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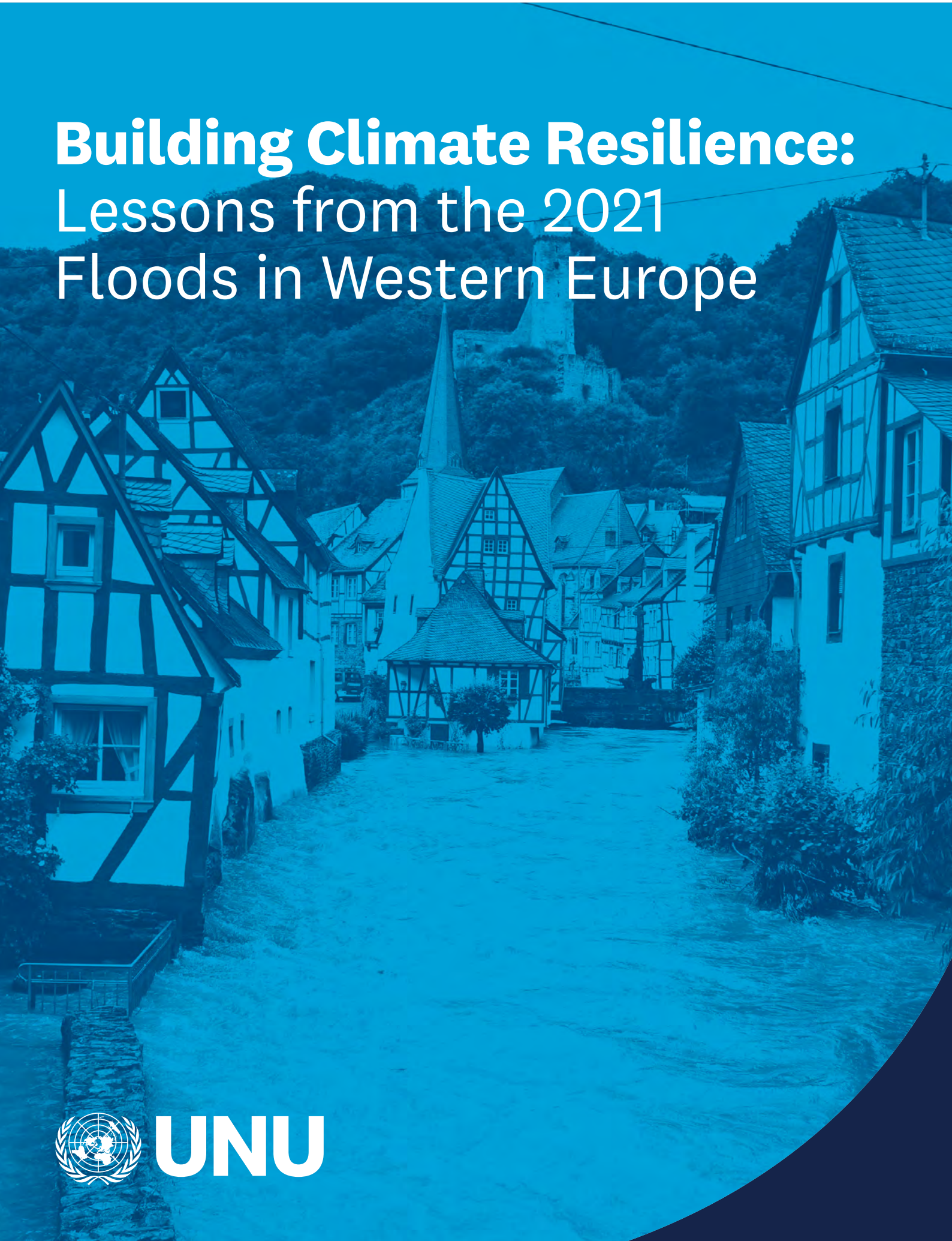
Building Climate Resilience: Lessons from the 2021 Floods in Western Europe



UNU

Building Climate Resilience: Lessons from the 2021 Floods in Western Europe

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Elz flood in the village center of Monreal, July 2021. Markus Volk / iStock

This picture shows damaged cars in a flooded street in the Chênée district in Liège, on July 16, 2021, after heavy rains and floods lashed western Europe.
BERNARD GILLET / BELGA / AFP

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Executive Summary

In July 2021, the Rhine-Meuse region straddling Belgium, Germany and the Netherlands was affected by devastating floods that have led to the loss of more than 240 lives and damage worth billions of Euros.

The event was closely watched by regional agencies that had to organize response and recovery, and also received noticeable global attention. Diverse sets of responses and reflections accumulated among researchers, local and regional governments, local and international media, development organizations, public offices and citizen groups, wherein links to climate change and gaps in our preparedness for unexpected, extreme events were a common element of the discourse.

In response to the floods, and in recognition of the cross-border effects of climate change, the United Nations University institutes in Belgium (UNU-CRIS), Germany (UNU-EHS) and the Netherlands (UNU-MERIT) have launched the "UNU Climate Resilience Initiative" with the aim to share knowledge, shape policy and drive action – and ultimately shift the focus from risk to proactive adaptation, innovation and transformation. Within the context of this initiative, researchers from the three institutes have conducted research in the flood affected areas and organized the two-day "Flood Knowledge Summit 2022: From Risks to Resilience", which took place from 7 to 8 July 2022 in Maastricht, the Netherlands. Complementing existing national initiatives and efforts in the three countries, the event aimed to connect different actors – including affected citizens, first responders, authorities, researchers and civil society – from the region, the European Union (EU) and the Global South to share experiences, engage in dialogue and facilitate learning regarding how to strengthen climate resilience for all. This summit served to map various efforts to understand the data, information, governance and knowledge gaps at national, subnational and regional levels in order to address growing risks of climate change, including how to adapt to not only climate-induced extreme events like floods but also other hazard events, and created a regional momentum to support multidimensional efforts towards building resilience.

Drawing on our research and outcomes of the Flood Knowledge Summit 2022, the UNU Climate Resilience Initiative has identified five key areas in which further research and action is needed to tackle climate risks and facilitate pathways towards climate resilience:

1.

Better understanding current and future risks:

Develop integrated approaches that consider all hazards and their possible compounding and cascading effects with regularly updated hazard information and future scenarios of climate risks.

2.

Strengthening emergency response preparedness and coordination:

Improve the understanding and dissemination of early warning messages and the availability of technical instruments for emergency response (e.g. emergency vehicles and recovery equipment), as well as cross-border and cross-sectoral cooperation and coordination.

