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INSURANCE FOR A BETTER WORLD

Flood Risk Management in Germany

Building flood resilience in a changing climate

June 2020

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The Geneva Association

The Geneva Association was created in 1973 and is the only global association of insurance companies; our members are insurance and reinsurance Chief Executive Officers (CEOs). Based on rigorous research conducted in collaboration with our members, academic institutions and multilateral organisations, our mission is to identify and investigate key trends that are likely to shape or impact the insurance industry in the future, highlighting what is at stake for the industry; develop recommendations for the industry and for policymakers; provide a platform to our members, policymakers, academics, multilateral and non-governmental organisations to discuss these trends and recommendations; reach out to global opinion leaders and influential organisations to highlight the positive contributions of insurance to better understanding risks and to building resilient and prosperous economies and societies, and thus a more sustainable world.

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1. Executive summary

As the world responds to the COVID-19 crisis and governments prepare their economic stimulus plans, the potential compounding effects of weather-related extremes such as floods, tropical cyclones and wildfires could significantly challenge a country's emergency management capacities and slow down socio-economic recovery. This study is focused on building resilience to floods in a changing climate. It points to the need for a paradigm shift from reacting to crises towards a risk-based, anticipatory, holistic and all-of-society approach to managing the potential impacts of catastrophes.

Flooding is one of the most important physical climate risks in many countries, affecting households, communities, businesses and governments on a regular basis.

There are several kinds of floods:

- Fluvial floods (river floods)
- Pluvial floods (flash floods and surface water)
- Coastal floods (storm surge and coastal tidal flooding)

Each kind differs in terms of occurrence, potential damage and management measures.

Building resilience has become a priority for many countries around the world in recent years, due to the major socio-economic effects of flooding, including threats to human lives and livelihoods as well as direct and indirect economic impacts.

The costs associated with floods are growing in many places due to the combined impacts of

- Increasing concentrations of people and assets in areas of high flood risk linked to land use, urbanisation and development practices; and
- The increasing frequency and severity of weather-related events linked to climate change (e.g. changing storm and precipitation patterns and rising sea levels) (Intergovernmental Panel on Climate Change (IPCC) 2018).

Over the last decade, underpinned by three international framework agreements,[1] some governments have started to adopt a more proactive approach to disaster

1 The United Nations Hyogo Framework for Action (2005–2015), Sendai Framework for Disaster Reduction (2015–2030) and The Paris Agreement, which have been adopted by over 190 member states.

risk management (including for floods), engaging a variety of stakeholders (The Geneva Association 2016, 2017). Despite some progress, a number of hurdles remain related to policy and regulatory constraints, institutional and sectoral silos and capacities, conflicting and/or competing priorities and insufficient coordination within and across layers of government and with other key stakeholders, such as the private sector and non-governmental organisations (NGOs).

As part of its commitment to strengthening socio-economic resilience to extreme events and climate change, The Geneva Association has undertaken this study to take a deeper look at the evolution of flood risk management (FRM), particularly in light of the changing risk landscape. Specifically

- This study offers a comprehensive review of FRM in three high-income countries with mature insurance markets: the U.S., England (a constituent country of the U.K., as defined by the Commonwealth) and Germany;
- Special attention is given to mapping the evolution of governance, institutional frameworks and the interplay of different components of FRM, including risk assessment, risk communication and awareness, risk reduction, risk prevention, risk financing, risk transfer (e.g. insurance and alternative risk transfer) and reconstruction measures;
- Trends and patterns are explored and key findings and recommendations for stakeholders aiming to improve FRM systems in any country are provided;
- The study did not set out to draw comparisons among the three countries, or to identify and promote best practices. In fact, a best practice in one country may not be so in another, as it cannot be isolated from the governance, institutional and cultural environments in which it was originally developed.

The methodology, overall findings and recommendations of the entire study are provided in The Geneva Association (2020a). Case studies for the U.S. and England are available in The Geneva Association (2020b) and (2020c), respectively.

This report provides a comprehensive review of FRM in Germany and highlights successes, lessons learned and continued challenges.

Key findings:

- **Flood risks:** Germany is exposed to coastal, fluvial and pluvial flooding, particularly in urban areas where localised surface water and urban flash floods are an area of growing concern.
- **Flood events:** Major flood events, including storm surge in 1962, river flooding in 2002 and 2013 and more recent flash floods, have shaped Germany's approach to FRM.
- **Institutional roles and responsibilities:** The federal political system distributes flood risk responsibilities across levels of government and various stakeholders, which can result in different management approaches. FRM is therefore fragmented with no clear champion with the remit to coordinate between different agencies, sectors and tiers of government.
- **Legislative actions:** Recurrent high-impact flooding has attracted increasing political attention and led to pieces of legislation addressing flood risk, underpinned by systematic reviews after major flood events in 2002 and 2013 (conducted by the German Committee for Disaster Reduction (Deutsches Komitee für Katastrophenvorsorge e.V., DKKV)) and the 2016 flash floods in southern Germany.
- **Risk information and communication:** Various stakeholders provide flood hazard and/or flood risk maps, which differ in content and methodology. Publicly available risk information is not specifically tailored for different end-users. The insurance industry (led by the German Insurance Association, Deutsche Versicherungswirtschaft (GDV)) produced the first countrywide flood hazard zoning system (ZÜRS) in 2001, which has since been extended. Data protection and privacy concerns are current challenges for flood data and knowledge sharing while political pressures around land use and development hinder the use of risk zoning in maps. The GDV, in cooperation with a science-based institute, has also developed a Germany-wide heavy rainfall hazard zoning map, derived from topography characteristics. This is already available for the insurance market and is being discussed and tested with the relevant committees and municipalities for flash flood and surface water flood prevention in Germany.

- **Alerts and early warnings:** All water-related issues and civil protection and emergency management services are managed at the state level. Therefore, the organisation of flood forecasting, warnings and civil protection differs throughout the country. Technological advancements have significantly improved the quality and lead times of warnings in recent decades.

- **Emergency preparedness:** At the local level, fire brigades, ambulance services and relief organisations are responsible for smaller and less severe events on a regular basis. At the federal level, as required by law, the Federal Office of Civil Protection and Disaster Assistance (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe, BBK) regularly undertakes risk analysis for civil protection from different hazards and publishes the results in parliamentary reports.

- **Risk reduction:** Multiple approaches to reducing flood risk currently exist. The extensive structural flood defences in place – dikes, levees and other water control infrastructure systems – are financed, owned and operated by the federal states, municipal water authorities and dike associations. There is no federal database to track investment in risk reduction.

- **Property-level protection:** According to the Federal Water Act of 2009, property owners are responsible for protecting their property from flooding, for example through the implementation of property-level mitigation measures (PLPMs). Despite a lack of state-run programmes that financially support property-level mitigation, incentives such as insurance and the recently introduced 'flood passport' (Hochwasserpass) should help to systematically improve property-level risk reduction. Overall, there is a growing uptake of PLPMs by property owners.

- **Planning and land use:** The Flood Control Act and second Omnibus Flood Control Act (2018) have helped improve recognition of flood risk in land zoning and planning. Stricter building codes in 100-year flood zones and new regulations for the use of flood-prone areas outside statutory inundation areas have been introduced, although the effectiveness and implementation of these new rules are still unclear.

- **Risk finance:** Germany is committed to risk-based compensation through private insurance, while support via ad-hoc state funds was available for those impacted in the past. These state funds have been reduced and are currently only used to provide support in case of hardship. There is currently no regulation that mandates state, federal and local governments to protect their assets from flooding through specific insurance schemes, and uptake of insurance by local authorities is very low. However, state governments increasingly request flood insurance of municipal assets as a condition for receiving any additional government disaster relief pay-outs.

- **Risk transfer and insurance:** Insurance is provided by the private market and uptake is voluntary. Fluctuating demand and strong regional differences in insurance penetration have in the past led to policy discussions about the need for a mandatory system. Information campaigns and changes in state compensation have contributed to a recent increase in insurance penetration to around 41%.

- **Reconstruction:** Large-scale government aid and insurance pay-outs mean that reconstruction tends to be quick, but there is limited evidence of 'building back better' and improving resilience in reconstruction.

- **Multi-stakeholder engagement:** Several efforts have been made to increase cross-sectoral and cross-governmental collaboration, but these have been limited to a small number of actors. Property developers or the private sector, for example, tend to be mostly absent from FRM discourse. Collaboration between the insurance industry and government is helping to provide risk information and increase awareness.

- **Overall FRM approach:** Overall, there is evidence that FRM in Germany is shifting towards a more anticipatory and coordinated system, at least on paper. However, links between FRM and climate adaptation planning do not appear to be formalised. The 2002 floods marked a reorientation towards an integrated FRM system in Germany, but the overarching focus remains on maintaining standards instead of enhancing wider resilience. Data mapping and modelling for surface water flooding is still lagging and legally evolving (e.g. data protection laws, possible liability claims against local authorities).

The flood risk management system in Germany

Risk assessment and communication

- Several activities across the country and within individual states (Länder) are underway, involving different actors, such as the Federal Institute of Hydrology (BfG) and the German Weather Service (DWD).
- The German Insurance Association (GDV) and insurers have developed a countrywide flood hazard zoning system: ZÜRS (not accessible to the general public).
- There are several initiatives and activities to assess risks with cities, local authorities, non-profit groups, academic institutes and private risk modelling firms. There are limited efforts to integrate different maps, datasets or models.

Response and reconstruction

- While large-scale government aid and insurance pay-outs have led to relatively quick reconstruction and recovery after recent flood events in Germany, in 2002 and 2013 the opportunity to combine reconstruction with risk reduction was largely missed.
- Limited evidence of 'building back better'.

Risk governance

- Each level of government has few absolute duties:
  - Federal (Bund): sets general standards
  - State (Länder): responsible for all water issues, civil protection and actual risk management on the ground; manages fluvial and coastal flood risk
  - Municipal/local: manages pluvial flood risk
- FRM is coordinated through various inter-governmental mechanisms such as the joint Bund-Länder working group on water (LAWA).
- Multi-level governance can result in different management approaches across institutions and government levels.
- Legislative action has been triggered by major floods.
- EU Floods Directive sets out an overarching framework.

Risk financing for public assets

- Germany is firmly committed to risk-based compensation through private insurance. This long-standing policy commitment is reinforced by individual 'duty of care' to mitigate flood damages. Local authorities increasingly take out insurance for their physical assets.
- In most of the federal states, the government has little or no legal obligation to compensate damages to homeowners and businesses, which are funded through 'insurance or the accumulation of reserves'.
- In case of financial hardship, governments still provide pay-outs as part of the German social welfare system.

Source: The Geneva Association

Early warnings linked to emergency preparedness

- The DWD is leading efforts to develop and issue weather warnings and flood warnings.
- Civil protection and emergency management services are managed at the state level.
- Flood warnings and civil protection can differ throughout the country.
- The Federal Office of Civil Protection and Disaster Assistance (BBK) undertakes risk analysis for civil protection from different hazards and publishes them in a parliamentary report.

Risk transfer

- Flood insurance coverage is voluntary, provided by the private market as supplementary cover to standard policies.
- Penetration rates differ across regions for historic reasons.
- Following information campaigns and changes to state compensation, penetration rates have increased, currently sitting at 41%.
- The insurance industry and government partner to provide risk information and increase awareness (Kompass Naturgefahren, formerly ZÜRS public).

Risk reduction

- Law does not state 'individual entitlement to flood protection'.
- According to the 2009 update of the Federal Water Act, 'every person who may be affected by floods is, as far as possible and reasonable, obliged to take appropriate precautionary measures'.
- Responsibility for flood protection lies with the 16 federal states, leading to different levels of flood protection.
- According to the Federal Water Act of 2009, property owners are responsible for protecting their properties, for example through the implementation of property-level mitigation measures (PLPMs).
- The uptake of PLPMs by property owners is growing.
- 'Flood passport' initiative (Hochwasserpass) will recognise property-level risk and resilience.

