The taxonomy is important for private and public finance.

Case study: France

A successful investment mechanism in France is the Fund for the Prevention of Major Natural Hazards (Fonds de Prévention des Risques Naturels Majeurs), which is also called the Barnier Fund (Fonds Barnier). It is linked to the public–private insurance scheme CATNAT, which was initiated as an insurance against hazards otherwise treated as uninsurable, based on the constitutional principle of solidarity in France.

The CATNAT scheme is funded through a supplementary mandatory premium determined by the government on top of property insurance policies as well as motor vehicle insurances. A percentage of the CATNAT reserve goes to the Barnier Fund, which is the main financing instrument for co-funding disaster risk prevention measures in France (OECD, 2019d).

Case study: Norway

A public–private partnership between Finance Norway, the industry organization for the Norwegian financial industry, and 10 Norwegian municipalities demonstrated a successful initiative to share claims data on an asset level from the insurance industry with the local governments.

Ten years of claims data at near 100% of market share were provided to the municipalities, who then mapped the information to better inform municipality and county council planning. This included calculations of risk to river and urban flooding, highlighting areas at risk that previous information did not capture. Patterns of claims, which were gathered as part of the project, showed areas at risk, and thus helped to inform flood mitigation investment decisions including management, maintenance and land-use planning.

This project led to a national collaboration between the public and Finance Norway to establish a national loss data platform with all loss data available, giving all the municipalities in Norway and the County Governor access to the loss data

Source: UNDRR (2019b)

Case study: Serbia

The COVID-19 pandemic showed that a systemic approach is needed when investing in recovery. This should lead to building better, greener and more resilient systems than before.

UNDRR, in collaboration with the Serbian Chamber of Commerce and Industry, and with the support of the United States Agency for International Development, created the building resilience of small- and medium-sized enterprises (SMEs) to disasters initiative.

A discussion with stakeholders showed that while the Serbian Government adopted significant regulatory and systemic measures, many SMEs were not aware of them or did not use them to protect themselves and recover from disasters.

Prompted by the COVID-19 pandemic, the government and policymakers can now develop measures, such as creating incentives tailored to SMEs for investing in prevention and building long-term resilience, as well as establishing incentives for risk insurance.

There are two main recommendations that SMEs can include in their work: enhancing knowledge, skills and practices related to DRR, and setting up a systemic approach to the integrated management of risks (UNDRR, 2021d).

Faced with an increasingly tight fiscal space and existential dilemmas over whether to allocate scarce public resources to immediate relief or to invest in a more inclusive sustainable recovery, political leaders have recognized the value of investing in risk reduction. It can bridge the short term with the long term, while addressing climate change and ensuring overall sustainability. It requires a shift across the financial system from short-termism to a "think resilience" approach.

Political commitment, public buy-in and resources are critical enablers. Policy options should not be perceived as a temporary trend or linked to a particular party or politician but as ways to ensure sustained and sustainable change.

Current approaches are not commensurate with the scale of the challenge. The COVID-19 pandemic exposed how severely Europe has systemically underinvested in resilience and prevention.

It would therefore be valuable to consider a "disaster resilience taxonomy" for better tracking on DRR investments, return of investment and how to measure a resilient future to support increasing investment in prevention (of disasters). This would also enable monitoring the real-world outcomes of investments – how they have delivered greater disaster resilience. By extension, it is important to consider defining "unsustainable expenditures". There is a risk that "non-green measures" continue to unintendedly bankroll future disaster risk if there is no focus on this issue.

Dedicated guidance with a menu of options could be developed, which would cover banking sector regulation, reviews of central banks and supervisor mandates, including enabling conditions, lending streams, and conditions for incentivizing and leveraging private finance with public finance. Examples are the European Bank for Reconstruction and Development, European Central Bank, European Investment Bank and European Union funds, including structural funds, which are already putting enabling conditions related to DRR in order to access funding.

Another step would be integration of DRR into national investment strategies with adequate budgeting and leveraging of private finance for DRR investments. This would be operational/policy guidance to support finance institutions and national governments to turn these policy options on financing for DRR, with a focus on infrastructure, into action.