3.

Insuring losses:

Ensure integration of insurance into a larger climate strategy at an early stage by involving all relevant stakeholders and improving insurance literacy among societies to increase individual insurance uptake.

4.

Strengthening risk governance:

Enhancing regional coordination for disaster risk governance, including flood risk governance. Multilevel risk governance should be implemented in national and cross-border basins supported by up-to-date assessments, scientific evidence and community-level information to coordinate competencies and mandates, as well as building stakeholder capacities from supranational to local levels.

5.

Developing trans-formative recovery pathways from extreme flood events:

Facilitate transformative recovery pathways by understanding the enablers (e.g. cooperation and trust in alliances between citizens and government actors, empowering people with training) and conflicting barriers (e.g. psychological factors such as insecurity and mistrust, lack of understanding of the recovery process) while considering pre-existing vulnerabilities and socioeconomic differences for "building back better."

Introduction

Floods are one of the most costly and widespread climate-related hazards, causing severe impacts on human and natural systems.

Since 1990, floods have accounted for 44 per cent of disasters worldwide, affecting more than 1.6 billion people and leading to economic losses of at least $651 billion (Centre for Research on the Epidemiology of Disasters (CRED) and United Nations Office for Disaster Risk Reduction (UNDRR), 2021). In 2021, amid the global COVID-19 pandemic, the Rhine-Meuse region in Germany, Belgium and the Netherlands was affected by devastating floods that left at least 240 people dead and caused damage to infrastructure worth billions of Euros (United Nations Regional Information Centre, 2021). As discussions were ongoing in Europe on how to better prepare for, cope with, recover from and adapt to such extreme flood events in the future, the region was confronted with yet another significant drought in 2022, following earlier drought events in 2018 and 2019. One year after the devastating floods, low flows in major rivers such as the Rhine, have affected waterborne transport and energy production, and the lack of water availability forced local governments to restrict water withdrawal from rivers and streams. At the same time, the world has witnessed further catastrophic floods in Australia, Nigeria, Pakistan, Thailand, Venezuela and Vietnam in 2022 (Milman and others, 2022), a trend that is likely going to continue as we move into anthropogenically-forced warmer climates (Intergovernmental Panel on Climate Change (IPCC), 2021, 2022). However, climate change was not the only driving force behind the devastating floods; their impacts were exacerbated by a lack of both preparedness and public awareness (Ismail-Zadeh, 2022).

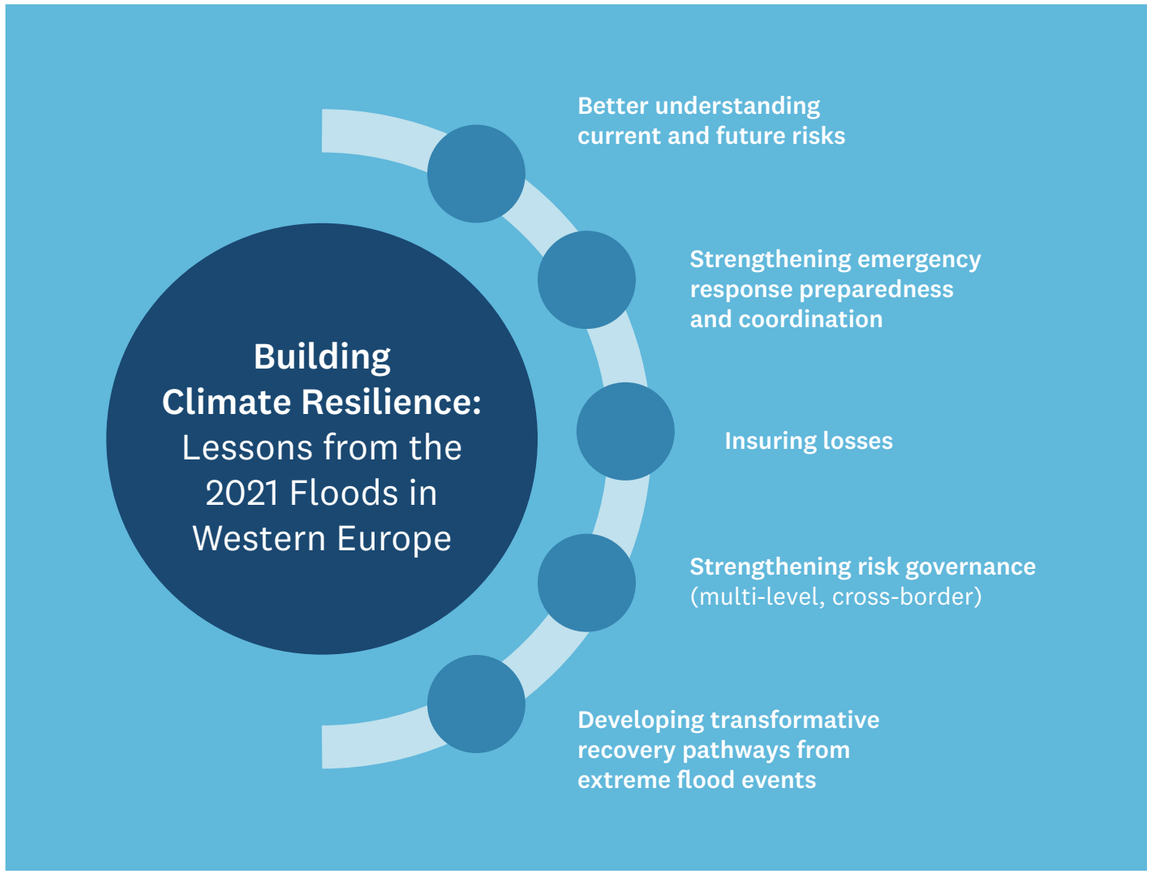


Figure 1. Five areas in which further research and action is needed to tackle climate risks and facilitate pathways towards climate resilience
(source: authors)

Looking at these events and trends, questions of how to best address growing climate risks and ensure climate-resilient development become more important than ever. While these recent catastrophic events have caused loss of life and devastating impacts on well-being, livelihoods and ecosystems, as well as revealing enduring gaps in our preparedness for and response to such extreme events, they also present opportunities to take stock of persisting challenges and identify lessons for the future. Drawing on experiences from the 2021 floods in Western Europe, this report presents five areas in which further research and action is needed to tackle climate risks and facilitate pathways towards climate resilience **(Figure 1)**.

