

JCAR ATRACE

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Post-Flood Recovery in Europe

Lessons Learned, Policy Recommendations, Knowledge Agenda

JCAR ATRACE · Deltares · RWTH AACHEN UNIVERSITY · LIÈGE université · VU VRIJE UNIVERSITEIT AMSTERDAM

1. Introduction

In recent years, Europe has faced increasingly severe flood events that have tested the resilience of communities, infrastructure, and governance systems across borders. The catastrophic floods of July 2021 in Germany, Belgium, and the Netherlands, the extreme floods in Northern France in 2023-2024, and the intense October 2024 floods in Valencia, Spain have resulted in substantial loss of life, widespread destruction of homes and businesses, and prolonged disruptions to essential services. While rapid reconstruction is essential to provide relief to communities, recovery also offers a critical opportunity to improve long-term sustainability and strengthen resilience of an affected region.

The international workshop on 'Post-Flood Recovery and Building Back Better' (April 14-16, 2026) focused on how these dual objectives can be better aligned in practice. The international workshop was organized in Verviers (Belgium) and Bad Neuenahr-Arhweiler (Germany), two locations that were severely hit in 2021. The workshop was organized under the umbrella of the JCAR ATRACE project by Deltares, RWTH Aachen University, VU Amsterdam and Liège University. The aim of the workshop was to draw lessons from recent devastating events, and to stimulate ongoing collaborative efforts to advance knowledge and practice in this critical domain.

Sharing best practices and challenges related to recovery is an urgent matter since practical experience with large-scale recovery, particularly in transboundary contexts, remains limited and is not widely shared. The examples discussed in the workshop show there are substantial challenges related to the coordination of recovery: securing adequate funding, addressing psychological and social impacts on communities, and implementing 'Build Back Better' principles to enhance long-term resilience. Building Back Better refers to not only restoring what was lost but also seizing the opportunity to enhance spatial planning and flood risk management to reduce future risks such as those posed by climate change.

This policy brief summarizes these challenges and provides lessons learned from recovery experiences in areas affected by flood disasters. This document provides recommendations for policy, initiates a research agenda, and highlights areas where scientific research can support the recovery process, while acknowledging additional future challenges such as climate change.

According to the UNDRR, recovery is the restoration or improvement of livelihoods, health, and social/economic systems in a disaster-affected community, aligned with sustainable development and "Build Back Better" principles. It involves restoring physical infrastructure and societal systems to reduce future disaster risks.

Key Components of UNDRR Recovery:

- **Build Back Better**: Using recovery to increase long-term resilience by integrating risk reduction into rehabilitation and reconstruction.
- **Comprehensive Scope**: Addresses social, cultural, environmental, economic, and physical assets.
- **Recovery Readiness**: Proactive planning, financing, and policy setting to ensure swift, inclusive, and sustainable recovery before disasters happen.
- **Preventing Future Risk**: Focuses on reducing future vulnerability rather than just restoring the previous state.

UNDRR
UN Office for Disaster Risk Reduction

High-level representatives from Belgium, Germany and the Netherlands stressed the importance of the flood recovery process and to cooperate across borders.



Anne-Catherine Dalcq
Ministre de l'Agriculture et de la Ruralité, en charge de la Forêt, de la Nature, de la Chasse et de la Pêche, Wallonia, Belgium



Erwin Manz
Staatssekretär im Ministerium für Klimaschutz, Umwelt, Energie und Mobilität des Landes Rheinland-Pfalz



Jaap Slootmaker
Director-General, Water and Soil, Ministry of Infrastructure and Water Management, the Netherlands

2. General Observations & Policy Recommendations

2.1 Recovery is first of all about people

Recovery is, above all, about people. Flood victims frequently experience profound trauma, having lost not only physical assets but also a sense of security and normalcy. In the Ahr Valley, studies conducted three to four years after the 2021 flood revealed that among older adults (65+), 47% screened positive for anxiety, 38% for depression, and 39% for post-traumatic stress disorder (Song et al., 2026). Women often reported higher exposure and slightly greater mental health burdens. Similar patterns emerged in Wallonia, where Mayor Philippe Godin of the town of Pepinster (Belgium) stated that approximately 600 of the original 9,800 residents left permanently after the flood event, citing trauma and uncertainty about future safety.