There is a strong need for a new "social contract" on investing in disaster resilience, which sets out the responsibilities and liabilities of national governments, financing bodies and the private sector to manage the negative externalities. This social contract should also draw greater attention to ensuring no one is left behind. The gender-specific impacts and the impacts on vulnerable groups of the programme measures need further analysis and monitoring. It would be beneficial if the participation of these groups would be strengthened in the development of the plans.

Chapter 5: Recommendations and conclusions

The challenges and practices outlined in this report have articulated an incomplete picture of the state of risk in the Europe and Central Asia region. This is by design and out of necessity. The diversity of the countries in this region is so immense that no single report could do justice to the experiences of the countries, regions, cities, communities and families that face disaster impacts.

A seemingly simple storm or earthquake can have impacts that cascade across sectors and borders. The knock-on effects can have repercussions for markets or communities that would seem to be far removed from the direct impact. Disasters like these are the outward manifestations of the risk that has built up within and across systems. The risk itself is systemic, although it is not often recognized as such. The challenges in Chapter 3 relating to technological risk and cyber risk provide excellent examples of the ways systems that have been intentionally constructed to facilitate business, travel, life or economy have also become sources of risk themselves.

Complex disasters are the subject of highly complex responses. No single intervention can treat the impact of flooding of the type witnessed in Germany in 2022 or Storm *Eunice* that battered the United Kingdom. Such disasters become the work of volunteer organizations and churches, construction teams, arborists, schools, civil engineers, hospitals, etc.

Systemic risk must similarly be understood to be the subject of systemic risk reduction action. This is to say that no grand intervention will undo the rich network of risk that has been constructed over the past centuries, and no perfectly intricate plan will ensure society is perfectly positioned for the myriad ways risk eventually turns into disaster.

The recommendations below take the form of broad principles and good practices that have been extracted from earlier in the report and distilled into normative recommendations for the Europe and Central Asia region. In general, they address the responsibilities of policymakers, the risk science community and the public. Without dwelling too much on the overlapping nature of these groups, the groups not named but not exempted (e.g. the media or the private sector), and without specifically naming the parties most responsible for undertaking the recommendations, it is worth noting that a healthy ecosystem of those three groups is often what dictates the success of reducing risk.

Recommendation 1: Develop better ways of understanding, interpreting and communicating systemic risk

This theme arose in every challenge in Chapter 3. The recommendations speak to better understanding of how impact is expressed and how risk is created – in all cases to improve risk understanding and risk reduction action.

This report has noted several ways in which understanding of systemic disaster impact can help to develop better strategies to deal with systemic risk. For example, understanding the health, ecosystem and water safety impact of wildfires will point the way to vulnerable systems that need to be protected before disaster manifests. Likewise, having systematically recorded disaggregated disaster impact data permits detailed analysis of trends, hotspots and areas in need of richer attention that can guide policymakers towards risk reduction options.

In Challenge 1, about reducing the risk of extreme wildfires, the suggestion is that better understanding and communication about the causes of fires would bring public policy in line to reduce risk. It also indicates the potential in better understanding links between fires and infrastructure, health impacts, toxicity in water systems and scenarios for ecosystem-based landscape management. The argument is that better application of what is known about fire risk across policymaking and public behaviour could reduce a great deal of risk related to wildfires.

Challenge 2, about resilient infrastructure, highlights the value of well-articulated and applied standards in data collection, analysis and application. Challenge 3 points to the importance of vulnerability analysis and stress testing to ensure cyber risk defences are up to the challenges posed by threats to the intricate, distributed IT infrastructure upon which societies, governments, business and life rely.

Challenge 4, about technological risk, and Challenge 5, about disaster displacement risk, stress the importance of richer data to cover a broader range of risk drivers and potential impacts. This includes a better regional balance of data collected about aspects relevant to technological risk, improvements in data-sharing investments in government capacity to collect and use data to make evidence-based policy, and the application of trend analysis. They note that the use of past impacts as predictors of future risk are inadequate and that stakeholders should seek more realistic ways of interpreting priorities.

It is recommended to:

- Develop national disaster loss tracking systems that are:

    Disaggregated;

    Used to analyse trends and formulate policies;

    Based on enhanced capacity-building support for data collection, reporting and analysis.

- Use lessons from past disasters to understand vulnerability.
- Use the data that exist but think about applying them more broadly.