A couple hug as they stand amongst debris left by flood waters in a street in the town of Bad Neuenahr-Ahrweiler on July 15, 2021.
Christof STACHE / AFP

1. Better understanding current and future risks

In order to build climate resilience, we have to strengthen our understanding of the exposure and vulnerabilities of people, infrastructures, economic sectors and systems (e.g. ecosystems and their services; see Box 3) facing extreme climate events (United Nations, 2015; Kreienkamp and others, 2021; IPCC, 2022). Here, we point at several persisting challenges that need to be addressed to better understand current and future risks:

First, the 2021 floods, occurring amid a global pandemic and followed by a significant drought year, have shown that a hazard-by-hazard approach to understanding and managing risks as for example implied by the EU Floods Directive (Directive 2007/60/EC[1]) is no longer sufficient. Instead, integrated approaches that consider all hazards and their possible compounding effects are urgently needed.

Second, the event has also shown that there is a need to regularly review and, where needed, update existing hazard information and maps as existing flood maps have underestimated the extent and depth of extreme floods in many flood-affected areas. Furthermore, return periods for extreme flood events need to be revised based on state-of-the-art climate projections due to rising temperatures continuing to influence precipitation patterns. As a result of rising temperatures, and the fact that warmer air can absorb more moisture, IPCC warns that many regions, including Western Europe, might face increases in heavy rainfall and resulting flash floods (IPCC, 2021; Else, 2022).

For floods in larger river basins, this relationship is less clear, notably due to: (1) the compounding nature of different flood drivers, such as temperature driven decreases in snow accumulation and increases in evapotranspiration that lead to decreases in soil moisture, i.e. soils that can buffer more rainfall; and (2) other factors such as catchment size and seasonality (Blöschl and others, 2019; Brunner and others, 2021; Sharma and others, 2018). The picture, however, becomes clearer when distinguishing between moderate and extreme events. A recent study in Nature highlighted that increases in precipitation yield larger and more consistent increases in flood magnitude for relatively extreme rainfall events compared to those that can be outweighed by the soil-drying effects of warming temperatures (Brunner and others, 2021). This is also supported by previous simulations that confirm that in some parts of Europe (i.e. especially in Western and some parts of Eastern Europe), the return period of what is currently a 100-year river flood may in the future decrease to 50 years or less (Dankers and Feyen, 2008).

1. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0060

Therefore, scientists have highlighted that the concept of return periods based on historical climate records can lead to underestimation of actual hazard frequency and, hence, risks (Slater and others, 2021). In addition, the 2021 floods have shown that the effects of bridges need to be more systematically included in flood hazard models as they can increase flood extent and depth during such events.

Third, the flood event of 2021 has clearly revealed that pre-existing social vulnerabilities must be better understood, monitored and integrated into disaster (risk) management. This includes understanding not only the susceptibilities of different segments of society to such extreme events (e.g. people with special needs who need assistance in case of floods) but also existing capacities of citizens and authorities to cope with extreme events and recover from them – a fact that has also been highlighted in a recent study by de Bruijn and others (2022).

Fourth, the 2021 floods have underscored the need to not only reduce current risks but also prepare for and prevent future ones – a need that was also highlighted in the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015). Future scenarios of climate risk – in all dimensions of hazard; exposure of people, ecosystems and assets, as well as their vulnerabilities – are vital for risk-informed decision-making (Birkmann and others, 2019; UNDRR, 2022). As UNDRR has highlighted, "Unless [...] governments have a clear understanding of the risks they face as well as fully discuss with the public and other stakeholders about risk scenarios, implementation of meaningful disaster risk reduction measures may be ineffective," (UNDRR, n.d.). However, such information is currently not available for many countries, let alone districts or communities in Europe, and does not form a central part of the communal flood risk assessments required under the EU Floods Directive.

Fifth, while the assessment of possible direct flood impacts (e.g. on human health (see **Box 1**), critical infrastructures and buildings) is well developed, our knowledge and methods for the assessment of cascading effects (i.e. the propagation of impacts) is much less developed and presents another gap in the EU Floods Directive (Arrighi and others, 2021; Arvidsson and others, 2019; Fekete, 2020; Nones and Pescaroli, 2015). As Pregnolato and Arrighi (2022) highlight, "Impacts on infrastructure are not necessarily due to the physical contact with floodwater but also result from a reduced performance of the service/functionality, which usually propagate outside the flooded area and beyond the impacted infrastructure (e.g. power disruptions resulting in communications failures)." Such cascading effects have also been observed in the 2021 floods; for example, when damaged roads or destroyed bridges led to knock-on effects for emergency response (Fekete and Sandholz, 2021). To inform comprehensive climate risk management, risk analysis should therefore not only be based on an all-hazards but also on a multi-risk approach that considers compounding, cascading and possible systemic effects (i.e. the potential for breakdown or collapse of systems of high societal importance) (Hagenlocher and others, 2020).

Box 1: Multifaceted impacts of climate change on mental health

Extreme events can impact mental health through several exposure pathways, such as direct impacts (e.g. severe weather events and associated losses) and indirect impacts (e.g. social and economic disruptions, forced migration). Possible mental health and psychosocial outcomes would be largely extensive – acute stress disorder, post-traumatic stress disorder, depression, anxiety, panic attacks, insomnia, mood disorders, strained social relationships, impaired cognitive abilities, alcohol and substance use and tragically suicidal thoughts (World Health Organization (WHO), 2022). Our qualitative research in Belgium and the Netherlands also revealed that mental health issues have longer-lasting impacts than expected. A flood, an evacuation, homeowners losing properties and irreplaceable items and cleaning, demolishing or rebuilding their own houses cause an enormous mental impact. Moreover, such mental health impacts could also affect many relief workers, such as informal and formal aid practitioners and volunteers. In response to the 2021 floods, there were several types of psychological support available. For instance, in Germany, psychological support was offered to flood victims (SWR AKTUELL, 2021), and the North Rhine-Westphalian Ministry of Social Affairs along with the regional associations of Westphalia-Lippe and Rhineland have opened trauma clinics to those affected by the flood (Die Landesregierung NRW, 2021). Importantly, including a longer-term specialized mental support system seems to be essential for future disaster response planning, and not only for a short period immediately after floods, as often the recovery process will sustain for longer for many of the affected.