Philippe Godin
Mayor of Pepinster, Wallonia, Belgium

Immediate humanitarian needs must take absolute priority: safe shelter, food, clean water, medical care, and psychosocial first aid. Valencia demonstrated efficiency after the flood event of 2024: water treatment and supply systems were restored within days to weeks, enabling a quick return to basic functionality. However, there are more humanitarian needs than short-term relief activities. Ms. Weigand, head of the district Ahrweiler in Germany mentioned the psycho-social impacts may persist for years. German research by Zenker et al. (2025) conducted after both the 2002 and 2021 floods shows elevated mental strain long after physical reconstruction began. Social vulnerability amplifies impacts. For example, elderly citizens, low-income households, tenants, and people with reduced mobility face deeper and longer-lasting challenges. Recovery processes should address these differences within a community, and recovery processes should be prioritized to ensure equitable access to support (Rufat et al., 2015).



Cornelia Weigand
Head of District Authority Kreis Ahrweiler, Germany

- **Recovery protocol:** It is recommended that regional recovery frameworks mandate a comprehensive 'people-first recovery protocol' in the first phase. This begins with 72-hour humanitarian responses followed by psychosocial care, law enforcement activities to prevent looting, develop community engagement platforms, and implement transparent risk communication tailored to different groups.

- **Honest and transparent communication is essential.** Mayor Daan Prevoo of the city of Valkenburg (Netherlands) stressed: "Be honest with citizens about the risk of flooding, share all available information, and acknowledge the traumatizing nature of the event." Involving affected people as active participants through surveys and participatory workshops, builds trust and accelerates decision-making.



Daan Prevoo
Mayor of Valkenburg aan de Geul, Netherlands

2.2 Recovery Takes a Long Time

There was a clear consensus at the workshop that a meaningful recovery from a major flood event typically spans 10 to 15 years. This long timeline creates an inherent tension to the citizens' primary desire: to restore normal life as soon as possible. Residents want to see visible progress and quick return to normalcy, while politicians face pressure to implement quick, albeit perhaps unstainable solutions. Decision-makers have a responsibility to design the recovery process such that solutions transform an area into a more sustainable society in the long term and to anticipate future risks, such as climate change. Four years after the 2021 flood event, the reconstruction phase in the Ahr Valley was still far from complete. Temporary housing and bridges had become semi-permanent fixtures, and larger public projects (e.g. schools, fire stations, and comprehensive flood defenses) had only just begun. Valencia appears to follow a similar pattern: the first year focused on cleaning, emergency stabilization, and restoring basic utilities. It was not until the second year that more transformative, nature-based solutions began.

Phases of recovery: The tension between short term needs and long-term sustainable recovery is a difficult issue to communicate to the community. Therefore, the constant involvement of citizens and organizations participating in the reconstruction is key to



Stéphanie Beucher
Deputy Inspector-General, France

developing a common understanding. Ms. Stephanie Beucher, showed that structuring the recovery process into recognizable phases with clear targets helped the community embracing the recovery process. She referred to the national recovery and resilience plan of France, which defines the phases in the 'Recovery continuum'.

Following Figure 2, Birkmann et al. (2023) identified five phases in the recovery process of the Ahr Valley: (1) immediate disaster assistance, (2) relief via temporary infrastructure, (3) cleaning, (4) reconstruction of housing and critical lifelines, and (5) broader livelihood and community recovery.