Risk prevention through planning and land use

- Before the 2002 floods, there was very limited recognition of flood risk in development planning and land zoning practices.
- This changed in 2005 with the introduction of the Flood Control Act. The effectiveness of these measures is not clear.
- The second Omnibus Flood Control Act 2018 introduced stricter building codes in 100-year flood zones and new regulations for the use of flood-prone areas outside statutory inundation areas.

Other considerations for FRM

- Monitor, assess and provide ongoing feedback.

  Currently

  - Tracking and monitoring FRM performance tends to be conducted in the form of post-event assessments.
  - Several post-flood reviews have been undertaken by the German Committee for Disaster Reduction (DKKV). These have uncovered strengths and weaknesses but there is no formal monitoring of improvements.
- Incentivise risk-based decisions.
- Multi-stakeholder coordination platforms.

Cross-governmental collaboration
to address

- Urban pluvial floods.
- EU directives.
- Cross-border challenges along river basins due to different community interests.

Cross-sectoral collaboration

- Partnership between the insurance industry and government to provide risk information and increase awareness.
- Educational, specialised and technical training programmes.
  - Currently some programmes are carried out by academia and trade groups.
- Climate change considerations.
  - While climate change is increasingly recognised as a key risk factor, there appears to be a lack of strategic focus on how to achieve future flood resilience. In this regard, engagement of the expert community with FRM and adaptation appears limited, at least at the federal and state levels.
  - Local communities and cities are more advanced, having accounted for expected increases in heavy precipitation events in spatial planning decisions and in updating drainage and sewer systems.

Flood risk management in Germany: Pre-1950–2019

	pre-1950s	1950s	1960s	1970s	1980s
Approach to managing flood risk	Encroachment, rectification and canalisation Building of large dams to regulate discharge	Technocratic safety approach with strong focus on structural flood protection Focus on water infrastructure to support economic reconstruction 10–20% of natural flood plains remained by the 1970s Peak in water pollution in river systems reached by the late 1970s			Renaturalisation Natural safety
Major flood events	**1947: Oder flood**		**1962: North Sea flood**		**1981: Weser flood**
Major laws			**1960: Federal Water Act (Wasserhaushalts-gesetz).** Framework legislation giving responsibility to federal states in managing floods		**1988: Integrated Rhine Program.** Combining natural development and flood protection
Institutional changes and noteworthy developments	Redrawing of national borders in Europe including major river basins such as Rhine and Oder after WWI and WWII	Establishment of federal regime with decentralised flood management resting in the individual federal states Foundation of national and international working groups to coordinate decentralised flood risk management (LAWA and ICPR)	Devastating 1962 flood initiated major improvements in flood protection along the German coast German army was deployed in Hamburg for emergency purposes, violating the German constitution prohibiting using the army for internal affairs A clause that excluded disasters was added in 1968		Germany and France sign a treaty for a joint flood plain restoration programme along the Rhine river

Source: The Geneva Association

1990s	2000–2004	2005–2008
Shift from pure technically oriented flood protection towards a more integrated FRM approach as laid out by LAWA (1995)		
1993 floods: USD 620 million overall losses, USD 186 million insured losses **1994 floods: USD 770 million overall losses, USD 258 million insured losses** **1995 floods: USD 399 million overall losses, USD 144 million insured losses** **1997: USD 382 million overall losses, USD 38 million insured losses**	**2002 floods: USD 11.83 billion overall losses, USD 1.87 billion insured losses**	
1999: Three pillars of modern flood management (Environmental Minister Conference)	**2002: Disaster Relief Act** EUR 7.1 billion	**2005: Omnibus Flood Control Act**. Included the preparation of flood management plans per catchment and stricter regulations for built-up areas in flood-prone areas came into effect. In addition, private precautionary action was requested from every person living in a floodplain in accordance with their resources and capabilities
German reunification Federal state of Baden Württemberg abandons compulsory state-provided flood insurance (as part of home insurance) due to EU anti-monopolisation laws New federal states in the former GDR do not include flood insurance under household insurance	**2002: Government Review**. Von Kirchbach et al. (2002) **2003: 5-Punkte-Programme.** Five-point action programme on how to improve flood risk management was agreed upon and paved the way for amendments in related legislation **2003: Flood Review DKKV**. Revealed major deficiencies in Germany's flood risk warning and communication (DKKV, 2003) **2004: State-level programmes.** The Free State of Saxony, the most severely hit state in 2002, planned 1,600 measures **2001: ZÜRS** (fourth zone introduced 2003). Zoning system used to assess the insurability of properties **2002: Negotiations about compulsory flood insurance** **2004: German industrial standard.** Introduction of DIN 19700 for the assessment of the risks of dam failures	**2005–2007: Research programme RIMAX** **2007: EU Floods Directive.** Flood-adapted spatial planning has received a considerable boost through the European Floods Directive (2007/60/EC) as well as through changes in the Federal Water Act in 2005 and 2009 (Thieken et al. 2016).

	2009–2012	2013–2015
Approach to managing flood risk	Shift from condition-based governance to performance-based policy regulations that define targets and thus offer a broader scope of implementation	
Major flood events	**2010 floods: USD 1.31 billion overall losses USD 400 million insured losses (river dykes burst, dam failed)**	**2013 floods: USD 10.4 billion overall losses USD 2.2 billion insured losses** **2014 floods: USD 600 million overall losses, USD 270 million insured losses**
Major laws	**2009: Revision of the Federal Water Act.** Resulted in a shift from condition-based governance with precise 'if..., then...' rules to performance-based policy regulations that define targets and thus offer a broader scope of implementation	**2013: Disaster Relief Act (EUR 8 billion)**
Institutional changes and noteworthy developments	**2010: New standard insurance conditions** (opt-out option for natural hazards supplement), adaptation success. Smaller flood events in 2005, 2006, 2010 and 2011 already revealed that regional and local governments as well as flood-prone residents and companies had adapted to flood risk and had implemented precautionary and preparatory measures (Kreibich et al. 2011a, Kienzler et al. 2015a, Thieken et al. 2016). **2011: An additional open-access multihazard web portal Kompass Naturgefahren** launched by the GDV for pilot regions. Seen as a prototype for a web-based hazard and risk information platform for the whole country, the web portal was decided on in October 2014 by the Conference of Ministries of the Environment (UMK). **2011: Loss compensation guidelines (BY; SN). Information campaigns on flood insurance** (since 2009). (Together with upper water authorities). The campaigns mainly inform about the availability, costs and advantages of flood insurance in Germany.	**2013: New negotiations about compulsory flood insurance** (ended June 2015, no compulsion) **2013: A modular warning system (MoWaS)** that states and communities could tap into triggers certain so-called 'warning multipliers' via mass media, internet portals, and the federal emergency information app (Notfall-Informations- und Nachrichten-App des Bundes, NINA) **2014–2015: National Flood Protection Programme (EUR 5.44 billion).** A joint effort between the federal government and all federal states, covering around 100 measures with investments of more than EUR 5.4 billion (DKKV 2015) **2014: Updated flood maps released**. This resulted in a reduction in the share of homes assigned to high-risk areas from 1.5% of all buildings in 2008 to 0.65% of all buildings in 2016 (GDV 2016) **2014: Hochwasserpass (building certficate) introduced.** Joint initiative of the GDV and civil and water engineers **2015: Statutory rules** that aim to prevent surface sealing in these areas are part of the Saxon Water Act (SächsWG §76 as of 2015)

Source: The Geneva Association

2016	2017
USD 2.87 billion overall losses **USD 1.34 billion insured losses** **Surface water/pluvial flood in Berlin with estimated EUR 60 million damage** **Flash floods in southern Germany**	**USD 318 million overall losses** **USD 70 million insured losses**
	Omnibus Flood Control Act II (Hochwasserschutzgesetz) 2017/2018. Regulations for the use of flood-prone areas outside statutory inundation areas, for example, requirements for flood-adapted building design and flood-secured oil tanks. In recent flood events, floating oil tanks were identified as an important damage driver, particularly in areas that had been inundated due to dike breaches (DKKV 2015). In 2017, legal instruments to prevent increases in damage potential behind dikes or other structural flood defenses were established in the second Flood Control Act.
The DWD planned to map flash flood hazard zones and improve local warnings. **Zurich published recommendations on flash floods and risk reduction** (Zurich PERC). **LAWA decided to provide a centralised web-mapping service** for flood hazard and flood risk maps for Germany (Nationale HWGK/HWRK). **The Bavarian Environment Agency commissioned the project HiOS (Hinweiskarte Oberflächenabfluss und Sturzflut):** After the severe flash floods in Simbach am Inn in Bavaria in 2016, this was launched to develop and test a procedure for the evaluation and classification of the risk to Bavarian municipalities from surface runoff and flash floods.	

	2018	2019
Approach to managing flood risk		
Major flood events	USD 10 million overall losses USD 0 insured losses	USD 15 million overall losses USD 3 million insured losses
Major laws		
Institutional changes and noteworthy developments	**LAWA published recommendations** for minimum standards of flood hazard and flood risk maps to produce consistent maps for all federal states to comply with the EU Floods directive. **LAWA published its first strategy report** for effective management of surface water flooding. LAWA calls on local communities to investigate the communal risk of surface water flooding and to develop local mangement plans, including information for the public. **The GDV launched its Stadt.Land.unter campaign** and released a German-wide heavy rainfall map in cooperation with the DWD. The campaign aims to inform the general public about the risks from heavy rainfall and surface water flooding.	**State of Bavaria decided to no longer pay disaster support** for flood risk victims starting July 2019, urging homeowners and businesses to take out insurance. **The DWD and GDV completed their four year research project on heavy rainfall**, surface water flooding and damage. The project created three surface water flood hazard zones for the whole of Germany, which are now implemented in ZURS Geo, the main risk assessment tool of the German insurance industry. According to these maps, 11.8% of properties in Germany are located in the highest hazard zone. Based on the methods developed in the project the DWD now issues an annual extreme rainfall report. The project also included three pilot cities which should directly benefit through improved knowledge of their surface water FRM.

Sources:
Becker et al. 2007, Bubeck et al. 2017, Meurer 2000 and Penning-Rowsell and Becker 2019

2. Introduction

Germany is exposed to coastal, fluvial and, more recently, surface water and flash flooding, particularly in urban areas. Riverine flooding is a major concern across the whole country, with all the big river catchments experiencing severe losses due to major floods over the last 25 years. In addition, localised urban flash floods are an area of growing concern.

FRM efforts in Germany have traditionally focused on riverine floods and storm surges along the coast as these pose risks of national significance. In 1962 a storm surge caused severe losses in Hamburg,[2] triggering large-scale investments in flood controls along the German coastline. These investments have prevented significant losses (estimated to be in the EUR double-digit billion range) from four major storm surges since 1976.[3]

This report provides a comprehensive review of FRM in Germany, applying a holistic, multi-stakeholder, forward-looking framework (The Geneva Association 2020a; Annex).

Section 3 provides an overview of flood risk in Germany and the evolution of FRM is examined in section 4. Section 5 focuses on the different components of FRM in Germany. The latest trends towards an all-of-society approach to flood resilience are discussed in section 6 and section 7 provides concluding remarks.