When we look at mental health support systems at the global level, most countries lack the capacity to address the preexisting needs, according to the WHO Mental health Atlas (WHO, 2020). It is estimated that one billion people currently live with a mental health condition (UN News, 2022). They are supported by just 13 mental health workers for every 100,000 people, while governments spend, on average, just over 2 per cent of health budgets on mental health (WHO, 2020). People in low- and middle-income countries face even more severe difficulties in accessing support, with 75 per cent of people with depression either undiagnosed or not treated (Evans-Lacko and others, 2018). The situation is often worse in societies in which mental health issues are culturally taboo. Effective mental health programs and focused health interventions for psychosocial well-being too often remain missing or underrepresented aspects of climate discourse, especially in Global South contexts. The existing mechanisms to support climate-related mental health services by government and non-government agencies are often disaggregated, and in many countries specific action plans and initiatives to support affected households and communities are absent (WHO, 2014). There is a visible gap in the coordination of effective practices to provide affected people with required mental health and psychosocial services (MHPSS).

Noting the significance of mental health for individuals' recovery and resilience, building better climate adaptation capabilities needs to be achieved through stronger resilience by providing mental health care as part of amplified climate services. This gap area in climate action planning has not received the attention it deserves. We urge for enhanced focus on the climate and health nexus; in particular, mental health aspects, both in research and practice, and these services could become a part of a new research agenda that combines perspectives of disaster and humanitarian responses with elements of mental health support systems to better manage climate and disaster risks. Therefore, we propose a collective and global level "call for action" that builds on empirical and rigourous methodological approaches together with sound evidence to incorporate the provision of mental health support systems into disaster risks management planning as well as to develop MHPSS instruments towards integrated climate services at the global level (Okamoto and Nagabhatla, 2022).

Residents cross a flooded area between Bergen and Nieuw Bergen, via a shuttle service operated by the Dutch Army, on July 19, 2021 after a major flooding in the southern province of Limburg.
Vincent Jannink / ANP / AFP

2. Strengthening emergency response preparedness and coordination

Recent hydroclimatic extremes across the globe, including the catastrophic floods in Europe in 2021, have highlighted the need to strengthen our emergency response preparedness as well as coordination. Here, we focus on the practicalities of implementing such measures and the logistics involved, as well as delving deeper into the coordination of measures across different levels and borders. In doing so, we argue that special attention should be given to the role that scientific institutions can play in developing new methods and technologies for future challenges.

First, improving the dissemination and understanding of early warning (EW) messages is key. Mechanisms exist at both the European and national levels to provide regular warnings and notifications to civil protection systems (e.g. the European Flood Alert System[2]). However, the flood events in 2021 have raised the question of whether all stakeholders involved receive and understand the content and scope of EW messages. Data from an online survey in flood affected areas in Germany (n = 1,315) revealed that more than 29 per cent of the respondents did not receive any warning and that of those who were warned, 85 per cent did not expect very severe flooding and 46 per cent did not know what to do (Thieken and others, 2022). This has major implications on the actions of affected persons and resulting responses from authorities. Furthermore, despite numerous warnings and notifications, it was difficult for citizens and authorities in flood affected areas to assess the extent of the impending flooding and where the greatest impact was expected to occur (e.g. what a water level of 5 m at a specific gauging station means) (Szönyi and Duthi, 2022). This underscores the need for expert knowledge to frame, interpret and contextualize EW messages and to respond appropriately. In this regard, the role of scientific institutions becomes critical. There is also an urgent need to involve academic institutions and other independent actors in the aftermath of a crisis to conduct debriefings and fully identify lessons learned. In addition, poor understanding of EW messages and subsequent decision-making can have far-reaching consequences as the tendency to legalize crisis management and response increases. As a result, crisis managers can be held accountable in court, where they must defend themselves for their actions and decisions during a crisis. Thus, authorities in charge of warning must protect themselves, document all their decisions and explain why they acted or decided in a certain way. This ultimately leads to reduced agility and adaptability in emergency response, as the actors involved focus more on documentation than actual response.

2. https://www.efas.eu/en

Second, further development and expansion of common technical resources, such as emergency vehicles, salvage material, mobile medical care and emergency shelters, are needed. The European Union Civil Protection Mechanism (EUCPM)[3] is a voluntary mechanism with a pool of resources provided by EU Member States and six other countries outside the EU, established for situations where an emergency exceeds national capabilities. However, the affected country must request assistance and indicate its specific needs. During the 2021 floods, several key technical resources were identified as missing. For example, in both Belgium and Germany, rescue helicopters that could be deployed at night were needed at the time of the floods but were simply not available in sufficient numbers within the EUCPM. This shows that even at the EU level, critical resources are still lacking to enable responders to react immediately and effectively.

Third, the role of citizens as first responders is crucial. It became evident during the 2021 floods that citizens were among the most important players in the response. They are often the first to warn, respond and be present on the ground. At the same time, crisis management is often "blind" to the situation on the ground (e.g. due to weather conditions, inaccessibility of the affected area, etc.). In such cases, with proper training and guidance, impacted communities could be the best source of information about affected areas, people in need and the resources that need to be provided. In the short to medium term, priority should be given to engaging communities and improving their preparedness. More initiatives should be established to further develop the capacity that already exists, rather than focusing solely on top-down approaches. In practice, this means investing in increasing awareness within communities and readiness to participate in emergency response drills. In addition, risk culture and awareness should be continuously promoted by bringing citizens together to talk about risks, the future, fears, aspirations and needs.

Fourth, floods do not stop at borders or sectors. The current lack of cross-border and cross-sectoral cooperation and coordination remains a challenge that needs to be addressed. One of the most important lessons from the 2021 floods was the lack of joint coordination across levels and sectors, even within the affected countries. Emergency management must consider a holistic, long-term and cross-border perspective that links risk and disaster management.

Due to the principle of subsidiarity, the EU has primarily a supporting and coordinating role towards its member states. Moreover, with 27 member states, there are 27 different civil protection cultures that need to be considered. Therefore, local knowledge is crucial for an effective response to emergencies, and it is not surprising that there is no common civil protection policy in the EU. There is a great need for joint capacity-building activities, training and simulation exercises. Therefore, EU countries should share and learn from each other based on past experiences and existing expertise. The recently established EU Civil Protection Knowledge Network[4] should lead the way and facilitate these processes. Moreover, the EU can facilitate training and exercises for international operations and even help develop opportunities for smaller, regional exercises, fostering exchanges among practitioners. Understanding how to better collaborate across borders should be an absolute priority. Nevertheless, transboundary crisis management remains one of the biggest challenges, and better warning mechanisms are needed for countries in the same river basins. Cross-border cooperation, mutual learning and exchange among the three countries of the Rhine-Meuse region should continue and be facilitated outside of crisis situations.