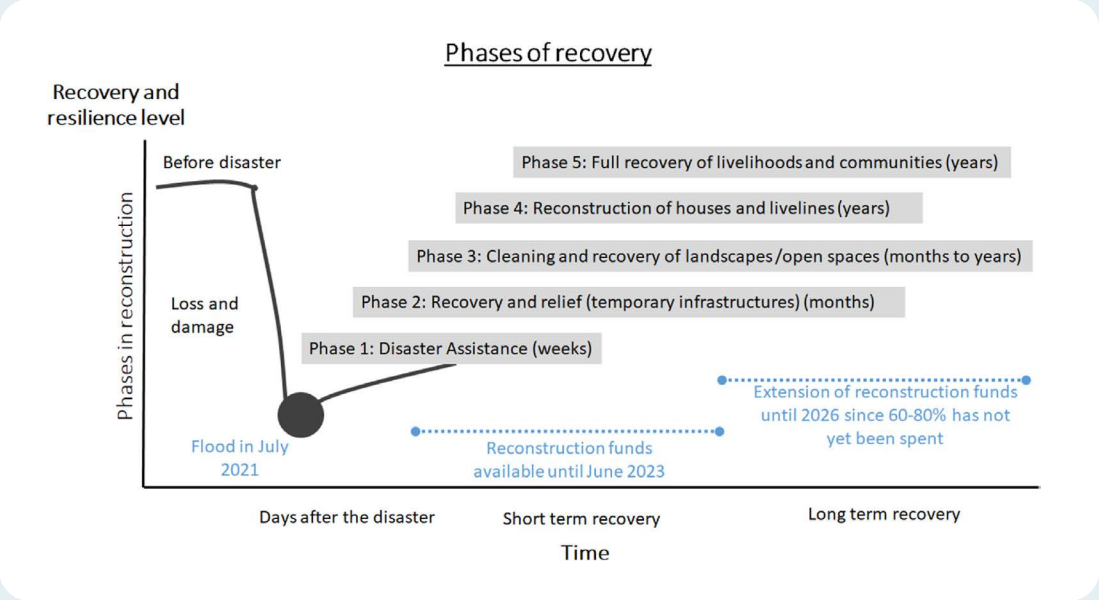


Figure 2. Phases of recovery observed in the flood affected areas in Germany (Source: Birkmann et al., 2023).

It is also important to acknowledge the position of the recovery process within the whole flood risk management cycle (Figure 3). This cycle represents the repetitive -and staged- character of flood risk management (FRM). Before the event, FRM activities focus on flood prevention in all its forms: from technical, spatial planning, finance, to communication activities. After a flood event, quick repairs and responses are needed followed by the rest of the post-flood recovery process. However, it became clear during the workshop that recovery also entails long-term investments in flood prevention and ongoing analysis of all steps carried out during the FRM cycle. Hence, the recovery stage in the diagram overlaps with the "early" stages of flood prevention during a comprehensive flood management.

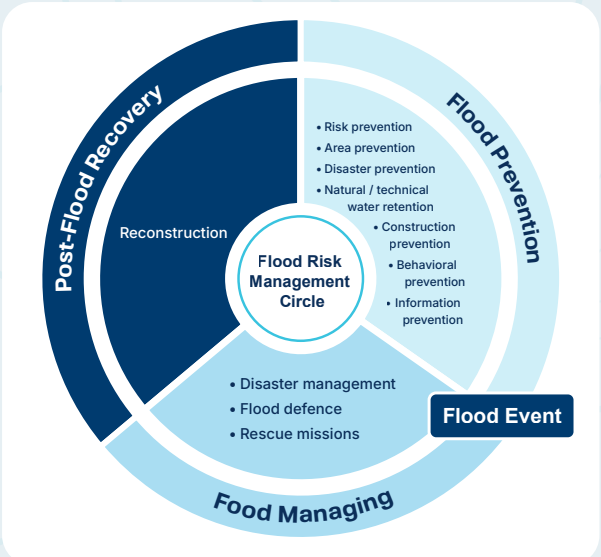


Figure 3. Stages in flood risk management before and after a flood event (9). (Adopted from Vanneuville et al 2011 by L. Burghardt)

2.3 Impossible to Fully Prepare but Planning Still Matters

Representatives from the different flooded areas agreed that no preparatory actions can fully anticipate the unprecedented extremes that caused the aforementioned flood disasters. In the Ahr Valley, a 100-year flood in 2016 served as a wake-up call and prompted updated plans. Yet the 2021 event produced water levels 4–6 meters higher than the 100-year event, overwhelming defenses and causing over 130 fatalities in the Ahr



Rogelio Llanes Ribas
Director de la Oficina de Coordinación e Impulso de la Ejecución de las Ayudas, Spain

Valley alone. Many deaths occurred outside officially mapped hazard zones. These flash floods also evolved much quicker as compared to larger riverine floods, demanding much better forecasting approaches focused on rapid-onset events and aiming at impact-based warnings. In Valencia's 2024 DANA event, extreme rainfall (locally more than 700 mm in 24 hours) overwhelmed urban drainage and exposed gaps in emergency communication.

Nevertheless, the workshop affirmed that planning still improves response capacity. Pre-event preparation reduces surprise, shortens response times, improves response coordination, and creates windows for long term sustainable decisions. Using the aforementioned phases of the recovery process, regional and local authorities can plan for exercises in early responses and collect risk management information to map the most vulnerable areas. For strategic water management decisions, the Netherlands has shifted spatial planning principles with 'water and soil' characteristics steering decision-making and emphasizing adaptive land use management.