2 Located between the Baltic Sea and the North Sea, Hamburg is the second-largest European port.
3 https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2012/2012-02-13-50th-anniversary-of-storm-surge-in-hamburg-subsequent-flood-controls-prevent-billions-in-losses.html

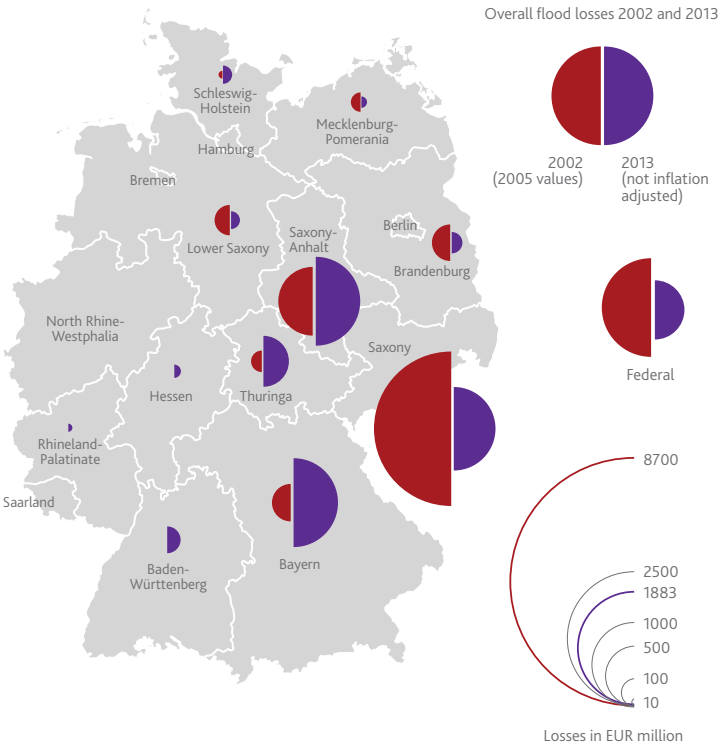
3. Drivers of flood risk in Germany

Germany is divided into 16 federal states (see Figure 1a for an overview of all federal states and main rivers). The three largest river catchments are the Danube catchment in the south east, the Rhine catchment in the west and the Elbe catchment in the north east. All three are transboundary, crossing borders with many of Germany's neighbouring countries. Two flood events along the Elbe and Danube and their tributaries in 2002 and 2013 were the most expensive in terms of economic losses in the last three decades and led to significant improvements in the German FRM system. Figure 1b shows a comparison of the overall flood losses by state for the two events, which directly affected Bavaria, Thuringia, Saxony, Saxony-Anhalt and Lower Saxony.

Figure 1:

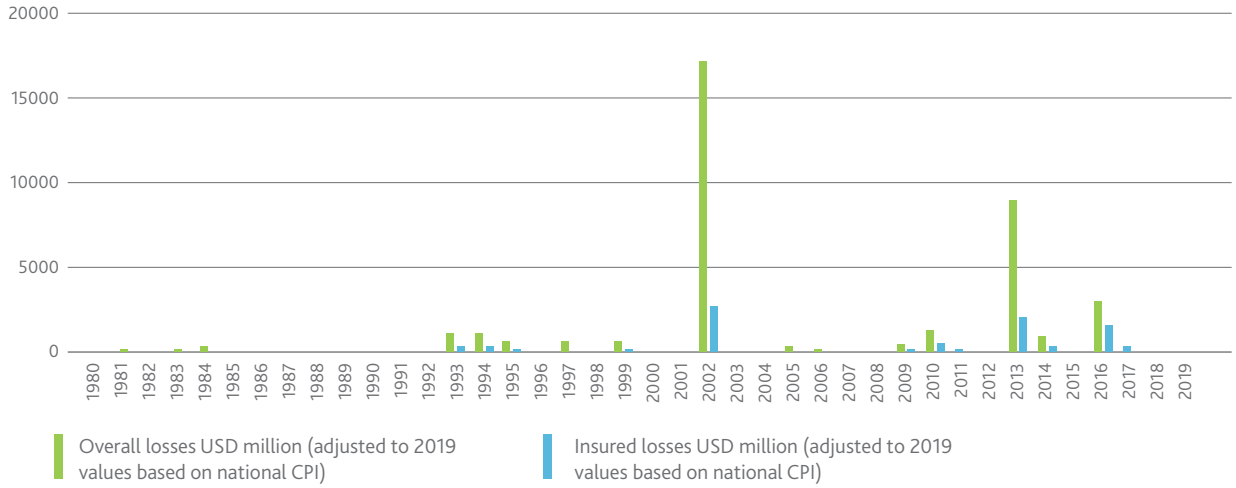
(a) Overview of the 16 federal states (Länder) and main river systems in Germany

(b) Distribution of overall flood losses and affected federal states from the 2002 and 2013 floods along the Elbe and Danube rivers and their tributaries



Sources: Kienzler et al. 2015 and DKKV 2015

Figure 2: Overall and insured losses in USD million for floods and flash floods in Germany between 1980 and 2018



Source: NatCatSERVICE Munich Re
Note: Losses are inflation adjusted via the country-specific consumer price index and by considering the exchange rate fluctuations between local currency and USD.

Figure 2 provides the total economic and insured losses associated with floods in Germany from 1980–2019. In addition, Table 1 provides a list of the most prominent flood events, impacted regions and total and insured losses.

In recent years, small-scale pluvial floods (also called surface water flooding) and flash floods have become an issue, particularly in urban areas. For example, pluvial floods caused severe damage (approx. USD 600 million) in the city of Münster and surrounding municipalities in July 2014 and insured losses of USD 1.3 billion in southern Germany in May and June 2016.

Table 1: Overview of the 10 most expensive (highest overall economic losses) flood events in Germany between 1980 and 2019

Period	Event	Affected area	Overall losses (USD million, original values)	Insured losses (USD million, original values)	Fatalities
11–20 Aug 2002	Flood, flash flood	Saxony, Saxony-Anhalt, Lower Saxony, Mecklenburg-Western Pomerania, Berlin, Schleswig-Holstein, Bavaria	11,600	1,800	21
30 May–12 Jun 2013	Flood	Bavaria, Baden-Württemberg, Saxony, Saxony-Anhalt, Brandenburg, Thuringia, Schleswig-Holstein,Lower Saxony, Mecklenburg-Western Pomerania	10,400	2,200	8
31 May–9 Jun 2016	Flood	Bavaria, Baden-Württemberg, Hesse, Lower Saxony, Hamburg, North Rhine-Westphalia, Saarland,	2,000	830	7
6–16 Aug 2010	Flood, flash flood	Saxony, Saxony-Anhalt, Bavaria, Brandenburg	1,100	380	4
27–30 May 2016	Flash flood, severe storm	Baden-Württemberg, Bavaria, Hesse, North Rhine-Westphalia, Rhineland-Palatinate, Thuringia	830	500	4
21–27 Dec 1993	Flood	North Rhine-Westphalia, Baden-Württemberg, Hesse, Bavaria, Rhineland-Palatinate	600	180	5
28–29 Jul 2014	Flash flood, severe storm	North Rhine-Westphalia: Baden-Württemberg, Hesse	600	270	2
17 Jul–10 Aug 1997	Flood	Brandenburg	370	35	
13–18 Apr 1994	Flood	Lower Saxony, Saxony, Saxony Anhalt, Thuringa, Bavaria, Baden-Württemberg	360	180	2
22 Jan–3 Feb 1995	Flood	Hesse, Baden-Württemberg, North Rhine-Westphalia, Bavaria	350	130	5

Source: NatCatSERVICE Munich Re

3.1. Population growth and development

A number of socio-economic factors contribute to rising flood risk levels, including land use and land cover practices such as soil sealing,[4] ageing drainage infrastructure and insufficient catchment-wide flood prevention planning.

3.2. Climate change

Factors related to climate change are exacerbating flood risk in Germany. Climate models predict that intense convective rainfall and periods of heat and drought are likely to occur more often in the future, while rising sea levels are expected to increase risks of coastal flooding. Brasseur et al. (2017) provide a comprehensive summary of climate impacts in Germany, highlighting a set of already-visible developments:[5]

- A shift in precipitation regimes from summer to winter, combined with milder winters, increases the proportion of precipitation that is not stored as snow and therefore directly leads to discharge, increasing the likelihood of winter floods;

- Rising sea levels in combination with an increase in severe winter storms across the North and Baltic Seas (expected increase in storm speed of up to 14% until 2100) mean that high storm surge levels are expected to be more frequent and longer-lasting along the German coastline. This will likely reduce return periods of severe storm surges from 350 years (present) to 100 years by 2050, requiring significant expansion of coastal flood protection throughout the 21st century (Grabemann and Weisse 2008).

4 Soil sealing is rapidly increasing in many urban areas in Germany with new developments especially in larger cities: https://www.gdv.de/de/medien/aktuell/muenchen-ist-die-am-staerksten-versiegelte-grossstadt-36418

5 https://www.umweltbundesamt.de/en/topics/climate-energy/climate-change-adaptation/impacts-of-climate-change/climate-impacts-germany/climate-impacts-field-of-action-water-resources#textpart-4

4. Evolution of flood risk management in Germany

4.1. Major floods as drivers of flood risk management actions

Recurrent high-impact floods have led to growing political, public and industry concern about the need for action. Specifically

- Two big floods in the Rhine catchment in 1993 and 1995 initiated a shift from pure technically-oriented flood protection towards a more integrated FRM approach, as laid out by the Bund–Länder working group on water (Bund/Länder-Arbeitsgemeinschaft Wasser, LAWA 1995);
- The Elbe floods in August 2002 resulted in USD 11.6 billion total damage and became the most expensive disaster event caused by a natural hazard in Germany. The floods marked a reorientation toward an integrated FRM system in the country;
- Widespread flooding in June 2013 caused damages of USD 8 to 10 billion and triggered a progress assessment by the DKKV with particular focus on lessons learned from the 2002 floods;[6]
- Several localised flash floods and pluvial floods in urban areas from 2014–2017 initiated discussions on local FRM in urban areas and expanded the focus beyond just river and coastal flooding (Vogel et al. 2017; LAWA 2018).

4.2. Institutional roles and responsibilities

Roles and responsibilities remain somewhat fragmented due to the federal system. The federal (Bund), state (Länder) and municipal governments each have few specific flood management duties (Hartmann and Albrecht 2014). FRM is coordinated through various intergovernmental mechanisms such as LAWA. The federal government only sets general standards for FRM through so-called legislative framework. The states have the main responsibility for all water issues and civil protection and thus implement the legislative framework and determine actual risk management on the ground (Bubeck et al. 2015). While the management of fluvial and coastal flood risk is organised at the state level, pluvial flood risk is a local responsibility. However, in some states (e.g. Bavaria and Baden-Württemberg) the local authorities are supported by the state government, for example by provision of guidelines.[7]

This can result in different management approaches across institutions and levels of government (DKKV 2003; Heintz et al. 2012; DKKV 2015). For example, so-called water cooperatives (Genossenschaften) were set up in North Rhine-Westphalia. These institutions focus on districts based on smaller river basins and are responsible for implementing FRM plans in a formally affirmed cooperation with regional authorities (Bezirksregierungen). In other parts of Germany informal collaborations have been established to implement the Floods Directive across states and river basins. Formalised flood protection plans for all 16 states were implemented for the first time in 2005 after a change in federal water law made them mandatory. Before that, only informal concepts existed

6 As the national platform for disaster risk reduction (DRR) in Germany, the DKKV is a centre of excellence for all questions related to national and international DRR. Its aim is to integrate the concept of disaster risk reduction in the way people think and act in politics, science and society. The DKKV provides advice, research and support. As well as natural hazards, the DKKV also focuses on technical, scientific and social threats. Disaster prevention and strengthening of resilience are also important components of the fight against hunger and the work of Welthungerhilfe, which has been a DKKV member since 2007. For more information see: https://www.welthungerhilfe.org/about-us/partners/networks/dkkv-german-committee-for-disaster-reduction/

7 https://pudi.lubw.de/detailseite/-/publication/47871

in some states with few restrictions for inundation zones (Hartmann and Spit 2015).

These developments were primarily triggered by the major flooding in 2002, which initiated reviews of the FRM system; it was subject to further review after the 2013 floods (e.g. for Saxony by von Kirchbach et al. 2002, 2013; for all of Germany by the DKKV 2003, 2015).

4.3. Legislative actions

Major FRM legislative action has been triggered by severe flooding. A number of improvements to FRM in Germany were seen after the 2002 floods with the passing of the Disaster Relief Act, which granted EUR 7.1 billion for reconstruction (Surminski and Thieken 2017).

A five-point action programme was also agreed upon, which included a joint federal–state FRM programme, organisation of international conferences for a transnational FRM strategy in transboundary river basins and plans for better cooperation within the European Union. This led to the Omnibus Flood Control Act of 2005 and changes to the Federal Water and Spatial Planning Acts (Mehryar and Surminski 2020).