Recommendation 2: Foster more resilient societies through the development of financial, regulatory and behavioural tools reflecting shared priorities among risk science, policymakers and communities

If so much is known about risk, why is a better job not being done to reduce it? GAR2022 made clear how challenging it can be to overcome inertia, psychological biases, political will and behavioural motivations to make risk reduction policy (UNDRR, 2022a). This report expands on the theme by proposing a few levers at the disposal of policymakers, risk specialists and civil society to propel the changes needed to build more resilient societies.

This begins with ensuring broad-based, stable and predictable funding for research and experimentation in risk reduction. This must not be ring-fenced to "DRR studies", but should be mainstreamed across faculties in the same way risk reduction is expected to break government silos. Business studies and history and biology and geography faculties can and should be resourced to contribute more directly to the risk reduction agenda. This can be extended to the inclusion of risk awareness and civic responsibility into educational curricula.

Tools can be employed that allow recognition and neutralization of biases that might undermine all-of-society investment in risk reduction that will be required to live sustainably in the coming years. For example, stress-testing exercises could reveal weaknesses in systems that may not have been evident. Stress tests build on probable scenarios and the experience of concerned stakeholders to articulate realistic versions of disasters that have not yet occurred in the target context. Then, based on known vulnerabilities, capacities and other data, participants deduce how the disaster would unfold if the circumstances were more severe or at an inopportune time of year, for example.

Thus, any unfounded comforts that may have existed about readiness to manage different disasters can be unveiled and given due attention.

Some of the challenges noted the possibilities afforded by judicious application of regulations to enforce behaviour where other nudges are less effective. This includes in matters relating to transnational governance, that policymaking should be explicitly science informed and that shifting from a policy of disaster response to risk reduction must have a legal reference point.

Underpinning the application of these policy levers is the expectation that those seeking to foment more resilient behaviour do so transparently, fairly and with accountability for their decisions.

It is recommended to:

- Ensure funding exists for inclusive, experimental programmes to understand and tackle risk creation.
- Acknowledge and take steps to combat known biases. Many sociological blind spots are well known – they should be disconnected to ensure risk is reduced most realistically.
- Use stress tests and scenarios.
- Use standards and regulation judiciously and with a rigorous evidence base of efficacy. Apply them transparently and make public evaluations of their effect.

Recommendation 3: Focus on attenuating impact, reducing vulnerability and building preparedness

The drivers of most hazards are not within the power of most actors to influence directly. Increasing volumes of carbon in the atmosphere that propel the climate emergency are largely – though not completely – the responsibility of city authorities, risk scientists, ministries of agriculture and so forth. However, it is possible for the collective actions and priorities of these groups to influence the volume and rate of greenhouse gas emissions. Although they are the result of economic choices, electoral choices and lobbying, they do play an important role.

In addition, there are many actions that most people can take on at nearly every political scale; these relate to attenuating impact. If hazards cannot be prevented from occurring, they can at least be stopped from becoming disasters. Many of the challenges in Chapter 3 emphasized recommendations to manage vulnerability, build preparedness and ensure the welfare of people, assets and systems such that they would manage the stresses of disasters better in the future.

The challenges also highlighted the importance of better integration and availability of forecasting and early warnings for more hazards. Many countries have flood and storm early warning systems, but there are great gains to be made in expanding the applicability of early warning and early action programming. In particular, fire susceptibility and extreme temperature susceptibility are identified as ripe for better warning and longer-term vulnerability management.

Several challenges also pointed to the value of linking predictable finance and legislation to manage more hazards. The focus must not rest only on floods and storms, but on all hazards. Mudflows, industrial accidents, epidemics and wildfires are incredibly damaging, and must be part of the legislative frameworks for protection and prioritization.

The importance of all-of-society adaptation strategies that bridge across sectors and scales was also noted. Adaptation strategies with wildfire in mind are usually focused on landscape management and water husbandry, but health, education, energy and transportation sectors can be better prepared and aligned to reduce the impact of such disasters. Investing in ways that are hazard agnostic has many benefits. The most obvious is that it enhances resilience and supports sustainable development while also serving as a bulwark against hazards and disaster impact.