- **Recovery playbook**: Every flood-prone region and municipality should develop a pre-agreed 'recovery playbook' well before the next event. This document should define roles and simplified procedures, guide stocking of required materials for emergency response and (temporary) replacement of critical infrastructure services, identify funding sources, and use stress-tests scenarios and climate change projections to evaluate proposed spatial planning and water management measures.

- **Risk assessment**: Risk-based approaches must be a mandatory part of preparatory actions. Risk assessment studies collect hazard, exposure, and vulnerability data. This information jointly shows the risk situation, supports the prioritization of proposed recovery projects, and reveals the weak and vulnerable spots of an area.

- **Mandatory risk assessments**: Risk-based assessments should be an integral part of flood risk management plans (FRMP) developed under the EU flood directive. This includes a post-event review of pre-existing plans. Integrate multi-risk considerations (e.g. flood and heat risks) and require regular updates using the latest climate projections. Use these assessments transparently to justify relocation, buy-outs, or elevated design standards. Share methodologies across borders via JCAR or EU platforms to accelerate learning.

2.4 Local Authorities Know Their Area Best



Joris Gaens
Mayor of Voeren, Flanders, Belgium

All local and regional authorities responsible for the recovery process in the affected regions stated that local governments should be in the leading role in the recovery process. Local governments have the best knowledge of their territory, maintain short communication lines with their citizens, and are aware of the details, constraints, and opportunities of the local context. However, since smaller municipalities frequently lack the necessary capacity and multidisciplinary expertise (hydrology, spatial planning, social services, procurement, etc.), support from regional and federal governments is essential.

- **Facilitate local governments.** Mayor Joris Gaens of the town of Voeren (Belgium) acknowledges the capacity gap of local governments. He and other mayors stated that recovery succeeds when higher levels of government focus on providing finance, labor resources, technical expertise, and streamlining rules while empowering locals to lead implementation.

- **Recovery coordinators:** The coordination of the recovery process across governmental domains, financial resources that come from different institutions, and the execution of projects requires a 'Recovery coordinator' with a clear mandate. This coordinator maintains 'short lines' between local authorities and regional government, aligns funding sources, and enables direct dialogue on plans and initiates crisis legislation. An example is the 'Special Commission for Reconstruction (SCR)' established in Wallonia about 12 days after the 2021 flood event. This was a single entity, led by two high-level civil servants, whose mandate was to coordinate the first phases of the recovery within the first year after the event.

- **One stop shop**: Flood affected citizens often have to contact multiple organizations to get the assistance and funding they so dearly need. This increases stress and slows down their individual recovery process. Minimize this by setting up an organization that helps the population through all procedural steps of the recovery process.

2.5 Building Back Better

Stakeholders participating in a recovery process often have difficulties understanding the term 'building back better' (BBB) as it can have different definitions in various geographic contexts. During the field visits and discussions, one the take-away was that authorities are intuitively converging on the idea of "building back differently' because what is 'better' is context specific and varies across the different recovery cases. However, it was agreed that the principle of BBB steers the recovery process towards achieving a long-term sustainable vision for the region and to develop solutions that support such vision. This requires rethinking the way cities are constructed and governed—being different not only in physical terms (physical measures), but also through institutional cooperation and becoming more flexible, prepared, and adaptive to extreme events. It was also stated that there is no single solution to reduce flood risk, and BBB mostly means combining a mix of measures to achieve long term sustainability, including structural protection, urban redesign, nature-based solutions, and financial instruments.

- **Catchment vision**: Apply a catchment-scale vision to guide the BBB process. Such a vision systematically combines different solutions, varying from structural engineering, nature-based solutions (NBS), land use planning, flood proofing of buildings and insurance. Evaluate every intervention using, for example, multi-criteria analysis and account for possible co-benefits: reduction of flood risk, environmental values, economic vitality, and social equity. The master plan developed for the Vesdre region in Wallonia after the flood is an example of a strategic document adopting a multidisciplinary and catchment-level perspective.

- **Resilience**: Apply key principles of resilience by increasing the adaptability of a region (e.g. by using stress testing, section 3) against extremes and by reducing exposure must be an underlying principle of BBB strategies.