This also paved the way for catchment-level flood management plans and stricter zoning regulations in flood-prone areas to prevent the development of new homes and commercial projects in statutory inundation areas. However, the corresponding law (Federal Water Act or Wasserhaushaltsgesetz § 78) neither defines mandatory building codes for existing buildings nor specifies how violations are sanctioned. It also remains unclear whether it has led to the anticipated uptake in private precautionary flood risk measures by homeowners.[8]

The EU Floods Directive (triggered by the 2002 floods) led to updates to the Federal Water Act in 2009, indicating a shift in flood risk governance (Surminski and Thieken 2017). It also introduced performance-based policy regulations that define targets and thus offer a broader scope of implementation (Hartmann and Albrecht 2014). In January 2018, the second Omnibus Flood Control Act came into force, which lays down regulations for the use of flood-prone areas outside statutory inundation areas, e.g. requirements for flood-adapted building design and flood-secured oil tanks. However, it is not yet clear whether these new regulations will have the intended effect of flood risk reduction. Floating oil tanks were identified as important damage drivers, particularly in areas that had been inundated due to dike breaches (DKKV 2015).

Recent pluvial floods in urban areas have prompted strategy discussions among insurers and different levels of government on how to best manage these events. While FRM responsibility lies with the local municipality, a strategy paper by LAWA made recommendations on how federal and state governments should support local municipalities in managing pluvial flood risk.[9]

8 https://www.gesetze-im-internet.de/whg_2009/__5.html
9 https://www.lawa.de/documents/lawa-starkregen_2_1552299106.pdf

5. Flood risk management in Germany

5.1. Flood risk information, communication and awareness

Flood hazard and risk maps

A variety of stakeholders provide flood hazard and/or flood risk maps in Germany (Table 2). Flood hazard and flood risk maps are produced by state ministries or agencies (usually the state environmental agencies). As a result of the Floods Directive, hazard and risk maps for each state became available and accessible across Germany in December 2013.

Hazard maps differ in content, visualisation and search options between states, while risk maps are more consistent (DKKV 2015). LAWA tries to standardise the different maps by providing recommendations for minimum requirements.[10]

Table 2: Flood map providers and their users in Germany

Provider	Description	User
Federal states/The German Federal Institute of Hydrology	Public river and coastal flood risk maps[11]	Planners, homeowners and modellers, but not specifically targeted to any of these groups
The German Insurance Association	Flood risk zoning maps with four river flood risk levels and risk zones for heavy precipitation (ZÜRS Geo)	Insurance industry
The German Insurance Association	Risk maps for different natural hazards including flooding[12]	Private households, businesses (proof of concept for a future nationwide online portal on natural hazards; as a consequence only available for 5 out of 16 federal states)[13]
Federal states and the German Weather Service	Current river water levels and flood warnings (Hochwasserzentralen), meta portal that links all the flood information pages of the 16 Länder[14]	Publicly available, used by emergency responders, private households and businesses (only partially suitable for non-experts)
Federal states	Five-day flood forecasts (availability and quality varies between states)	Publicly available, used by emergency responders, private households and businesses
Commercial modellers, insurers	Probabilistic flood risk models, insurance catastrophe models	Insurers, brokers and reinsurers
The German Weather Service, federal offices	Targeted flood warning service for infrastructure as part of a disaster warning service through different warning apps[15]	Publicly available, used by emergency responders, private households and businesses
Cities, local authorities	Local pluvial flood maps	Homeowners, planners and emergency responders

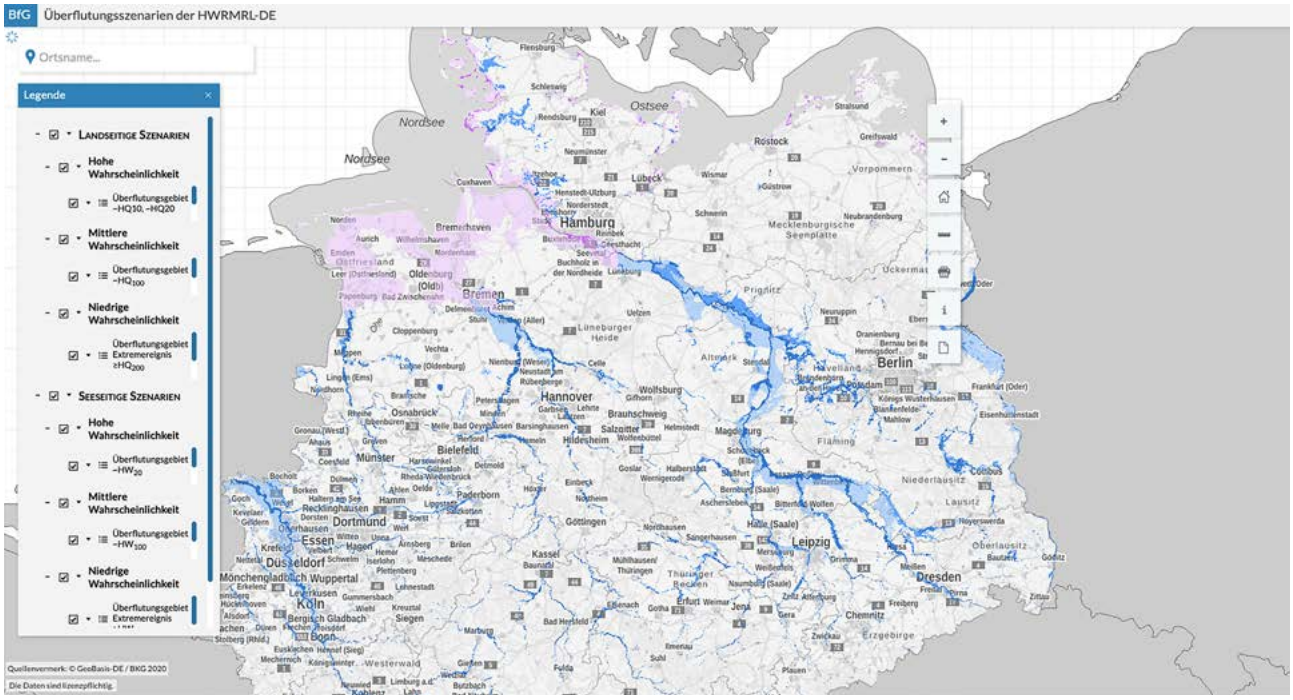
Source: The Geneva Association

10 https://www.lawa.de/documents/lawa-empfehlungen_aufstellung_hw-gefahrenkarten_und_hw-risikokarten_2_1552298996.pdf
11 http://geoportal.bafg.de/mapapps/resources/apps/HWRMRL-DE/index.html?lang=de
12 http://www.kompass-naturgefahren.de/platform/resources/apps/Kompass_Naturgefahren/index.html?lang=de
13 https://www.gdv.de/de/themen/news/kompass-naturgefahren---risiken-per-mausklick-erkennen-8242
14 https://www.hochwasserzentralen.de/
15 NINA, KATWARN, DWD Warnwetter

The flood hazard maps of all 16 states are made available through the geoportal of the German Federal Institute of Hydrology (Bundesanstalt für Gewässerkunde, BfG) (Figure 3). It also provides links to the flood risk maps provided individually through different outputs by the agencies of the 16 federal states. The web-mapping service and reporting platform WasserBLIcK were introduced in 2017 to provide a standardised platform for reporting to the European Commission, as demanded by the Floods Directive. However, these are not targeted at a specific user group. Both the flood hazard and flood risk maps are currently revised and updated until December 2019. The maps must subsequently be evaluated and updated every six years.[16]

Other detailed flood risk information is available through agencies of each state, with varying levels of detail and accessibility.[17] After an increase in local surface water, or pluvial floods, in urban areas, many local authorities in cities have started to produce their own surface water flood risk maps. While some cities have decided to make those maps publicly available (often through the city's own web portal), many have concerns about how the public availability of surface water flood maps might affect their liability in case of a flood event.[18]

Figure 3: Screenshot of the geoportal of the Federal Water Agency. The geoportal presents consistent visualisations of the flood hazard maps provided by all 16 federal states. It also offers links to flood risk maps, which are provided individually by the federal states[19]



Source: BfG 2019

16 https://www.lawa.de/documents/lawa-empfehlungen_aufstellung_hw-gefahrenkarten_und_hw-risikokarten_2_1552298996.pdf
17 http://ec.europa.eu/environment/water/flood_risk/flood_atlas/countries/pdf/germany.pdf
18 https://www.saarland.de/dokumente/res_umwelt/Handlungsempfehlungen_Starkregen_SL_.pdf chapter 2,5
19 http://geoportal.bafg.de/mapapps/resources/apps/HWRMRL-DE/index.html?lang=de

In addition to the public flood hazard and risk maps provided by state agencies, flood risk maps are produced and provided by the insurance industry. The lack of a nationwide set of flood risk maps by the end of the 1990s prompted the insurance industry (led by the GDV) to produce the first countrywide flood hazard zoning system (ZÜRS) in 2001.[20] The first set of maps was based on a coarse DEM and rough hydraulic modelling approach and did not consider structural flood protection, such as dikes. They were therefore heavily criticised by the water authorities and others. However, the mere existence of nationwide maps led to discussions about the need for flood hazard and risk mapping, and a new and improved set of maps with local (official) flood hazard zones was ultimately produced in cooperation with the water authorities (Kron 2013).

ZÜRS was mainly developed to assist the insurance industry in assessing flood risk and is now an important tool for insurers when underwriting flood risk. With the roll out of ZÜRS Geo 2019 the tool now also includes nationwide surface water flood maps. This was the result of a collaboration between the GDV and the German Weather Service (DWD).[21]

There are ongoing attempts to improve the quality of maps. The GDV, in cooperation with a science-based institute, has also developed a Germany-wide heavy rainfall hazard zoning map. It encompasses three hazard zones, derived from topography characteristics. This is already available for the insurance market, and as of April 2020, is being discussed and tested with the relevant committees and municipalities for flash flood and surface water flood prevention in Germany.

Several initiatives aimed at better integration of flood maps have been launched. Since 2014, the more sophisticated maps created by the public water authorities in accordance with the Floods Directive have been integrated into ZÜRS. According to the GDV, the release of the new maps in 2014 resulted in a reduction in the share of homes assigned to high-risk areas (1.5% of all buildings in 2008 to 0.65% in 2016 (GDV 2016)). This led to reclassification of 67,000 homes from high- to lower-risk zones and 5000 homes from medium- to high-risk zones (GDV 2016). This shows the potential benefits of data exchange. However, concerns remain about the inconsistencies between flood risk maps produced by the public and private sectors. Some insurers have expressed the need for better understanding of the differences between the various types of flood risk maps. Although they have suggested the possibility of combining or comparing public and private sector data, they also have concerns due to a lack of understanding of exactly who produces flood risk maps and for what purpose.[22]

This triggered an ongoing discussion between the authorities and the insurance industry about whether a separate system informing the general public about natural hazards in a user-friendly and understandable way should be designed. The discussion involves legal questions about data protection. In 2012, the GDV and the state government of Saxony developed the public information system ZÜRS public (later changed to Kompass Naturgefahren) as a proof-of-concept feasibility study. It combines the flood risk maps from state agencies with the information available in ZÜRS and introduced a user-friendly and easily understandable self-service user interface. Using their address, private households and small businesses can obtain information about the exposure of their property to different natural hazards. Ultimately, data from only 5 of the 16 federal states were incorporated in the system due to concerns about data protection. The current system will not be developed further. Instead, the goal is to develop a new nationwide online portal for natural hazard data, following examples like the federal natural hazards service in Austria and incorporating lessons learned from Kompass Naturgefahren.[23]

Flood risk awareness

Nationwide flood maps and flood-related information produced by the public sector are now openly available, although uptake and usage remain unclear. This has led to a range of initiatives, for example, providing specific local information about risk and response measures at municipal level (Thieken et al. 2016).