There are immense co-benefits of investing in green and blue infrastructure. Such infrastructure promotes disaster prevention, development and social welfare while protecting ecosystems. Likewise, any long-term investment in social welfare, equality, justice and access will have the net benefit of fostering a society where care is at the core. It is in those societies where communities pull together to help each other, where municipal and regional institutions work in harmony and where being affected by a disaster once does not condemn someone to an endless cycle of re-victimization.

Contingency plans and mitigation strategies can be powerful last resorts when disasters are inevitable. These measures should be tested, maintained, reviewed and reinforced, otherwise growing risk can quickly make them irrelevant.

It is recommended to:

- Focus on reducing vulnerability and building preparedness.

- Improve forecasting, assessments and integration of non-probabilistic hazards, to make planning for resilience more complete.

- Provide more predictable finance and legislation for more hazards, which will better protect from impact.

- Include all of society, especially by those charged with drafting sector, subnational, national or other adaptation or DRR strategies to manage risk.

- Consider the co-benefits of investing in green and blue infrastructure. Even if they appear to be less economically viable in the near term, their long-term resilience value is immense.

- Enact contingency plans and mitigation strategies by any group or stakeholder for any risk scenario.

Recommendation 4: Underpin integrated policies to manage risk by a commitment to broad-based, inclusive and multisectoral participation of all interested stakeholders

Perhaps the most universally cited recommendation across the challenges in Chapter 3 is related to the importance of broadening the basis for the formulation of priorities and the implementation of policies to reduce risk. The DRR world has long lamented the challenge of siloed responsibilities, isolated policies and the importance of the all-of-society approach. But fixing those things is easier said than done. A few specific and practical examples of some of the avenues towards a more holistic and coherent approach to risk reduction can be extracted from the above good practices.

GAR2022 notes that as a strategy to cope with the rich complexity of the real world, people tend to prefer simplified versions that cut out details to make things more manageable (UNDRR, 2022a). In policymaking, this is sometimes manifest as sector strategies that unaccountably omit connected sectors or parts of the equation that are hard to quantify. In risk assessments, it might manifest as a failure to account for the fact that fire hazards not only damage agricultural land, ecosystems and buildings, but that they also have connections to water quality, air quality, health, power generation, erosion and transportation networks. Assessing risk to all of those is complex and difficult, but failing to consider them is delusional. This also applies to cyber risk, which is not only a concern for technology companies; it also relates to financial security, safety measures, crime and corruption, social welfare and many other parts of life. Society must behave as though it knows there will be indirect impacts from hazards and that the construction of risk is complex.

Connected to this is the fact that some of the greatest sources of risk are not systematically accounted for in risk reduction plans or risk assessments. Cyber risk is not part of many risk reduction plans, neither are the implications of rapidly changing demographics, density, economic growth or infrastructure. Even if hazards remain constant, by simple dint of adding to the stock of people and things people fear to lose (exposure), risk increases. Private stock, public stock, infrastructure, economic and cyber vulnerability, and resilience must be treated as part of DRR strategies and development plans.

There is a growing preponderance of resources to understand risk. The availability of high-resolution satellite imagery, drones, analyses and assessments has never been greater. And the growing availability of tools to collect, collate and access those resources via dashboards, databases and experts is also a source for hope. These must be better aligned with the needs of the users, rather than the producers. The availability and accessibility of data do not necessarily meet the needs of the actors trying to make informed decisions. For this, the capacities and priorities of the users should come first – this forms the basis upon which the utility of the tools can be judged.

Therefore, the user base must be understood to include more than disaster management agencies and national-level decision makers. The power of all-of-society efforts to reduce disaster risk is in the all-of-society participation in all parts of the process. This requires a fundamental change in the way disaster risk is managed in most contexts. *Nihil de nobis, sine nobis* is a Latin phrase meaning "Nothing about us without us"; it has roots in European democratic movements and with strong contemporary connections to campaigning from disability-rights activists. The message is clear – if policy is being made that affects a group of people, those people should have a seat at the table throughout the process. This requires broad thinking about who is implicated, their representation and voice and priorities. It also requires a commitment to communication and cooperation from all parties.

It is recommended to:

- Recognize there will be indirect impacts from hazards.
- Consider also indirect and non-fiscal losses in risk assessment.
- Realize there are important co-benefits to climate change adaptation and DRR. These are not separate worlds.
- Think about infrastructure vulnerability and resilience as part of DRR strategies and development plans. Changes in the exposure set will change the risk.
- Develop a firm foundation of trust for representation and communication between local and transnational stakeholders.