2.6 Legislation

Numerous examples were provided showing that legislation often forms a barrier to quick responses and to a sustainable recovery process:

- **EU tender requirements**: A recurring barrier is the EU-level procurement requiring international tenders. This procedure requires time that is not available, especially in the first response phase of sheltering and providing relief to people who have lost everything. Also in the later phases, international tendering may slow down the recovery process and exclude local and regional contractors who know the terrain, understand community needs, and can deliver faster while creating local jobs.

- **Guidelines instead of lengthy permit processes**: Requiring permits for demolition, rebuilding and restructuring can be a lengthy process, which may form an obstacle in the early phases of the recovery process. The workshop has clearly called for reducing the application timelines but also the excessive bureaucracy: reducing paperwork can speed up decision-making especially in the early phases of recovery. The Belgian region of Wallonia addressed this issue effectively by allowing guidelines in the development and reconstruction process instead of following full legal procedures. It has been agreed in this region that these guidelines could later evolve into permanent law.

- **Integrate recovery planning explicitly into the EU Floods Directive**. The current floods directive could be expanded by more explicitly incorporating measures from the whole disaster risk cycle, including warning systems, recovery planning, and measures to improve cross-border cooperation.

3. Knowledge agenda

3.1 Risk-Based Recovery Strategies

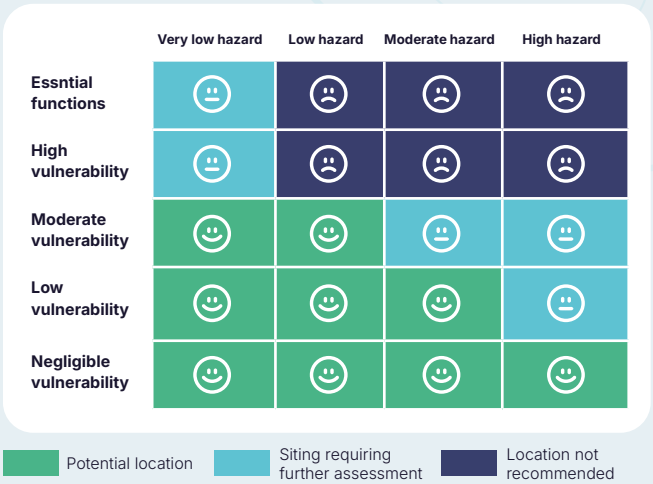
Experiences in all case studies showed that the basis of all recovery solutions is a thorough analysis of the risk situation. Most cases report that they conducted a risk assessment of their area at the beginning of the reconstruction process. The workshop identified a few risk assessment related research activities:

- **Flood hazard mapping** is a prerequisite for recovery planning and projects as these maps delineate the areas that can be inundated and how urban development in these areas (if needed) should anticipate flooding. Research can help produce flooding maps for the current and future situation using climate scenarios. Major floods reshape riverbeds and floodplains through erosion. Therefore, recovery plans must include rapidly updating bathymetric and topographic data (e.g. LiDAR surveys), which is crucial for reliably updating flood maps. Uncertainties in hazard mapping need to be clearly communicated and translated to additional caution in providing permits for building zones. Furthermore, official flood maps (e.g. the 100-yr flood zone) are reflecting the current situation and may underestimate the future flood risk. It is recommended to integrate climate change flood maps (e.g. future 100-yr flood map) in current flood risk management practices.

- **Vulnerability and exposure analysis**: More research is needed into how a 'hazard-vulnerability matrix' (Figure 4) can guide urban design decisions at neighborhood and building levels. Hazard, exposure and vulnerability information can be used in matrices (as applied in Wallonia; Teller et al. 2022), which may support and prioritize urban design rules. For example, the zones that are highly vulnerable and have a high probability of flooding may be designated for a buyouts and setback program with fair compensation for the relocated inhabitants. Other areas may be more suitable for establishing building codes that promote flood-proofing or community-scale measures such as soil-water storage.

- **Assessing economic effects of infrastructure failure**: The loss of critical infrastructure can lead to cascading risk. For example, due to electricity failure and road closure, indirect economic losses and business interruptions can occur. More research is needed to quantify these indirect economic effects for different sectors. These cascading risks also need to be assessed in advance, for example by a coupling with impact-based early warning systems.

- **Stress testing and the use of climate scenarios** support assessing the robustness of solutions against more extreme conditions. While such conditions do not occur with high probability, such scenario analysis may help decision makers and water managers assess possible weak spots in their recovery planning. Stress tests contribute to mitigate levee effects and may also support the discussion about protection levels which may differ across the various infrastructure types.