Campaigns to increase flood risk awareness are often supported by insurers. Driven by low uptake of voluntary flood insurance in Germany, the GDV has started risk awareness campaigns in collaboration with the water authorities, ministries, consumer protection agencies and other stakeholders. The campaigns mainly inform about the availability, cost and advantages of flood insurance in Germany as well as private protection measures to lower flood vulnerability. The first campaign started in Bavaria in 2009 and 9 of the 16 states have since launched such campaigns, some in multiple steps (e.g. focussing on different target groups). There was a considerable increase in flood insurance as a result: 19% in 2002 to 41% in 2018 (GDV 2018).[24] However, some studies claim that

20 ZÜRS stands for Zonierungssystem für Überschwemmung, Rückstau und Starkregen (Zoning system for flooding, backwater and heavy rainfall)
21 https://www.gdv.de/de/themen/news/forschungsprojekt-starkregen-52886
22 Based on interviews with stakeholders.
23 HORA: https://www.hora.gv.at
24 Not taking into account policies that only cover pluvial flooding.

changes in preparedness can hardly be attributed to these awareness campaigns (Osberghaus and Philippi 2016).

Flood markers are widely used across Germany to record flood water levels and to maintain high flood risk awareness (DKKV 2015). While there were initial concerns in some places that the installation of flood markers would lead to bad publicity, there is no clear evidence of any detrimental effects; in fact it helped to increase awareness among the wider public.[25]

While flood hazard maps and other approaches play an important role in increasing flood awareness, they must be accompanied by information on risk-reducing measures and their costs in order to bring about changes in behaviour of flood-prone residents (see Grothmann and Reusswig 2006; Bubeck et al. 2012).

5.2. Flood alerts and early warnings

Flood forecasts, alerts and warnings are also issued to the general public. In Germany, the DWD is legally responsible for weather monitoring and forecasting, detecting extreme weather events and issuing alerts and warnings (Golnaraghi 2012).[26] While the DWD itself only prepares warnings related to meteorological phenomena (e.g. heavy rainfall), it also disseminates warnings from other services responsible for flood forecasting and warnings (Golnaraghi 2012).

All water-related issues, civil protection and emergency management services are managed at the state level. The organisation of flood forecasting and warnings and civil protection therefore differs throughout the country. The 2002 floods revealed major deficiencies in Germany's flood risk warning and communication systems (DKKV 2003); for example, delayed or missing warnings, unclear messages and alerts and outdated contact details (DKKV 2003). Since then, there have been continuous improvements to data and models, increasing levels of collaboration between the DWD, the water authorities and the civil protection agencies, and some federal states have reorganised their warning systems (Surminski and Thieken 2017; DKKV 2015).

Technological advancements have significantly improved the quality and lead times of warnings in recent decades. There are now an increasing number of mobile apps available that integrate and release official warnings, such as those from the DWD: the warning app NINA is operated directly by the BBK and KATWARN is run by a commercial operator. Since 2018 NINA and KATWARN exchange information, so that users of both apps receive the same warnings at local district level. In addition, the DWD released its own app WarnWetter, which they use to inform the general public and emergency responders about upcoming severe weather events and weather-related hazards such as floods, avalanches and storms.

5.3. Emergency preparedness measures

Similar to other areas of FRM, civil protection and emergency management in Germany follows the doctrine of federalism and subsidiarity. Local fire brigades, ambulance services and relief organisations are responsible for smaller and less severe events on a regular basis. In the face of an anticipated flood event or rain storm, local emergency management takes preparatory action (e.g. installation of mobile flood barriers) (Lüder et al. 2018). When the magnitude of the event is too large for local emergency management capacities, local emergency responders can request additional resources through the joint emergency control centre of all federal states (Gemeinsames Melde- und Lagezentrum des Bundes und der Länder, GLMZ).[27] At the federal level, the GLMZ can send the Technical Relief Agency (Bundesanstalt Technisches Hilfswerk, THW) and in very severe cases the German army can be deployed to support emergency response operations. The army was deployed during the 2002 and 2013 floods to support the emergency response and disaster relief along the Elbe and Danube rivers (DKKV 2015).

The BBK regularly undertakes risk analysis for civil protection from different hazards and publishes them in parliamentary reports. These risk assessments are required by federal law and follow a standardised and internationally certified method. Since 2012, yearly reports have been issued covering both ex-ante risk analysis of a specific hazard and ex-post analysis of a large event that happened during the reporting period. So far, these reports cover analysis of the 2013 floods and a general risk analysis for storm surges. The BBK made the risk analysis methodology available for use by the respective state agencies throughout the country. This methodology also underpins all civil protection strategies at both the state and federal level. It is constantly updated and improved through mutual exchange between the BBK and the state agencies.[28]

25 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/481533/Public_dialogues_on_flood_risk_communication_lit_review.pdf

26 For details refer to chapter 5 of Golnaraghi 2012.

27 Materials such as sand bags or additional emergency responders can be requested through the GLMZ.

28 https://www.bbk.bund.de/DE/AufgabenundAusstattung/Risikomanagement/RisikoanalysenBundundLaender/risikoanalysenBundundLaender_node.html

5.4. Risk reduction measures

There are a wide range of approaches to reducing existing flood risk to assets and communities. These range from large-scale engineered solutions, such as pumps, dikes and levees, to small-scale softer measures, such as water sensitive spatial planning, nature-based solutions and property-level flood protection.

While there is no 'individual entitlement to flood protection' in Germany and according to the 2009 update of the Federal Water Act, 'every person who may be affected by floods is, as far as possible and reasonable, obliged to take appropriate precautionary measures' (LAWA 1995), extensive flood defence infrastructure is in place, with dikes, levees and other water control structures that are financed, owned and operated by the federal states, municipal water authorities and dike associations.

There is no federal database on investment in flood protection; however, a range of investment programmes have been launched (Surminski and Thieken 2017). For example, Saxony, the most severely hit state in 2002, announced 1600 planned measures thereafter (SMUL 2007). This was the first coordinated attempt to align the flood protection efforts of the individual states in a countrywide strategy, launched in 2014. A National Flood Protection Programme was agreed in a joint effort between the governments of all federal states and the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, covering around 100 measures with planned investment of more than EUR 5.4 billion over the next 20 years (DKKV 2015). The core aims of this programme are the following:

- A stock-take of all relevant flood protection projects
- Analysis of current gaps
- Prioritisation of flood protection projects

Most of the budget is dedicated to increasing polder[29] areas and relocating and upgrading existing levees in response to breaches that occurred during the 2002 and 2013 floods.[30]

Despite this more coordinated approach, responsibility for flood protection still lies with each state, leading to different levels of protection along the main rivers that cross several states. For example, along the Rhine safety standards vary between 1/30 years and 1/1000 years (Linde et al. 2011).

Flood protection in Germany is based on the principle that everyone should have the same level of protection, generally set at a 100-year safety level. This regulation differs from countries like France or the U.K., where a more nuanced, risk-based approach is taken (Krieger 2013). However, federal states like Baden-Württemberg have started to move away from using design levels as the only metric and increasingly fund flood defences with lower protection standards if they have a favourable cost–benefit ratio. However, overall technical protection against flooding has improved in many flood hazard zones (Box 1).

Box 1: Examples of flood protection in Germany and its impact

Following large investments in flood protection since 2002, the 2013 floods were a first stress test for flood defences in Germany. Many success stories were reported, verifying flood protection measures. For example, with improved mobile flood control the city of Regensburg experienced less damage during the 2013 floods. The district of Stadtamhof was completely awash during the 1988 floods; however, in 2013, the flood protection system meant that the city experienced only small-scale flooding despite the higher water level. Nevertheless, extensive levee breaches further downstream along the tributaries of the Danube led to severe flooding in the area of Deggendorf.

Overall, technical protection against flooding has improved in many flood hazard zones. In the Elbe catchment area levees were rebuilt or reinforced and mobile flood barriers held back the water masses in the Elbe, Danube and Vltava. In Dresden in particular, community preventive measures proved effective; over the previous few years, the municipal water authority had made extensive structural, technical and organisational changes that led to a 75% reduction in damage compared to 2002.[31]

29 A polder is a piece of land in a low-lying area that has been reclaimed from a body of water by building dikes and drainage canals. Although empoldering is usually carried out in low-lying coastal areas, it can be also carried out in inland areas such as lakes and rivers.

30 https://www.bmu.de/faqs/nationales-hochwasserschutzprogramm/

31 https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/natural-disasters/floods/flood-europe-2018.html

5.5. Property-level protection measures

In addition to government-led flood protection measures, property-level interventions are usually undertaken by homeowners or businesses. Overall, there is growing uptake of PLPMs by property owners. These interventions increase after each flood event, which in turn leads to reduced flood losses and impacts in future events (Grothmann and Reusswig 2006; Thieken et al. 2007; Kreibich et al. 2011; Bubeck et al. 2012; Kienzler et al. 2015).

The interplay between insurance and PLPM uptake is statistically difficult to evaluate for the entire country as there are significant regional differences in insurance usage and risk. In a countrywide investigation, Osberghaus and Philippi (2016) found that flood insurance and PLPMs are commonly seen as complementary safety strategies by homeowners. In areas with high insurance penetration rates (e.g. the Elbe river catchment) PLPM uptake appears to be low but rising. For example, 13% of residents affected by the 2002 floods retrofitted their homes; this figure rose to 35% after the 2013 floods (DKKV 2015). On the other hand, in areas with lower insurance penetration rates (e.g. in the Rhine catchment outside the state of Baden-Württemberg), PLPM uptake appears to be comparatively higher. A survey after the 2011 floods revealed that around 65% of affected residents in the Rhine catchment had retrofitted their homes (Kienzler et al. 2015). It should be noted that these figures do not differentiate between insured and non-insured households.

According to the Federal Water Act of 2009, property owners are responsible for protecting their properties from flooding by implementing PLPMs. This was bolstered by the new National Flood Protection Act that came into force in 2018. Specifically, it prohibits oil tanks within flood zones[32] and puts strong focus on building, retrofitting and building codes. However, the scale of PLPM implementation remains unclear.

State-run programmes that financially support property-level mitigation are currently lacking, but insurance companies are providing incentives and rewarding residents who undertake PLPMs on a regular basis with lower premiums based on risk-based pricing. In general, reviews of PLPMs after the 2002 and 2013 floods have shown that contributions from property owners were clearly more pronounced in 2013 (DKKV 2015). Many communities also started to make municipality-specific information available. Nevertheless, there is still a strong need for better information on private flood mitigation, especially in areas with less frequent flooding.

One promising approach to improve property-level risk reduction systematically is the recently introduced flood passport (Hochwasserpass). It provides systematic object-specific risk assessment[33] as well as recommendations for how to reduce flood risk at property level. After filling out an online form, homeowners receive a brief assessment of the flood risk and vulnerability of their building. Homeowners can then order a certified building survey with this information and the flood passport is issued after a detailed on-site assessment. Apart from information on the most suitable PLPMs, the flood passport can provide valuable information when negotiating mortgages or flood insurance coverage with banks and insurance companies, respectively (Thieken et al. 2016). However, it is too early to assess how widely the flood passport will be accepted by the mortgage and insurance industries. As a more legally binding approach, the insurance industry, represented by the GDV, suggests stricter building codes with regards to pluvial and river flooding.

5.6. Prevention through development planning and land use

Before the 2002 floods there was very limited recognition of flood risk in development planning and land zoning practices (DKKV 2003, 2015). Guidance existed through legislative frameworks at the national and state level but the main responsibility for land zoning and planning rested with local authorities.

Limited technical expertise and a lack of flood risk maps and skilled staff meant that flooding was usually not considered when making planning decisions (Surminski and Thieken 2017). For example, the town of Röderau-Süd approved the erection of a housing development and business park in the flood plain of the Elbe river, despite several recent flood events. These developments were severely damaged during the 2002 floods and as a result had to be subsequently relocated (mainly due to political pressure) (DKKV 2003, 2013).

Approaches to land zoning and planning changed in 2005 with the introduction of the Flood Control Act, which defined statutory inundation areas, included areas affected by 100-year flooding events and identified areas that are important for flood retention. It is now prohibited to erect new buildings or to hinder water flow by fences, bushes etc. in these areas. These designations can be locally unpopular and legal loopholes do exist (Otto et al. 2016). As such, there is potential for worse damage along the large rivers in Germany for two main reasons:

32 Oil tanks are commonly used for heating homes in Germany. These caused significant damage in the 2013 floods.
33 Object-specific means each building is assessed individually. So far this is only available for private households.