3. https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/eu-civil-protection-mechanism_en
4. https://civil-protection-knowledge-network.europa.eu

Helpers walk on a muddy street along the river among piles of furniture and debris during clearing work in Swisttal-Odendorf, near Euskirchen, North Rhine-Westphalia, western Germany, on July 22, 2021. Bernd Lauter / AFP

Box 2: City responses to climate risks

The world's population is now more urban than rural, with urban dwellers, assets and infrastructures facing increasing climate risks. In 2020, 55 per cent of the world's population lived in urban areas, with a projected increase to 68 per cent by 2050 (United Nations Department of Economic and Social Affairs (UN DESA), 2018). The projected increase in urbanization will add 2.5 billion more inhabitants to cities by 2050 (UN DESA, 2018) – further elevating exposure to floods and other climate-related extreme events (IPCC, 2022) while exacerbating flood risks due to surface sealing (O'Donnell and Thorne, 2020). Ninety per cent of those people will be inhabiting cities in Asia and Africa, with sizeable effects on some of the world's most vulnerable regions. By 2050, up to 60 per cent of the urban population in the Global South could live in informal urban environments with a triple jeopardy due to increasing frequency and intensity of weather-related hazards, including floods, population growth resulting in high levels of exposure and vulnerability due to such environments' development status (Hugo, 2011). Fragmented responses cannot address the issue; indeed, they can even worsen conditions, hamper adaptation efforts and exacerbate existing vulnerabilities.

This is a complex, multifaceted challenge that requires a similar range of approaches and interventions. There is a need for holistic research and programming that goes beyond considering physical risk, or that which is defined by socioeconomic status. It is important to consider the urban environment as a complex system providing social, cultural and ecological services. Through integrative, inclusive governance in which citizens play a full and participatory role, a smart form of urban governance can emerge which considers citizens' perspectives, including those of the underrepresented. There are also significant data gaps. For example, the development of a framework that allows the quantification of both urban risks and resilience would enable an investigation of the effectiveness of interventions. There is also a need to improve the way that governance at different levels of policy can be integrated with the efforts of urban leaders working closely with both national and local jurisdictions within the urban environment.

House in flood affected area in Germany.
Rene Kemp, UNU-MERIT (2022)

3. Insuring losses

Climate-related extreme events and natural hazards are causing devastating impacts, with losses exceeding billions of dollars.

In the period 2000 to 2019, disasters led to approximately $2.97 trillion in economic losses worldwide, including close to $651 billion (i.e. 22 per cent) due to floods (CRED & UNDRR, 2021). According to data from Munich Re, in 2021 alone flooding accounted for $90 billion in losses, of which $20 billion (approximately 22 per cent) was insured (Munich Re, n.d.). The catastrophic floods of 2021 in Western Europe mark a tragic peak in disaster loss statistics, with estimated losses of $54 billion being the costliest disaster in recent European history and the costliest flood event globally (Munich Re, n.d.). Here too, only 22 per cent of the losses were insured. In an era where climate risks and losses are growing, insurance can play an increasingly important role to buffer the effects and help affected people recover from the impacts (Kreft and others, 2022). Next, we identify current challenges in climate risk insurance, including some initial recommendations moving forward.

First, the German federal and regional governments allocated €30 billion as a special flood relief fund[5]. This generous compensation was important for the affected areas, especially as less than a third of the damage in Germany was insured despite rising climate risks (Gesamtverband der Deutschen Versicherungswirtschaft e.V., 2021). However, public compensation schemes also create a trade-off between solidarity and individual responsibility to prepare for the increasing risks of hydroclimatic extremes as they disincentivize the uptake of insurance.

Second, insurance is an important instrument for societies to receive financial relief to recover quickly from the impacts of extreme weather events, thus reducing negative welfare effects. The fixed cost of an insurance premium and guaranteed payouts can replace the high and unexpected cost of an extreme weather event. The effectiveness of insurance services for natural hazards depends on high insurance penetration. Furthermore, high coverage enables insurance companies to provide their services in case of extreme events and will increase society's level of financial protection. However, with less than half of the German population being insured against natural hazards, experts argue that higher insurance penetration is needed as extreme weather events of higher intensity are expected to occur more often in the future (Gesamtverband der Deutschen Versicherungswirtschaft e.V., 2022). Since the 2021 flood events, dialogue among different stakeholders representing the insurance industry and consumers has intensified and discussions on a mandatory insurance scheme are ongoing – also on the part of the government, with the insurance industry contributing and the government potentially acting as an insurer of last resort. Findings from qualitative interviews with representatives of the insurance industry as well as from consumer interest groups in Germany[6] show that flood risk and insurance awareness have increased since the 2021 flood events, and change is being pushed by all stakeholders.

5. https://www.bundesfinanzministerium.de/Content/EN/Pressemitteilungen/2021/2021-08-18-flood-relief-fund.html
6. Updating an earlier questionnaire to insurance stakeholders that was conducted before the 2021 flood event

Insurance and consumer associations are suggesting new concepts, and the government is examining the feasibility of a mandatory scheme for insurance. However, as many buildings damaged from the floods can be reconstructed at their original location, interviewees have raised serious concerns, claiming that regulations from the government are ineffective and not sufficiently prioritizing flood protection. This highlights that insurance is only effective if combined with preventive measures, such as prohibiting building in high-risk zones and promoting higher risk and insurance awareness. There is an urgent need for joint action among all stakeholders involved to achieve sustainable and socially just solutions for climate change adaptation. In addition, loss adjustment following an event needs to be critically assessed, reviewing for options to build back better or relocate.

Third, following major disasters, questions remain on how to not only rebuild but also build back better (see also section 5). More than a year after the 2021 flood events, there has been little reform of legal standards to increase insurance penetration and facilitate building back better. With the necessity for transformation urgent, climate change adaptation needs to be addressed holistically through integration of insurance into national, sub-national, cross-border, regional and trans-local strategies for climate change adaptation at an early stage.