Recommendation 5: Use smart investments in resilience and better monitoring to make finance work for resilience

Many recommendations relate to better use and management of financial resources. Risk increases as growth does, by virtue of the increased asset stock. In addition, finance will not naturally flow towards more sustainable and safe investments. Ushering in a transformation in this regard will require willing stakeholders in the finance sector, brave political leaders willing to accept that maximal growth might not be commensurate with sustainable life, and communities with the resolve and steady nerves to live through the transformation.

One of the recommendations is for clearer responsibility for risk creation and management. Explicitly requiring institutional investors and asset managers, as well as company directors, to integrate DRR, climate change adaptation and resilience into their decisions can help. This requires a commitment to increased efforts to understand and address the social and economic impacts of insurance coverage gaps and withdrawal of credit from activities, sectors or communities that are exposed to disaster risk. These first two points lead to the third, related to ensuring more responsible and transparent risk disclosure. This must include more than physical exposure to climate-related hazards, but also an honest disclosure of exposure to all hazards.

The recommendations also relate to the use of finance and financial data to ensure effective application in resilience-building and risk reduction. While there have been many efforts to use hazard data and data on losses caused by disasters, the use and interconnection with financial decision-making could be improved. This is especially the case for ensuring the financial rationale for risk reduction, for example, comprehensive evidence on the financial, economic, societal and environmental costs of hazards, or the value of preventive actions. It is critical to explore the application of global Earth observation data to geotag physical financial investments.

Demonstration of the value of resilience-related investment would improve access and uptake of data needed by actors who are working to integrate the consideration of a wider range of risks. Tracking financing flows in risk prevention as well as other fiscal data would support in identifying resource requirements versus allocation. Observatories at national, regional or global levels could help quantify and track investments, which will allow the public and private sectors to measure the real-world outcomes of investments in DRR. Such observatories could build on the OECD Development Assistance Committee methodology (OECD, n.d.) and further improve it by labelling prevention investments. National DRR-sensitive budget reviews can also demonstrate the direct and indirect proportion of DRR allocation and expenditures, in each specific sector.

Lastly, behavioural changes for the financial sector could complement those proposed above for the public. Namely, this means making resilience part of financial planning and investment. Ensuring the categorization of climate change adaptation as an environmental objective in the context of green financial products and services does not distract from the wider need to make all financial investment resilient to disaster risk and physical climate risk. This could be achieved by using a "think resilience" test to make DRR, climate change adaptation and resilience a baseline requirement for all finance instruments. Furthermore, it could be achieved through mandating credit rating agencies to explicitly integrate sustainability factors into their assessments, including corporate resilience to physical climate change and natural hazard risk.

It is recommended to:

- Ensure stronger checks to guard against inadvertent creation of new risk.
- Embed inclusive and equitable approaches to public investment and private regulation.
- Enact measures to ensure a more robust risk disclosure. This benefits everyone.
- Use data to track prevention financing and identify opportunities for risk-sensitive budget reviews.
- Strongly consider investing in resilience.

Abbreviations and acronyms

2030 Agenda	Transforming our World: the 2030 Agenda for Sustainable Development
AI	artificial intelligence
CO	carbon monoxide
CO_2	carbon dioxide
COVID-19	coronavirus disease
DRM	disaster risk management
DRR	disaster risk reduction
EEA	European Environment Agency
EECCA	Eastern Europe, Caucasus and Central Asia
EFFIS	European Forest Fire Information System
E-STAG	European Science & Technology Advisory Group
GAR	*Global Assessment Report on Disaster Risk Reduction*
IAEA	International Atomic Energy Agency
IDMC	Internal Displacement Monitoring Centre
IFRC	International Federation of Red Cross and Red Crescent Societies
ILO	International Labour Organization
IOM	International Organization for Migration
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC	Intergovernmental Panel on Climate Change
IT	information technology
MSP	multi-stakeholder platform
Natech	natural hazard triggering technological disaster
NGEU	NextGenerationEU
NIS	Network and Information Security (Directive)
OECD	Organisation for Economic Co-operation and Development
PCSD	policy coherence for sustainable development
PESETA	Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis
SDG	Sustainable Development Goal
SEE	South-eastern Europe
Sendai Framework	Sendai Framework for Disaster Risk Reduction 2015–2030
SME	small and medium-sized enterprise
UNDRR	United Nations Office for Disaster Risk Reduction
UNECE	United Nations Economic Commission for Europe
WMO	World Meteorological Organization
WUI	wildland urban interface