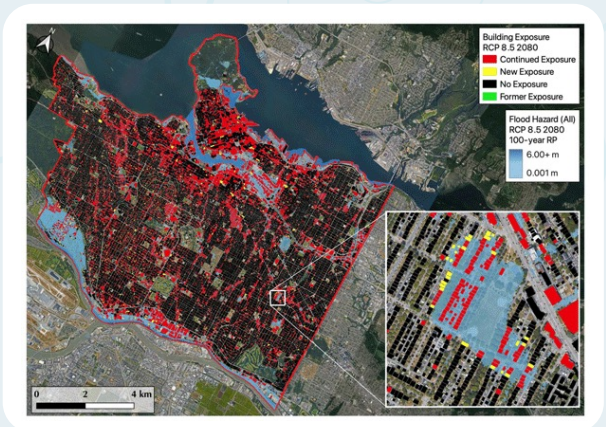


Figure 4. ***Left***: Vulnerability and Hazard for the region of Walonia (Belgium) used for urban development of floodplains. ***Right***: Overlay of a future flood hazard map (climate change scenario RCP8.5) with buildings

3.2 Urban design, innovative engineering

In most cases, space is a limiting factor, and in the recovery process, the optimal spatial allocation of proposed measures is key. For example, in Pepinster (Vesdre Valley, Belgium), a modestly sized flood wall preserves scenic views and tourism potential while complementary measures (lowered riverbeds and upstream retention areas) provide additional conveyance and storage capacity. The Netherlands increasingly relies on 'room for the river' which restores the historic floodplains of rivers. In many upstream areas, nature-based solutions (NBS) such as retention areas for temporary storage of flood water may serve multiple benefits (Bril et al., 2026). Valencia's recovery process integrates NBS elements alongside infrastructure repairs. France highlighted a multi-criteria analysis to balance ecological improvement with flood prevention, stressing stakeholder dialogue to reveal co-benefits. These NBS measures often have positive benefit/cost ratio's (Bril et al., 2026). Topics for further research are:

- **New urban design**: Sustainable urban planning and design should lead to the reconstruction process. Research is needed into new urban designs in recovery that aim at achieving multiple co-benefits: reduced flood risk, economic revitalization, enhanced green spaces, and improved livability.

- **Nature-based solutions** (NBS) are often integrated with other measures in the BBB process as they provide multiple co-benefits in addition to reducing flood risk. More research is needed into the value of the co-benefits of NBS.

- **Innovative engineering** is required to solve bottlenecks and failures during flood events. For example, since bridges collapsed, the task for engineers is to develop bridges with fewer pillars and folding bridge railings to minimize debris clogging (observed challenges in Ahr and Vesdre regions). Other innovations include elevated or flood-proof buildings, and multi-functional infrastructure and public buildings (e.g. schools may serve as shelters during an evacuation). Note that skilled workers and specialists are needed to implement these new measures and such capacity is often missing in the aftermath of a disaster.

3.3 Early Warning & Awareness

Every local community must be connected to reliable early-warning systems delivering not only forecasts but also forecasted impacts and clear actionable response advices. Communities and representatives of authorities can prepare by conducting live exercises that test early warning systems and responses. The workshop also concluded that early warning systems should be improved to provide localized risk information and provide warnings that are based on a clear understanding of which communication strategies have maximum effect to mobilizing communities. Such understanding requires more research using surveys to assess which gaps persist in translating forecasts into protective action, particularly for vulnerable groups. Warnings must prioritize life-saving actions and pay special attention to elderly, mobility-impaired, and low-income populations.

- **Training and joint exercises for communities** should be developed to build operational readiness, including the simulation of unprecedented extremes. Targets groups include vulnerable minorities and but also dedicated training for policy makers and first responders.

- **Assessing communication aspects in impact-based warning (IbF) systems & Raising awareness**: Develop IbF systems and use surveys to assess how forecasted impacts and cascading effects (e.g. on critical infrastructure and locations of buildings) can be communicated to trigger actions.

- **Raising awareness**. Assess how warnings are perceived by citizens and increase awareness, for example, by informing younger citizens at schools. Empirical research has repeatedly demonstrated that increasing risk awareness reduces the impacts of floods (e.g. Rodríguez Castro et al., 2025). A population that is more risk-aware responds more effectively to early warnings.