A resident monitors the flood waters from his garden, where he has been sitting overnight, in the village of Well on July 18 2021, following heavy rainfall and flooding in North Limburg. Remko de Waal / ANP / AFP

Rail workers stand near a derailed carriage belonging to the Belgium SNCB train service, the day after heavy rains and floods near the town of Rochefort on July 16, 2021.
JOHN THYS / AFP

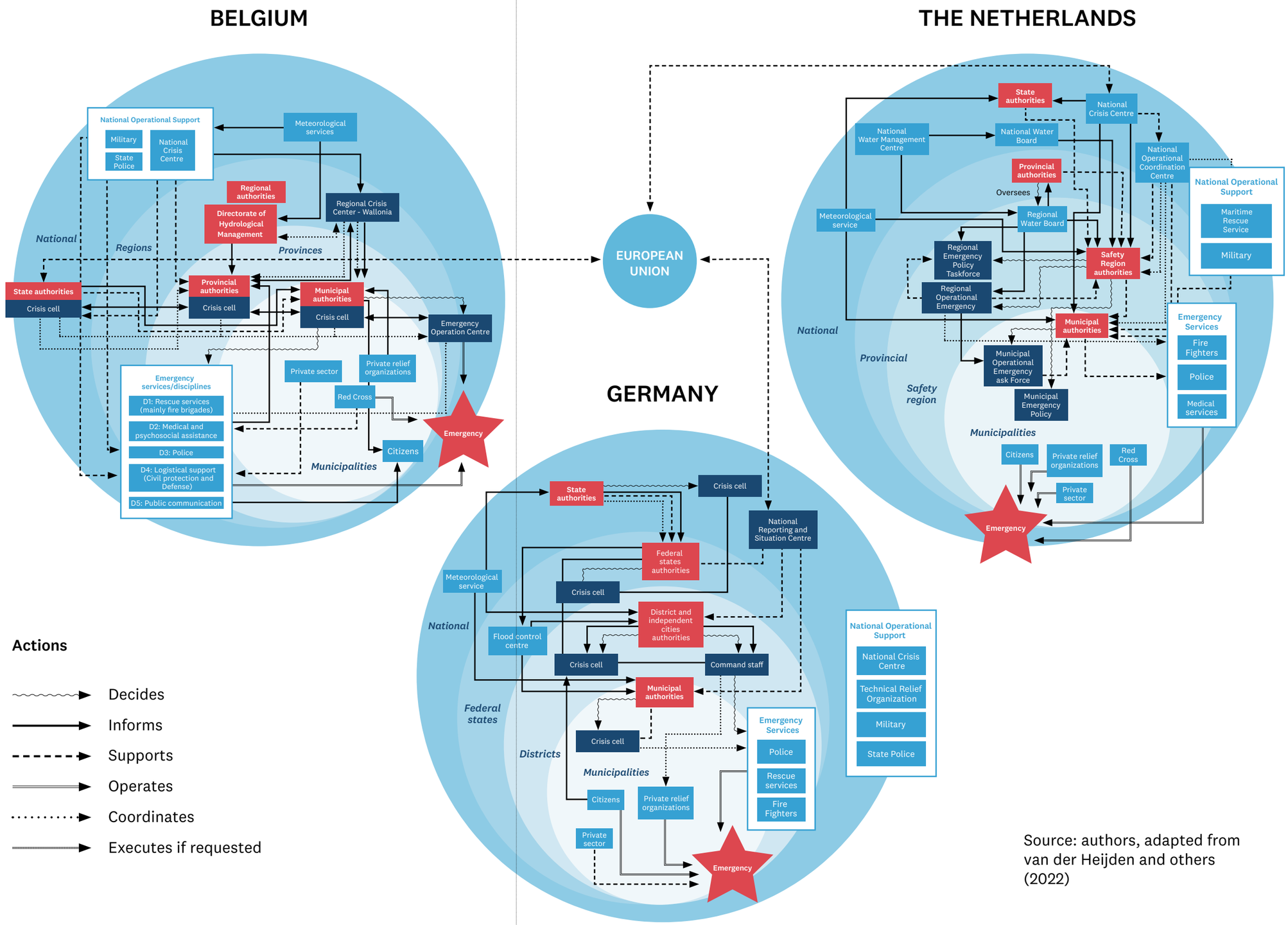
4. Strengthening risk governance

Functioning relationships among involved stakeholders, as part of a comprehensive risk governance scheme, are critical in disaster situations, but even more crucial in risk prevention.

The 2021 floods in Western Europe have revealed persisting gaps and needs in existing governance structures, as well as shortcomings in institutional relationships. As a result, possibilities for enhanced multilevel, multi-actor and cross-border risk governance have been identified (Nagabhatla and others, 2022). The risk governance dimension of this project aimed to create a common understanding of the stakeholder interactions at the level of disaster risk management agencies and institutions as a basis for a comparative context to respond in a coordinated manner at a national and supranational scale (de Ridder and others, 2020).

Analysis to identify challenges related to governments and governance systems operating at multiple levels – supranational to subnational to local – suggests that, first, we need to learn from existing disaster risk management systems and their handling of risks. Taking the flood events from July 2021 as an opportunity and acknowledging the need for synergies among neighbouring regions, we can clearly see the different strengths and weaknesses of each country's disaster risk management system (van der Heijden and others, 2022). For instance, in both Germany and Belgium, the federal level plays an essential role in coordinating emergency preparedness planning and response. This federal but decentralized approach to disaster risk management enables fast coordination at the local level but also presents challenges for communication and joint efforts across federal states, such as the use of different terms, definitions and even languages (Belgium). In the Netherlands, the omnipresence of water and flood risk has led to a historic expertise and the establishment of special institutions for water management. However, the country's centralized disaster risk management approach has been shown to hamper a swift flow of information and communication from local to national levels in the past – a finding that emerged from the analysis and comparison of flood emergency response mechanisms in Belgium, Germany and the Netherlands. As flood risk management systems reflect sociocultural, historical and sociopolitical norms, we reckon that such differences can make it difficult to synergize efforts at the regional level. This comparative overview (see **Figure 2**) aims to facilitate a common understanding of institutional functions and operations at various governance levels and shows the opportunities and barriers they may present for future cross-border cooperation and joint disaster risk management, particularly regarding the response among the three countries. Moving forward, research should focus on multilevel governance for disaster risk management, in particular for flood settings in cross-border regions to spotlight how "integrated governance systems" allow participation and capacity strengthening of communities alongside and complementing the usual top-heavy strategies. Future research should engage experts and take stock of case studies to study how multilevel governance operates in transboundary water management, and whether these approaches are a feasible way for communities and states to build climate-resilient futures.

