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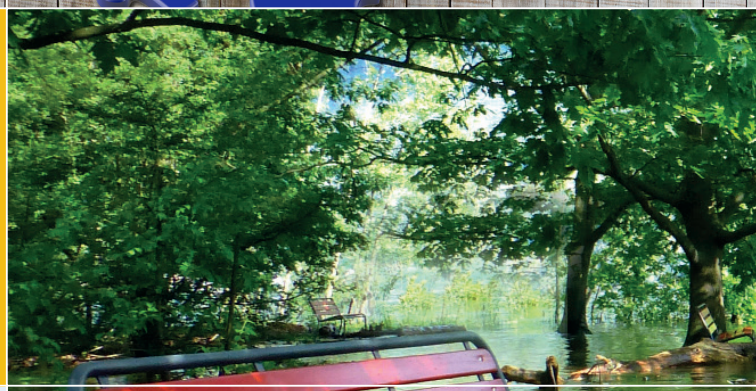
Synthesis Report on Disaster Risk Reduction and Climate Change Adaptation in Germany

prepared by the German Committee for Disaster Risk Reduction / Deutsches Komitee Katastrophenvorsorge e.V. for the ESPREssO project (Enhancing Synergies for Disaster Prevention in the European Union)

Sina Marx, Gonzalo Barbeito, Kevin Fleming, Bojana Petrovic, Stefan Pickl, Annegret Thieken, Martin Zeidler



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Synthesis Report on Disaster Risk Reduction and Climate Change Adaptation in Germany

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Prepared by:

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List of Abbreviations

AA	Department for Foreign Affairs (German: Auswärtiges Amt)
AFK	Permanent Committee on Adaptation to the Consequences of Climate Change (German: Ständiger Ausschuss zur Anpassung an die Folgen des Klimawandels)
AGBF	Working Group of the Managers of the Professional Fire Brigades (German: Arbeitsgemeinschaft der Leiter der Berufsfeuerwehren)
AKNZ	Academy for Crisis Management, Emergency Planning and Civil Protection (German: Akademie für Krisenmanagement, Notfallplanung und Zivilschutz)
APA	Adaptation Action Plan (German: Aktionsplan Anpassung)
ASB	Workers' Samaritan Federation Germany (German: Arbeiter-Samariter-Bund)
AWI	Alfred Wegener Institute for Polar and Marine Research (German: Alfred Wegener Insitut für Polar- und Meeresforschung)
BauGB	Federal Building Code (German: Baugesetzbuch)
BASt	Federal Highway Research Institute (German: Bundesanstalt für Straßenwesen)
BBK	Federal Office of Civil Protection and Disaster Assistance (German: Bundesamt für Bevölkerungsschutz und Katastrophenhilfe)
BBR	Federal Office for Building and Regional Planning (German: Bundesinstitut für Bauwesen und Raumordnung)
BBSR	Federal Institute for Research on Building, Urban Affairs and Spatial Development within BBR (German: Bundesinstitut für Bau-, Stadt- und Raumforschung im Bundesamt für Bauwesen und Raumordnung)
BfG	German Federal Institute of Hydrology (German: Bundesanstalt für Gewässerkunde)
BLAG	KliNa Federal Government's and Federal States' Working Group on Climate, Energy, Mobility and Sustainability (German: Bund-Länder- Arbeitsgemeinschaft Klima, Energie, Mobilität und Nachhaltigkeit)
BMBF	Federal Ministry of Education and Research (German: Bundesministerium für Bildung und Forschung)
BMI	Federal Ministry of the Interior (German: Bundesministerium des Innern)
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (German: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit) (until 2013: BMU)
BMVBS	Federal Ministry of Transport, Building and Urban Development (until 2013, presently: BMVI) (German: Bundesministerium für Verkehr, Bau und Stadtentwicklung)
BMVI	Federal Ministry of Transport and Digital Infrastructure (German: Bundesministerium für Verkehr und Digitale Infrastruktur)
BMZ	Federal Ministry for Economic Coorperation and Development (German: Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung)
BOS	Emergency and Rescue Services (German: Behörden und Organisationen mit Sicherheitsaufgaben)
CCA	Climate Change Adaptation (German: Anpassung an den Klimawandel)
CIP	Critical Infrastructure Protection (German: Schutz kritischer Infrastrukturen)
CPM	European Civil Protection Mechanism (German: EU Katastrophenschutzverfahren)
CSC	Climate Service Center
DAAD	German Academic Exchange Service (German: Deutscher Akademischer Austauschdienst)
DAS	German Adaptation Strategy (German: Deutsche Anpassungsstrategie)
DFG	German Research Foundation (German: Deutsche Forschungsgemeinschaft)
DFV	Union of the German Fire Departments (German: Deutscher Feuerwehrverband)
DKD	Deutscher Klimadienst