- Within a 100-year flood zone exceptions can be made for erecting new buildings when they are filling a gap between existing buildings (these exceptions are also treated individually, not taking into account the cumulative increase in risk in an area);

- Local authorities often treat flood zones as binary, meaning that they do not allow for buildings within a 100-year flood zone but issue building permits without any restrictions or requirements just outside these zones (Seifert 2012).[34]

The second Omnibus Flood Control Act of 2018 introduced further legal measures to prevent increases in damage potential, including stricter building codes in 100-year flood zones and new regulations for the use of flood-prone areas outside statutory inundation areas. This legislation follows LAWA's (2010) best practice guidance calling for local spatial plans and FRM strategies to address the resultant 'levee effect' (White 1945), whereby protection leads to more development and ultimately higher total losses and eventual failure. Apart from the introduction of spatial requirements for newly-built properties, there are very few examples of planned retreat in Germany, which were mainly carried out as part of urban deconstruction projects in areas with shrinking populations (Greiving et al. 2018).

5.7. Disaster risk financing measures for government

Germany is firmly committed to risk-based compensation through private insurance. This long-standing policy commitment is reinforced by individual 'duty of care' to mitigate flood damages (introduced in paragraph 5 of the 2009 Federal Water Act, Wasserhaushaltsgesetz). Some insurance is taken out by local authorities to protect public budgets from flood-related expenses for buildings and other assets; however, there is no regulation that mandates state, federal and local governments to protect their assets from flooding through specific insurance schemes. As a consequence, uptake of insurance by local authorities is very low. However, state governments are increasingly requesting insurance of municipal assets as a condition for receiving additional government disaster relief pay-outs in case of a flood, increasing the pressure on local authorities to insure their assets against flood losses.[35]

In most federal states the government has no or very little legal obligation to compensate damages to homeowners and businesses, which are instead funded 'through insurance or the accumulation of reserves' (LAWA 2010). For example, the government in Saxony has set a precondition for aid stating that the emergency situation should not be due to negligence of the person affected.[36]

Homeowners and businesses are expected to take out flood insurance. However, low penetration rates have caused some individuals or businesses to experience financial hardship after floods, leading federal and state governments to occasionally offer ad hoc compensation. In the run up to the 2013 federal elections, Chancellor Merkel promised billions in post-flood aid, similar to her predecessor in 2002. However, there are concerns that these unconditional government grants, totalling some EUR 14.5 billion after the 2002 and 2013 floods (Stegbauer 2014), may deter individuals from buying private insurance, undermining the viability and effectiveness of Germany's nominally risk-based system of compensation through private insurance (Demeritt et al. 2017).

In response to the federal government's unconditional politically-driven grants, some states have introduced changes to the provision of public post-disaster aid compensation. For example, the state of Bavaria announced that from 1 July 2019 it will no longer provide emergency financial aid following natural disasters to victims who could have purchased insurance. In June 2017, the heads of the federal states agreed to negotiate a piece of federal legislation that regulates governmental disaster relief pay-outs for those who were unsuccessful in taking out private insurance or had insurance offers with economically unreasonable premiums. These measures increase pressure on private homeowners to take out insurance.

Government pay-outs are still available in cases of financial hardship as part of the German social welfare system. However, the beneficiaries need to fully disclose their personal financial situation. After the 2016 floods, many business and homeowners claimed financial hardship but only a very small portion were eventually willing to disclose such details in order to receive a pay-out.

34 http://www.klimamoro.de/fileadmin/Dateien/Ver%C3%B6ffentlichungen/Ver%C3%B6ffentlichungen_Phase_II/mit_sicherheit_waechst_der_schaden_ryb.pdf
35 http://www.kommunale-versicherungen.de/html/kommunale_versicherungen.html
36 https://revosax.sachsen.de/vorschrift/12047-RL_Elementarschaeden

5.8. Flood insurance and other risk transfer solutions

Flood insurance coverage is voluntary, provided by the private market as supplementary cover to standard policies. Penetration rates differ across regions for historic reasons. Following information campaigns and changes to state compensation, penetration rates have increased, currently sitting at 41%. A summary of flood insurance in Germany is provided in Table 3.

Flood insurance has been available across Germany since 1991 as a supplementary contract to building or contents insurance, which usually only covers losses caused by fire, escape of water, frost damage and wind or hail storms (e.g. Thieken et al. 2006). This supplementary contract bundles flood risks with other natural hazard risks, including earthquakes, land subsidence and avalanches or snow build-up (also known as Elementarschaeden). The supplementary nature of flood insurance cover (i.e. as an 'add-on' to standard policies) leads to only small demand in areas where homeowners assume they are not at risk. This becomes a particular issue in cases where heavy precipitation events cause floods outside river basins. It has therefore been discussed whether technical perils like fire and water escape should be separated from natural perils like wind and hail in building insurance and an all-natural-perils cover offered instead.

At the time of the 2002 floods, the country was experiencing relatively low rates of coverage, with penetration rates of 19% for residential buildings and 8% for household contents. Baden-Württemberg, a state in the south of Germany, and the territory of the former German Democratic Republic (GDR) in eastern Germany were two exceptions. In Baden-Württemberg, flood loss compensation was included in compulsory building insurance until 1994. Due to EU regulations on preventing monopolisation, this had to be abandoned. Currently, more than 94% of property owners in Baden-Württemberg still have flood insurance coverage (GDV 2018). In the former GDR, flood losses were covered by household insurance. Up to 47% of residents in eastern Germany still have comparable contracts or have taken out supplementary insurance (GDV 2018). These differences were visible after the 2002 and 2013 floods, when surveys among affected households showed significantly lower numbers for penetration rates in Bavaria (below 20% in 2002 and 28% 2013) compared to affected regions in the former GDR (Saxony: 48% in 2002, 64% in 2013; Saxony Anhalt: 57% in 2002, 60% in 2013), despite an increase in penetration rates in all affected regions after the 2002 floods (DKKV 2015).

According to Munich Re, there is a major gap between economic and insured losses in Germany. The 2002 floods initiated a political debate about a compulsory flood insurance scheme which finally failed in 2004, mainly due to reluctance to provide a government guarantee for outstanding losses (Schwarze and Wagner 2004).

Table 3. Overview of insurance in Germany

Risk-based?	Yes
Mandatory or voluntary?	Voluntary
Public, private or a combination?	Private
Policyholder programmes	Separate insurance product, available as an 'add-on' to standard policies bundled with other natural hazard risks (Elementarschadenversicherung)
Incentivising risk reduction	Deductibles and price reflect risk levels, risk reduction measures help to reduce premiums and/or deductibles
Market penetration and coverage	Penetration rates differ across regions for historic reasons. Following information campaigns and changes to state compensation, penetration rates have increased, currently sitting at 41% Limited information available about business uptake of flood insurance Some local authorities use insurance to protect their own assets. Uptake is low, but expected to increase as state governments are starting to request flood insurance of municipal assets as a condition for receiving any additional government disaster relief pay-outs
Insurance-backed securitisation	Limited use

Source: The Geneva Association

The discussion was reignited following the major floods in 2013 but was rejected for a second time as the introduction of mandatory conditions would have likely required a change in the constitutional framework. There are various reasons for prevailing underinsurance. In the past, there was a lack of adequate insurance cover, especially in highly exposed regions. In less-exposed areas there was a lower level of risk awareness and thus less demand for insurance solutions, not least because the government used to assume the bulk of losses suffered by private individuals and businesses.[37] More information about insurance coverage in 2013 is provided in Box 2.

Box 2: Flood insurance penetration in 2013

Total economic losses from the 2013 floods came to USD 10.4 billion, of which only USD 2.2 billion was insured. However, it is important to note that the total includes damage to public infrastructure, which is self-insured by the government. Concerns about low penetration rates triggered recurrent discussions about introduction of mandatory cover. Nationally, around 34% of property owners had flood insurance in 2013. Although higher than in 2002 (18%), there were still major regional variations: Saxony, Saxony-Anhalt and Thuringia (40%), Bavaria (21%) and Lower Saxony (13%).

After two unsuccessful efforts to make cover mandatory, several other measures were implemented to increase penetration rates, which now sit at 41% nationwide (GDV, 2018). ZÜRS was established by the GDV in 2001, designating three flood probability zones; a fourth zone was added for low-risk areas after the 2002 floods (Falkenhagen 2005). Since 2002, the zoning system has increasingly been used in the risk assessment of natural catastrophe policies (Thieken et al. 2006; DKKV 2015). A major update to the system after implementation of the Floods Directive resulted in a decrease in properties classified as high-risk (GDV 2016). As a result, more properties were able to buy insurance.

ZÜRS was mainly developed to provide the insurance industry with a science-based source of flood risk information, required for risk assessment. Usage began after the 2002 floods and it has become as important as other criteria, such as the number of damage claims over the preceding 5 or 10 years (DKKV 2015). Still, in extreme risk zones that are already affected by 10-year floods, it is difficult for homeowners to obtain flood insurance coverage; however, this affects only 0.6% of the current building stock. The insurance industry has expanded its portfolio and now offers individual insurance solutions for 10-year ZÜRS flood zone 4.[38] With adequate deductibles, premiums can be kept at affordable levels, even in such high-risk areas. Changes to government disaster aid pay-outs, described earlier, are also expected to increase insurance penetration.

5.9. Reconstruction

While large-scale government aid and insurance pay-outs have led to relatively quick reconstruction and recovery after recent flood events in Germany, the opportunity to combine reconstruction with risk reduction was largely missed after the 2002 and 2013 floods. This can be attributed to the uncoordinated, ad hoc nature of government aid, legal constraints and a lack of incentives and information among stakeholders (insurers and government) when reconstructing damaged buildings.

In many cases flood-affected households were even discouraged to 'build back better', as one condition for government aid was restoration of the building to its pre-flood state. (Kammerbauer and Wamsler 2018).[39] The ad hoc nature of post-flood government aid in Germany has been widely criticised and 'should be replaced with a transparent national 'risk transfer' system, which considers insurance of property owners and combines reconstruction with risk reduction (thereby making structures more resilient to future floods)' (Thieken et al. 2016). Kron (2013) further suggests that the loss compensation process should be used to better inform homeowners about their risks and mitigation options.

For property relocation after a flood, the GDV provides conditions for building insurance that foresees repair costs equivalent to those of the building's current location, meaning that the government would be responsible for finding suitable properties (DKKV 2015). However, due to the high cost of new properties, relocation is not seen as a good option (Müller 2010).

37 https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/natural-disasters/floods/flood-europe-2018.html
38 https://www.ergo.com/en/Tummelplatz/Media-Relations-COPY/Medienportal/Pressemeldungen/PM-2014/20140912-AM
39 Analysis of reconstruction process in a small community in Bavaria following the devastating 2013 flood, found individual examples for risk reducing reconstruction and resilient repair Kammerbauer and Wamsler (2018). Among the interviewed households 83% stated that they have changed their heating system from oil to another energy source as a consequence of leaking oil tanks that caused irreversible damage to many building in that community. They further found that despite a lack of coordinated relocation of destroyed buildings in high risk areas, especially tenants without own property in the affected area decide not to return to their previous homes after the flood.

6. Towards an all-of-society approach to flood risk management

As FRM is a multi-faceted challenge, it requires coordinated action from a wide range of stakeholders. As such, clearly defined roles and responsibilities, effective collaborations and a clear understanding of the motivations and incentives behind the actions of different stakeholders are all important.

6.1. Cross-governmental collaboration

To a large extent, FRM is a state-level matter, and thus varies across the country. An example of the complex interactions between various levels of government is river-basin management. Responsibilities across a river cross-section (used as a waterway) are distributed among several levels of government, as shown in DKKV (2003) for the river Elbe at Dresden:

- Federal agencies are responsible for the navigation of the river Elbe and monitoring of water quality.
- The Free State of Saxony is responsible for the management of embankments.
- The city of Dresden is responsible for flood channels within the city.

In other federal states, e.g. Lower Saxony, Bremen and North Rhine-Westphalia, embankments are planned, implemented and maintained by regional levee associations that are – besides public subsidies – financed by mandatory annual fees on all property owners that benefit from the embankments in a specific region.