Figure 2. Comparative mapping of EU flood risk responses



Legend

- Activated Crisis Response Team
- Government Authorities
- Other Actors
- Group of Actors
- Crisis or Disaster

Actions

- Decides
- Informs
- Supports
- Operates
- Coordinates
- Executes if requested

Source: authors, adapted from van der Heijden and others (2022)

Second, understanding shared roles, responsibilities and capacities of various sectoral stakeholders involved in flood relief and recovery action helps to explore the potential for improved collaboration and decision-making during a flood emergency response. Findings from a series of qualitative interviews with key stakeholders involved in the management of critical infrastructure during the emergency response of the 2021 floods revealed a strong reliance on information and communication technology as well as transportation infrastructure for communication and information acquisition, which was severely damaged by the floods (Belgium, Germany). The functioning Dutch tools of flood risk assessment and means of channelling relevant information did not inform policymakers across the borders. Furthermore, challenges were identified at the level of emergency response lead and coordination (Belgium, Germany). In combination with disrupted infrastructure, this had significant impact on the involved stakeholders' communication and collaboration, causing a range of delays in provision of emergency response and water supply.

Further research and action are needed to steer discourse towards the potential of multilevel governance approaches for advancing and enhancing measures for transboundary cooperation, better coordination and collaboration across scales and sectors at the national, subnational, cross-border/regional and translocal levels while examining multilevel institutional relationships, capacities and competencies regarding flood risk governance.

Flood waters rush through the Geul in the centre of Valkenburg on July 15, 2021.
Sem van der Wal / ANP / AFP

Recovery in flood affected areas in Germany.
Saskia Werners, UNU-EHS (2021)

5. Developing transformative recovery pathways from extreme flood events

As extreme events become increasingly common, communities will more frequently have to recover from disasters*.

This prospect raises the question of how to organize recovery from disasters, an inherently prolonged and uneven process. As communities along the rivers Ahr, Roer, Erft and Geul recover, the desire to live as before the flood by rebuilding what was lost can be observed. At the same time, the recovery process holds promise to regain strength, learn, adapt and even transform to reduce future risks in a changing climate; in other words, to build back better, one of the priorities of the United Nations' Sendai Framework for Disaster Risk Reduction (UNDRR, 2015). Here, we present lessons from recovery efforts in the Rhine-Meuse region. In particular, we present examples of building back better as well as drivers and barriers for climate-resilient recovery.

First, a review of opinions on recovery and examples of climate-resilient development that emerged after recent flood events revealed that instances of building back better are still scarce. This holds across different cases. Often, relief organizations drive recovery, and immediate humanitarian needs are prioritized. Nevertheless, cases of sustained change emerging out of the recovery process can be found. These include the initiation of sustainable communal heating systems along the River Ahr in Germany, collaboration between government and insurers to fully compensate victims that allow for reallocation of funds and sustained self-mobilization of communities.

Second, to facilitate transformative recovery pathways, it is crucial to understand not only enablers/drivers but also barriers for "building back better." Drivers that have been identified include: (i) cooperation and trust in building new alliances between citizens and government actors; (ii) available platforms to enable self-mobilization and agency for change; (iii) long-term vision for change; (iv) governments addressing barriers faced by affected people; (v) empowering people, training and advising on ways to build back better; and (vi) local resources. In addition, the following barriers were identified: (i) psychological factors and insecurity; (ii) mistrust and polarization; (iii) time needed to see results; (iv) regulation discouraging change, e.g. insurance and reconstruction funds; and (v) lack of understanding of recovery processes within relief organizations.

* (e.g. from the global COVID-19 pandemic, the effects of extreme events, etc.).

Third, as much as risks are influenced by pre-existing vulnerabilities and socioeconomic differences among people, these two factors also impact the capacity to recover. We can observe that the recovery process is uneven in the affected communities, driven by capacities to access government support, the sustained presence of volunteer helpers and private savings, among other factors.

To conclude, examples of climate-resilient recovery are emerging, although they remain scarce. To facilitate transformative recovery pathways, it is crucial to understand the enablers or leverage points for sustained change as well as the barriers. Looking towards the future, recovery deserves further attention in planning and research as communities will find themselves in recovery processes more often. Recovery calls for taking a step back and systematically reviewing all expected hazards and impacts, drivers of vulnerability and how to recover in an inclusive, equitable and resilient manner. By engaging with recovery, we can give climate-resilient development and transformative adaptation a much needed impetus and address urgent concerns of vulnerable people by bridging adaptation and risk research, policy and practice.

For climate science, it is crucial to harmonize actions for climate resilience with development and to acknowledge the aspirations of all those involved in recovery. The co-creation of recovery pathways is an approach to be tested in this context. It can build trust and prepare for action during recovery by thinking through different scenarios. Internationally, we can observe that extreme events disproportionately affect people in vulnerable situations, exacerbate poverty and impact women more than men. Thus, a key perspective is to integrate social and climate justice, equity and gender, learning across scales and transformation in climate-resilient recovery.

Relevant knowledge gaps include how to learn from recovery efforts around the world, how to build trust for change after extreme events and what are the climate-resilient futures that people can turn to. We recommend sharing recovery experiences, conceptualizing recovery and using this experience to shift the focus from passive coping to proactive adaptation, innovation and transformative adaptation, and recovery pathways.

River Rhine in Cologne.
ShutterProductions / Shutterstock

Box 3: Ecosystem-based adaptation

Ecosystems provide various benefits and services, so-called ecosystem services, which can be categorized into provisioning, regulating, cultural and supporting services (Alcamo and others, 2003). Many of these services have the potential to reduce disaster risk by addressing one or several of its three dimensions: hazard, vulnerability and exposure (Walz and others, 2021).

For instance, healthy forest ecosystems and their soils are characterized by lower run-offs than grasslands (Chen and others, 2021; Scheidl and others, 2021) due to higher evapotranspiration and infiltration rates, soil water storage capacities and surface roughness (Eisenbies and others, 2007; Markart and others, 2021; Schüler, 2006). This leads to a lower and slower discharge of precipitation into river systems, contributing to the reduction of a flood hazard. For example, giving more space to rivers could also be achieved by temporarily using grasslands, sport fields or parks as additional flood plains during times of floods. Besides these flood risk reduction benefits, ecosystem-based solutions also provide co-benefits, such as clean air or cooling effects during heatwaves.