3.4 Finance and Insurance

Accessibility to finance and insurance are important drivers of a successful recovery process and it was clear during the workshop that accessibility to funding throughout the whole process is a challenge since: (1) funding is often scattered across different governmental layers, NGOs and insurance companies, (2) the timing and stated objectives of funding are often not synchronized with the needs and activities of the recovery process.

An example of financing recovery projects was provided by a representative of the European Investment Bank (EIB). The EIB is the largest financer of the water flood sector investing 4 bn euros every year. The EIB made clear that it is beneficial to invest in recovery and climate adaptation since the benefit-cost ratios for flood protection and ecosystem services reach ratios of 6:1 to 10:1 through the avoided damages and other co-benefits (concept of 'triple dividend'). In addition, the EU Cohesion fund and mechanisms like RESTORE also provide financial support for recovery projects. It has been calculated that between ~55-140 bn Euro is needed annually to finance climate adaptation projects in all sectors (EU, 2026). A study by Dottori et al. (2023) estimated that about 30bn euros per year is needed for infrastructure investments including flood protection. Adaptation has a cost; but inaction has an even greater cost.

- **EU recovery funding**: Assess how the EU could improve its support for recovery process through a more dedicated recovery envelope within the Cohesion Policy or the proposed RESTORE mechanism and to ensure continuity of financing recovery plans. For this, member states could develop 'recovery roadmaps' aligned with existing spatial plans, including milestones, responsible actors, and contingency funding for delays.

Insurance acts as 'soft adaptation' for communities in the recovery process. Insurance ensures the rapid payouts to rebuild and this reduces stress among impacted households and business. Insurance can provide an incentive for flood proofing of buildings as a premium discount can be granted to a policy holder when flood proofing measures are implemented to a building. Yet only about 27% of flood losses across the EU are insured on average, with wide variation between countries (Bellia et al., 2025). Protection gaps have widened as economic losses grow faster than insured losses. Furthermore, new insurance schemes need to be developed as some policies required building back in the original state whereas innovations in BBB are perhaps more effective.

Experience from the Netherlands in the aftermath of the 2021 event show that public compensation schemes were passed to impacted households much later as compared to commercial insurance (six months or more in some Dutch cases), which exacerbates trauma. Valencia's experience underscored complexities in claims processing, while German cases revealed that insured households recovered faster and were more likely to implement adaptation measures.

- **Assess public-private insurance**: more research is needed into the cooperation between governmental compensation after a disaster and private flood insurance. Layered public-private approaches with a role for both organizations may be when climate risk increases, and some areas may become uninsurable.

- **Close the flood protection gap with improved insurance schemes**: Research can support by quantifying the flood protection gap and analyze how, for example, the following actions may close this gap: (a) mandatory insurance elements within current schemes, (b) risk-based incentives through premium reduction or deductibles, (c) seek for better integration of insurance with EU funds.

4. JCAR ATRACE network's ambitions

- **Extend and deepen science-policy cooperation**: Small municipalities cannot manage recovery alone. Successful recovery requires multidisciplinary expertise and cooperation across administrative borders, legislative silos, economic sectors (agriculture, tourism, water management ...), and financial instruments. The Benelux Water Agenda and JCAR ATRACE Network can support and provide such expertise with research. This research is distributed over (a) short term rapid assessment studies (RAT) which can quickly support recovery and adaptation policy within months and (b) longer term PhD research which makes a deep dive into more complex research topics over a period of 3-4 years.

- **EU cooperation**: Science can support the recovery process by systematically analyzing and learning from past disasters and highlight best practices that can be upscaled to other areas. Recovery is increasingly recognized as an important topic within the EU Flood Directive and broader disaster risk management frameworks. Here, JCAR ATRACE can support the EU in its effort to develop policy on recovery by, for example: (a) integrating recovery planning within existing framework directives (Flood Directive, Civil protection mechanism, etc.), (b) assess the role of financial instruments for funding recovery projects using the EIB investments and the EU Cohesion funds, and (c) assess how the EU may play a role in developing public-private partnerships in flood insurance.

- **JCAR ATRACE knowledge agenda**: based on the recommendations and questions for science, JCAR ATRACE will update its knowledge plan and initiate new research to address the proposed research topics. Topics include among others: assess legislative simplification for recovery, urban design and adaptation, co-benefits quantification, innovative engineering, insurance and financial schemes, scenario-based stress-testing, and impact-based forecasting.

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