The EU Floods Directive and EU Water Directive have helped to establish cross-governmental collaboration, one example being the requirement to report progress at the national level. This triggered the development of the online coordination platform WasserBLIcK, which was introduced in 2016 and to which all federal states are now required to report.[40] LAWA aims to coordinate a multi-level government approach in Germany via reports, workshops, meetings and conferences.

Cross-governmental collaboration is also increasing in urban pluvial flood and flash flood management. The 2016 flash floods highlighted the fact that those tasked with managing floods at municipal level need to take into account a wide range of influencing factors, such as traffic, infrastructure, maintenance of sewers, use of open spaces such as playgrounds and type of pavements to better understand and manage this type of flood. As a result, local authorities are now seeking cross-governmental collaboration at the municipal level. This requires coordination across government departments and agencies, but also engagement across different sectors. This became clear during stakeholder discussions.

40 https://www.wasserblick.net/servlet/is/1/

Specifically, local authorities are seeking to learn from their peers, particularly with regards to engaging across departments and securing public participation and buy-in. This has led to a degree of cross-fertilisation amongst municipalities; for example, when one municipality starts to become more active in surface water risk management, neighbouring municipalities often follow. Box 3 provides an example for the city of Hanover.

Challenges are encountered where there are diverging community interests, for example along river banks. During stakeholder discussions, insurers raised concerns that this was often not well managed within Germany, while cross-border collaboration along rivers appears to be more formalised (e.g. the German-Dutch Flood Management Working Group).[41] However, a 2016 review conducted by the DKKV also found a lack of effective cross-border and interdisciplinary cooperation (Thieken et al. 2016).

Flooding caused by the 2013 floods in Germany

6.2. Cross-sectoral collaboration

There are several efforts underway to increase cross-sectoral collaboration in Germany, but this is limited to a small number of actors. Property developers and the private sector tend to be mostly absent from the FRM discourse (Thieken et al. 2016). The DKKV often takes on the role of facilitator to foster cross-sectoral collaboration and facilitate exchanges between flood risk experts and the emergency management community; this includes conducting reviews after significant flood events.[42] The DKKV review conducted after the 2013 floods (Thieken et al. 2016) found evidence of increased collaboration and coordination and identified many considerable improvements. In particular, it highlighted growing consideration of flood hazards in spatial planning and urban development, more engagement with the public on PLPMs, more effective flood warnings, improved coordination of disaster response across government agencies and more targeted maintenance of flood defence systems. The review concludes that such improvements have already led to more effective flood management and a reduction in damage during the 2013 floods. However, areas still in need of improvement were also outlined; there remained a need for balanced and coordinated strategies for reducing and overcoming the impacts of flooding in large catchments, cross-border and interdisciplinary cooperation, a transparent risk transfer system and better definition of the general public's role in the different phases of FRM (Thieken et al. 2016).

41 https://www.government.nl/latest/news/2015/12/02/cross-border-cooperation-on-flood-protection

42 For example, the study 'Review of the flood risk management system in Germany after the major flood in 2013' was carried out by experts from a number of Germany's pre-eminent academic and research institutes, including the University of Potsdam, GFZ German Research Centre for Geosciences, Helmholtz Centre for Environmental Research, the Institute of Meteorology and Climate Research and the DKKV. Another example of cross-sectoral collaboration and knowledge-transfer between academic experts and flood risk managers in Germany is the RIMAX risk management of extreme flood events programme that ran in 2005 and 2010. For more information see: https://www.umweltbundesamt.de/en/topics/climate-energy/climate-change-adaptation/adaptation-tools/project-catalog/rimax-risk-management-of-extreme-flood-events

Box 3: An example of managing pluvial flood risk: Hanover, Germany

Like most municipalities in Germany, Hanover has focused FRM efforts on river flooding through investments in structural flood protection and by setting up flood management plans to comply with the standards set by the federal state, who also funds these measures. However, after pluvial flood events in several German cities (including Hanover) over the past few years, the management of pluvial flood risk has recently gained more attention.

Different from river or coastal flooding, which is funded and managed by the federal states, responsibility for managing pluvial flood risk lies with the individual municipalities. Flood protection and FRM responsibilities in Hanover are split between several institutions and stakeholders. The most important stakeholder is the city's urban drainage authority (Stadtentwässerung), which manages and maintains the urban drainage system and is responsible for updating and extending it. Since 2013, the Stadtentwässerung is also the coordinating body for the management of both river and pluvial flooding in the city of Hanover. This includes coordinating all involved stakeholders before, during and after pluvial flood events, as well as analysis of and reporting on previous flood events in the city. It is further involved in decisions regarding urban planning and development to ensure that negative effects from new developments, such as lowering rainwater infiltration capacities through soil sealing, are reduced to a minimum.

The Stadtentwässerung is also in charge of informing the public in Hanover about flood risk and advises private households on how to protect their homes from flooding; a leaflet informing about the risk of pluvial flooding and possible precautionary measures for private households was released in 2018. In addition, citizens can report small pluvial flood events or damages to their home due to pluvial floods to the Stadtentwässerung via a standardised form. Reports by citizens are used to identify local hotspots for flooding.

A comprehensive risk map for pluvial floods based on hydrodynamic simulations is not yet available but is expected to be ready by 2020. Collaborations with a local engineering office and the University of Hanover are in place for risk mapping and development of a pilot project for a local pluvial flood warning system.

While most pre-event FRM responsibilities now lie with the Stadtentwässerung, several stakeholders are involved in case of an actual pluvial flood event: the municipal fire brigade is responsible for setting up temporary flood barriers and the emergency response, including pumping water out of basements; both the civil engineering department and the municipal transportation service are responsible for managing flood gates and rainwater retention basins; the municipal works have developed risk management plans to supply pumping stations with electricity in case of an emergency and are also able to temporarily move their control room to a flood-safe location.

While the described strategy for emergency response comprises both river and pluvial flooding risk, one key challenge for pluvial flooding is early warning. Existing management plans initially developed for river flooding use water level thresholds from the two main rivers in the city to release warnings for both the general public and emergency responders and trigger specific actions, such as closing flood gates etc. For pluvial flooding, warnings are so far limited to severe weather warnings from the DWD, which typically have short lead times and are not able to give detailed information on the exact intensity and location of the rainstorm.

To improve early warnings for pluvial flooding, several projects at the federal and municipal levels have been initiated. However, these systems are not yet mature enough to be used for operational warning and so emergency responders such as the municipal fire brigade are put on standby with experience-based knowledge only and without any clear thresholds.

The insurance industry also supports wider cross-sectoral engagement, particularly in the areas of flood risk information and knowledge exchange. Examples include ZÜRS, which is updated on an ongoing basis in cooperation with the water authorities, and the proof-of-concept study of a national hazard map web portal specifically designed for the general public.

There is only limited information available on how well citizens are involved in FRM (Thieken et al. 2016). Several municipalities are engaged in outreach, e.g. via Vereine (local-level non-profit clubs throughout Germany).

Flood loss prevention and reduction efforts in Germany are increasingly risk-based. After the Rhine floods of 1993 and 1995, LAWA (1995) was quick to remind Germans that 'it is impossible to guarantee preventing major floods'. However, it's recommendation that 'the state must respond by defining to what extent it can meet [public] expectations' of flood protection has been weakened by the fragmented multi-level structure of FRM in Germany. Additional complications arise from allocation of FRM responsibilities for different flood types (e.g. in cities, river flood risk is managed by the state, pluvial flood risk by the city), which can create confusion about risk ownership and responsibilities.

There is evidence that private-level flood protection can reduce building damage by up to 56% in Germany (Kreibich et al. 2005). To provide more incentives for individual risk reduction a compulsory public–private risk-based insurance system has been proposed, which could reduce annual expected damage from flooding by 12% by 2040 (Hudson et al. 2016). Data protection and privacy concerns are some of the biggest challenges associated with data and knowledge exchange. This was raised during stakeholder discussions where some municipalities reported that they are testing different trial approaches to data sharing across sectors (Box 4).

Box 4: Improving data sharing and knowledge exchange among stakeholders to improve FRM

The city of Cologne:

- Is one of the first communities in Germany to make surface water flood risk maps publicly available and has so far received mainly positive feedback;
- Carries out multi-stakeholder engagement activities involving the Cologne drainage works, urban planners and local universities (talks and workshops with civil engineering and architecture students to raise awareness for considering flood risk in buildings) to integrate FRM in the planning processes of new development projects;
- Has several outreach activities per year to engage with the local population on surface water flood risk (public information talks and participation in community meetings such as clubs);
- Established a bilateral cooperation with the DWD to use local recording stations run by the drainage works to calibrate precipitation radar.

There are also further challenges to cross-sectoral and cross-governmental collaboration:

- FRM can be politicised (Hudson et al. 2016)
- There is growing evidence that victim pressure steers preventative investment towards recently flooded localities rather than those at greatest risk (cf. Garrelts and Lange 2011).

7. Conclusions: Successes, continued challenges and lessons learned

There is evidence that FRM in Germany is shifting towards a more anticipatory and coordinated system, at least on paper. Recurrent high-impact flooding has led to growing political, public and industry concerns about the need for action. This has been underpinned by systematic reviews after major flood events in 2002 and 2013 (conducted by the DKKV) and the 2016 flash floods in Southern Germany.

The 2002 floods marked a reorientation towards an integrated FRM system. However, in practice the focus of FRM is still mainly on protection rather than system-wide resilience. This is underpinned by the main principle of FRM in Germany that 'everyone should have the same level of protection'. Unfortunately, a lack of trackable indicators, such as spending on flood protection, hinders assessment of progress. An aggregate database of investments in flood protection is not available and spending is usually distributed across a range of institutions and levels of government, making it difficult to trace.

There is no 'individual entitlement to flood protection' in Germany and according to the 2009 update of the Federal Water Act 'every person who may be affected by floods is, as far as possible and reasonable, obliged to take appropriate precautionary measures'. Despite a more coordinated approach, the responsibility for flood protection lies with each of the 16 federal states, leading to different levels of flood protection along the main rivers that cross several states. A 1/100 year safety level is the general aim. In addition to government-led flood protection measures, property-level interventions are usually undertaken by homeowners or businesses. Overall, there is a growing uptake of PLPMs by property owners. The interplay between insurance and PLPM uptake is statistically difficult to evaluate for the entire country as there are significant regional differences in usage of insurance and risk. While there is a lack of state-run programmes that financially support property-level mitigation, insurance companies are providing incentives and rewarding residents who undertake PLPMs on a regular basis with lower premiums based on risk-based pricing.

Tracking and monitoring FRM performance tend to be carried out by post-event assessments. While these reviews and assessments offer information about gaps and challenges, ownership of the lessons learned and the extent to which recommendations have been implemented often remain unclear. There have been several reviews and public inquiries after flood events in Germany. The DKKV review of 2016, which compared how the country coped in the wake of the 2013 and 2002 floods, offered insights into trends and developments and provided recommendations on how to improve flood resilience going forward. The post-event review capability (PERC) developed by Zurich Insurance 'provides research and independent reviews of large flood events, (…) looking at what has worked

well (identifying best practice) and opportunities for further improvements' (Zurich 2017).[43] It also reflected on governance structure, highlighting that flood resilience requires a more multifaceted approach, including engineering solutions, physical protection and better land use planning: 'Even institutionally strong Germany struggles to effectively prohibit building in legally designated flood hazard zones' (Zurich 2017).[44] However, it might not be the best approach to simply prohibit development along rivers in such a densely populated country.

Table 4 shows a set of perceived strengths and weaknesses of the current FRM system in Germany, formulated after consultations with experts, a roundtable event with representatives from local authorities, academia and the GDV and a review of the literature (conducted for this study).

likely to deter individuals from buying private insurance and undermining the viability and effectiveness of Germany's nominally risk-based system of compensation through private insurance), changes to the provision of public post-disaster aid compensation have been introduced in some states.

While large-scale government aid and insurance pay-outs led to relatively quick reconstruction and recovery after recent flood events in Germany, in 2002 and 2013 the opportunity to combine reconstruction with risk reduction was largely missed. In many cases flood-affected households were even discouraged to 'build back better', as one condition for government aid was restoration of the building to a level comparable to its pre-flood state.