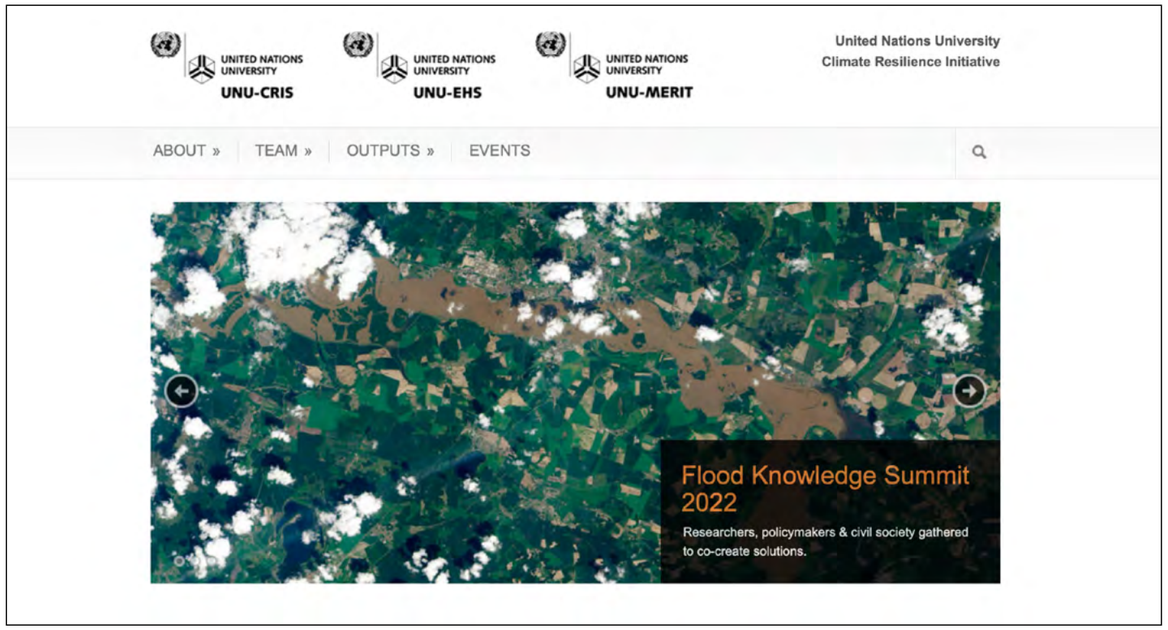
The potential of ecosystems and their services to contribute to disaster risk reduction (Sudmeier-Rieux and others, 2021) and adaptation is increasingly being acknowledged (European Commission, 2021). Enhancing a forest's ecosystem services for flood risk reduction requires dedicated forest management strategies. However, inclusion of forest ecosystem management considerations into local flood risk management strategies and their implementation remains challenging due to, inter alia, economic and structural challenges. For example, one common major forest management objective is to produce wood and timber. While management practices become more sustainable, they nevertheless come with impacts that reduce the water retention potential of a forest, such as forest roads. Furthermore, in practice many foresters have to harvest more timber at a faster rate than they think would be adequate to maintain forest health in order to meet short-term economic goals of poorer municipalities that are dependent on forest-based income. To reduce such financial pressure, other ecosystem services apart from timber need to be given a higher valuation. One potential way to do so could be their inclusion in flood prevention concepts in which forest-based management options are widely neglected. However, this requires sufficient capacities, enhanced coordination between forest and water management practitioners and increased availability of data on the local potential effects.

Conclusions and outlook

In the upcoming phase of this initiative, we intend to address the knowledge gaps identified in this report in close collaboration with partners from the region.

Among other measures, this will include enhancing regional coordination for disaster risk governance to be implemented in cross-border basins and supporting such regions by providing up-to-date assessments, scientific evidence and community-level information to enable them to coordinate their competencies, mandates and capacities from the supranational to local levels. The project researchers aim to document empirical evidence that talks to the effects and effectiveness of innovations like (multi-hazard) early warning systems for amplifying recovery and response systems in case of floods; analysis that maps the gaps and needs various levels of governance have anticipated, forecast, responded and shared information concerning flood risk management and resilience building at the national level, including in cross-border regions; and secure funding to carry out research to address the knowledge gaps put forward in this report. The UNU Climate Resilience Initiative also aims to systematize dissemination strategies and bolster partnerships for outreach and impact, liaise with other actors and agencies working on flood risk governance and plan and organize collective activities, outputs and impact pathways, including data, information and knowledge exchange between the Global North and Global South. Overall, the vision should be to steer collective and collaborative efforts, as well as transformative change focused activities, to share knowledge, shape policy and drive action for facilitating pre-emptive adaptation strategies, as well as building climate resilience towards achieving a **“climate secure future for all”** and transitioning from **“fear to hope”**.

CLIMATE SECURE FUTURE FOR ALL



Website https://cri.merit.unu.edu/

Flood Knowledge Summit 2022. Photo credit: authors (2022)

The UNU Climate Resilience Initiative

In recognition of the cross-border effects of climate change, the United Nations University (UNU) institutes in Bruges (UNU-CRIS), Bonn (UNU-EHS) and Maastricht (UNU-MERIT) have joined forces to launch the "UNU Climate Resilience Initiative" following the European floods of 2021. Working with partners across the main flood-affected countries in Europe, as well as other flood-prone areas of the world, this initiative aims to share knowledge, shape policy and drive action – and ultimately shift the focus from risks to adaptation, innovation and transformation. For more information see:

https://cri.merit.unu.edu/

Flood Knowledge Summit 2022: From Risks to Resilience

The Flood Knowledge Summit 2022 "From Risks to Resilience," the flagship of the UNU Climate Resilience Initiative, was organized on 7 and 8 July 2022 in Maastricht, the Netherlands, as the first milestone of the initiative, with pre-events targeting youth on the days before the summit. It hosted different actors (affected citizens, volunteers, authorities, scientists and civil society) from the region, the EU and the Global South to facilitate sharing experiences and dialogue on how we can build resilient societies, as well as learning from previous events and other flood-affected regions, including the Global South. In this two-day event, more than 70 speakers comprising practitioners, policymakers, students and researchers from the three countries, other parts of Europe and the Global South shared their insights, and about 170 participants (including both on-site and online participants) actively engaged in the discussions. For more information see:

https://cri.merit.unu.edu/fks2022/

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Dernau, Germany - 08 08 2022: Recognition of volunteers in Ahr flood reconstruction work. M. Volk / Shutterstock

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