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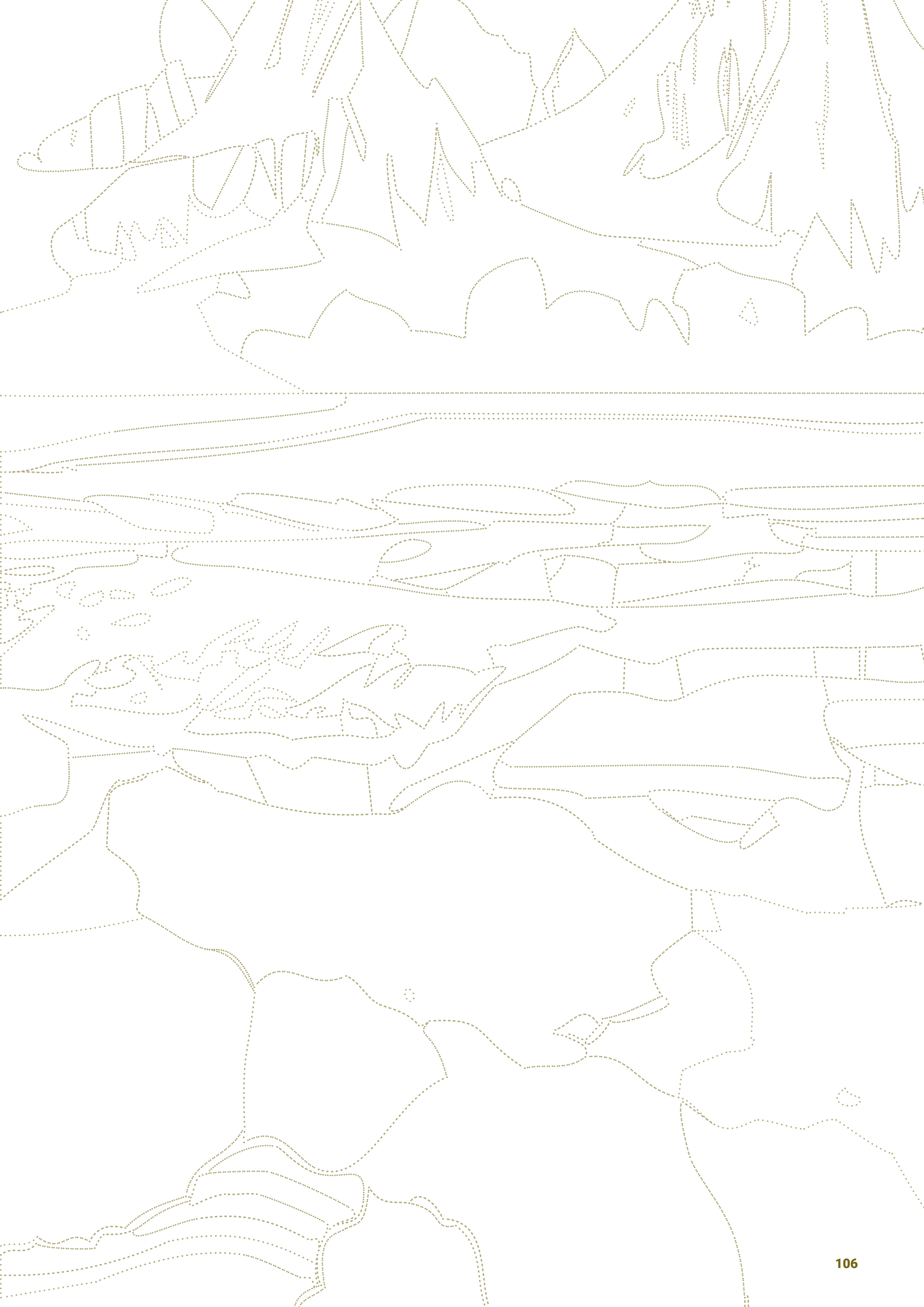

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