Table 4: Strengths and weaknesses of the current flood risk management system in Germany

Strengths	Weaknesses
• Availability and quality of risk information, although challenges around sharing data and information with stakeholders still exist • Systematic reviews after flood events (DKKV 2003, 2015) have been undertaken, yet ownership of the lessons learned and the extent to which recommendations are implemented often remain unclear • Investments in maintaining and upgrading flood defences • Partnership between the insurance industry and government to provide risk information and increase awareness	• Lack of incentives for risk reduction and prevention • Need for better flash flood and surface water flood maps • Limited cross-sectoral collaboration in land use and building regulation • No coordinated strategy for resilient repairs and 'building back better' between different stakeholders • Risk information not targeted to different groups and stakeholders (private households, businesses, infrastructure etc.) • Flood hazard information is often not accessible on interactive maps. Risk can not easily be assessed for concrete locations prior to construction • Focus on maintaining protection standards instead of managing risk • No clear link to longer-term climate adaptation, with limited engagement between FRM and climate adaptation experts • No visible national FRM champion with the remit to coordinate between different agencies, sectors and levels of government

Source: The Geneva Association

Homeowners and businesses are expected to take out flood insurance. However, low penetration rates in the past meant that some individuals or businesses experienced financial hardship after floods, sometimes alleviated by ad hoc compensation from federal and state governments. Following concerns about politically-driven promises of post-flood aid made by the federal government ahead of the elections in 2013 (thought

Due to its federal structure, Germany's national government only sets general standards. Specific actions and focus can vary significantly between the 16 states. This fragmentation of FRM can also make achievement of a risk-based all-of-society approach challenging. There have been several efforts to increase cross-sectoral collaboration, although these are limited to a small number of actors; important stakeholders, such

43 https://www.zurich.com/-/media/project/zurich/dotcom/sustainability/docs/risk-nexus-flash-floods-germany-2016.pdf?la=en&hash=030EAABAA2E575E0648C3B4AA5B36520

44 https://floodresilience.net/resources/item/zurichs-post-event-review-capability-global-lessons-for-reducing-risk-and-increasing-resilience

as property developers, may be absent from the FRM discourse. The insurance industry has meanwhile been facilitating flood risk information exchange, awareness-raising activities and engagement with government, usually through the GDV. While data collection and zoning for underwriting purposes is common, there is limited engagement with private home insurance customers. Some individual companies have identified flooding as a strategic area, but resilience and risk reduction efforts are not yet streamlined into recovery after an event. Again, data protection and privacy concerns are challenges associated with flood data and knowledge sharing.

A shift towards a more anticipatory FRM approach requires a change in behaviour not only from those at risk or involved in creating risks, but also those tasked with managing risks. This can only be achieved through system-based thinking and inter and intrasectoral engagement. This would require recognition of interdependencies, identification of common interests and establishment of collaborative relationships across different stakeholder groups and levels of government. This was also underlined by the PERC study conducted in Germany (Zurich 2017). The study found that there are very few incentives for individuals or businesses to invest in flood risk reduction and recommended that the government encourage people to take preventative measures by making pay-outs only to people or businesses who took prior steps toward prevention and obtaining insurance coverage.

The shift towards a more anticipatory focus is important, particularly in the face of a changing climate. While climate change is increasingly recognised as a key risk factor, there appears to be a lack of strategic focus on how to achieve future flood resilience. In this regard, engagement of the expert community on adaptation towards FRM appears limited, at least at federal and state level. Local communities and cities are more advanced, accounting for expected future increases in heavy precipitation events in their spatial planning decisions and when updating drainage and sewer systems. However, funding and incentives remain an issue.

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Annex: Questions used for mapping and analysing the evolution of flood risk management

1. **What is the evolution of flood risk in the country?**
    a. What are the types of flood risk, who is at risk and why?
    b. What are the underpinning causes of flood risk?
    c. What are the socio-economic impacts?
    d. Is flood risk growing? What are the drivers of rising flood risk in the country?
    e. Has addressing financial and social risks associated with floods become a national concern for people, businesses and the government? In what ways?

2. **Is reliable flood risk information available and accessible to support decision-making?**
    a. What are the underpinning data sources for flood risk analysis (hazard, exposure and vulnerability)?
    b. Are there official flood risk maps and are they publicly available? What types of information are being developed? What are the strengths and weaknesses of the official flood risk maps? How often they are updated?
    c. Are there other sources of flood risk information? Who is processing and providing flood risk information? What types of information is being developed? To whom is this information provided? How is this information provided to target stakeholders?
    d. Is flood risk information provided to target stakeholders? E.g. people, businesses, community organisations, different government agencies, local government and utilities? Are these maps decision-relevant?
    e. Has the level of risk (e.g. high, medium, low) been identified in different regions? Is this information used to zone the regions according to the level of risk? What are the fundamental assumptions?
    f. Are there targeted risk communication programmes? If yes, who provides them?
    g. What are the benefits, challenges and concerns associated with available risk information and the way it is being provided?
    h. What is the level of flood risk awareness in the country among different stakeholders? Is risk information impacting decisions (e.g. by people, businesses and government)?
    i. Are there any mechanisms for monitoring, assessing and incorporating the changing risk landscape (hazards, exposures, and vulnerability) in the risk maps? Are the underpinning causes of the changing risk landscape investigated and monitored (e.g. climate change, development patterns and practices?) What are the main challenges and concerns?

3. **How is FRM governed in the country, and how is it evolving? How are different stakeholders engaged in the system?**
    a. Who are the key stakeholders with official responsibility to manage floods and their impacts?
        i. Who has official responsibility for FRM in the country? Is this reflected in national to local legislative processes (e.g. government at national, state and local levels, the insurance sector, banking and mortgage lenders, public utilities, the media, NGOs and other community-based orgs, homeowners)? What are their roles?

ii. Who is responsible for addressing the needs and challenges faced by the most vulnerable groups of the population?

iii. What is the perception of homeowners, businesses and other stakeholders in terms of who is responsible? Does the existing system require that homeowners and business owners manage their own flood risks? Please describe.

4. **What is the approach to risk reduction (existing risks) and risk prevention (new risks), particularly in relation to rising risks associated with climate change and other socio-economic drivers?**

   a. Is FRM considered an integral element of socio-economic planning, budgeting and development in the country? Is FRM an integral element of climate adaptation policies and decisions, as opposed to being a stand-alone objective?

   b. Have (or are) disaster risk reduction and risk prevention plans been (or being) developed, implemented and supported/enforced by public policy and regulatory frameworks (at all levels of government)?

      i. Who is responsible for the development and implementation of these measures? Are the interlinkages of these measures considered part of the overall development and risk management strategy? Or are they implemented in isolation?

      ii. Is there a dedicated budget supporting these plans? How is the budget allocated between levels of government?

      iii. Are there incentive mechanisms to promote and enable the implementation of risk reduction and risk prevention by different stakeholders (homeowners, businesses, community-based organisations, local, state and federal governments, public and private utilities, etc.)?

      iv. Is there a process for monitoring and evaluating the impacts of these measures to improve them over time (what level, by whom, how)? For example, monitoring the impact of retrofitting for residential homes, businesses, government assets, infrastructure (public or privately owned) and communities; or the impact of floods on homes and buildings built based on new building code standards versus old ones?

5. **Are early warning systems and emergency preparedness in place and if so, how is this helping to reduce risks (reducing loss of life, livelihoods and economic damage)?**

   a. Who is responsible for developing and issuing the alerts and warnings? Are these warnings accessible, understood and responded to by different stakeholders?

   b. Who is responsible for ensuring alerts and warnings are linked to emergency preparedness on the ground?

   c. What is the receptivity of the general public, businesses and communities to these warnings?

   d. Are warnings leading to increased risk awareness, reduction of property damage and expedited response to and recovery from flooding?

   e. What types of actions are being taken by government (at all levels), businesses, communities and people, based on warnings, to reduce risk?

6. **Are those that are directly impacted by floods incorporating risk financing and contingency planning in their budgets and plans to increase financial resilience and expedite their ability to respond to floods (e.g. government (all levels), businesses, people)?**

   a. Is the government taking a strategic approach to its financial protection by combining financial instruments? E.g. prioritising cheaper sources of funding, ensuring that the most expensive instruments are used only in exceptional circumstances, using pre-planned budgetary instruments, contingent financing and risk transfer measures (e.g. risk pools) and insuring public assets?

   b. How has post-disaster aid funding been approached and appropriated?

   c. Does the country remain reactive (focused on post-disaster response and recovery) or is it strategically considering the need to build resilience to reduce current risks and prevent new risks? Describe in more detail with examples.

   d. Have post-disaster aid programmes undergone any reforms or modifications to incentivise and/or enable risk reduction and prevention and help with the expansion of insurance for the protection of people, businesses and government?

e. Does the government arrange for any contingency plans to protect its budget to ensure access to cheaper funds in case of disasters?

7. **Is there an active flood insurance market in the country? Is the value proposition of the insurance sector leveraged in building flood resilience in the country? Is the value proposition of the insurance sector understood by governments, businesses and people?**

   a. What is the status of insurance in the country? Is it provided as a national government service, through the private insurance market or a combination (public–private partnerships, PPPs)?

   b. What is the nature of the insurance programmes (insurance pools, integral part of home insurance or separate insurance products)? Is the insurance delivery:

      i. Risk-based?

      ii. Mandatory versus voluntary?

      iii. Incentivising risk reduction through reduced premiums or other mechanisms (please describe)?

      iv. Aimed at residents, SMEs, businesses, government?

      v. Market-based or enabled through policies and regulatory frameworks (if so, how)?

   c. Is there insurance-backed securitisation of cat and green bonds?

   d. What is market penetration and coverage?

   e. Is the insurance programme sustainable?

   f. What is the receptivity of government in engaging with the insurance sector?

   g. Is the insurance industry proactively engaged with government and other stakeholders to address strengthening of flood resilience? Please describe.

      i. Is the insurance industry engaged with government in reviewing flood risks to residents, business, government, and infrastructure and identifying innovative market-based solutions?

      ii. Is the insurance industry developing innovative risk transfer measures (with or without collaboration with the government?). Are these solutions available, accessible and affordable and are they being used by those at risk to distribute or pool the residual economic risks?

      iii. Are insurance solutions (by industry, government or both) incentivising behavioural change (e.g. insurance solutions available to residents, SMEs, etc.)?

   h. Are the government (at all levels) and/or the insurance industry engaged with customers and businesses to educate about risks, preventive mechanisms and the benefits of insurance?

8. **Following a disaster, are there systematic mechanisms to revisit, re-evaluate and decide on reconstruction plans and decisions?**

   a. Are there formal mechanisms and legislation in place to enforce the need to build back smarter (e.g. build back using updated building codes, relocate and do not build at all if the region(s) has been identified as a high-risk zone)?

   b. Are there efforts to reconsider land zoning in high-risk regions that experience recurrent risks? Are there any government plans for buy-outs and relocation from high-risk zones? Have these programmes and their impact been assessed?

9. **Are there monitoring and review processes in place for assessing/measuring the impact of risk communication, risk reduction, risk prevention, risk financing and risk transfer decisions and for providing feedback to improve the different components of FRM in the country?**

10. **Overall:**

    a. Is the FRM approach transitioning toward a greater focus on flood resiliency? E.g. is the approach focused not only on reducing current risks but also prevention of future risks linked to factors such as climate change?

    b. Is the approach characterised as fragmented (i.e. engaging many organisations with different but disconnected roles and initiatives) or is it evolving towards a holistic all-of-society approach (leveraging all components of the system)?

    c. Is there any evidence of cultural/behavioural change towards active management and reduction of risk (e.g. people, businesses, communities and all levels of government)? Is it linked to the level of risk? Are there incentives for this change?

As the world deals with the COVID-19 pandemic crisis, the potential compounding effects of weather-related extremes such as floods, tropical cyclones and wildfires could significantly challenge a country's emergency management capacities and slow down its socio-economic recovery. Floods are among the most concerning and costly weather-related events globally. Part of a major study on the evolution of flood risk management (FRM) in five mature economies, this report takes an in-depth look at the FRM system in Germany – governance, institutional frameworks and stakeholder engagement – against an analysis of the changing risk landscape.

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