DKK e.V.	German Climate Consortium (German: Deutsches Klima Konsortium)
DKKV	German Committee for Disaster Reduction (German: Deutsches Komitee Katastrophenvorsorge e.V.)
DKRZ	German Climate Computing Centre (German: Deutsches Klimarechenzentrum)
DLR	German Aerospace Centre (German: Deutsches Zentrum für Luft- und Raumfahrt)
DLRG	German Lifeguard Association (German: Deutsche Lebens-Rettungs-Gesellschaft e.V.)
DRK	Red Cross Germany (German: Deutsches Rotes Kreuz)
DRR	Disaster Risk Reduction (German: Katastrophenvorsorge)
DST	Association of German Cities (German: Deutscher Städtetag)
DWD	German National Meteorological Service (German: Deutscher Wetterdienst)
ERCC	Emergency Response Coordination Centre (German: Zentrum für die Koordination des Notfallschutzes)
EU	European Union
ExWoSt	Experimental Housing and Urban Development (German: Experimenteller Wohnungs- und Städtebau)
FONA	Research for Sustainable Development (German: Forschung für Nachhaltige Entwicklung)
FZ Jülich	Jülich Research Centre (German: Forschungszentrum Jülich)
GDV	German Insurance Association (German: Gesamtverband der Deutschen Versicherungswirtschaft)
GEOMAR	Helmholtz Centre for Oceanresearch Kiel (German: Helmholtz-Zentrum für Ozeanforschung Kiel)
GERICS	Climate Services Center Germany (German: Deutsches Klima Service Zentrum)
GFZ	German Research Centre for Geosciences (German: Deutsches GeoForschungsZentrum)
GG	Basic Constitutional Law of the Federal Republic of Germany (German: Grundgesetz)
GMLZ	Joint Information and Situation Centre of the Federal Government and Länder (German: Gemeinsames Melde- und Lagezentrum von Bund und Ländern)
HeRZ	Hans Ertel Centre for Weather Research (German: Hans Ertel- Zentrum für Wetterforschung)
HFA	Hyogo Framework Action (German: Hyogo-Rahmenaktionsprogramm)
HGF	Helmholtz Association (German: Helmholtz-Gemeinschaft Deutscher Forschungszentren)
HZG	Helmholtz Centre Geesthacht, Centre for Materials and Coastal Research (German: Helmholtz-Zentrum Geesthacht, Zentrum für Material- und Küstenforschung)
IDNDR	International Decade for Natural Disaster Reduction (German: Dekade zur Reduzierung von Naturkatastrophen)
IMA Anpassung	Interministerial Working Group on Adaptation to Climate Change (German: Interministerielle Arbeitsgruppe Anpassungsstrategie)
IMK	Conference of Interior Minister (German: Innenministerkonferenz)
IntMinKoGr	Interministerial (Crisis Management) Coordination Group (German: Interministerielle Koordinierungsgruppe des Bundes und der Länder)
IPCC	Intergovernmental Panel on Climate Change (German: Weltklimarat)
JHU	Hospitaller Emergency Service (German: Johanniter Hilfsdienst)
KAS	Commission on Process Safety (German: Kommission für Anlagensicherheit)
KaVoMa	Master of Disaster Management and Risk Governance (German: Masterstudiengang Katastrophenvorsorge und Katastrophenmanagment)
KFS	Disaster Research Unit (Katastrophenforschungsstelle)
KIT	Karlsruhe Institute of Technology (German: Karlsruher Institut für Technologie)
KlimaMORO	Spatial Development Strategies to the Climate Change (German: Raumentwicklungsstrategien zum Klimawandel)
KLIMZUG	Climate Change within Regions (German: Klimawandel in Regionen zukunftsfähig gestalten)

KLIWA	Climate Change and Consequences for Water Management, cooperative project between Rhineland-Palatinate, Baden-Württemberg, Bavaria (German: Klimaveränderung und Konsequenzen für die Wasserwirtschaft)
KLIWAS	Impacts of Climate Change on Waterways and Navigation (German: Auswirkungen des Klimawandels auf Wasserstraßen und Schifffahrt)
KomPass	Competence Centre for Climate Impacts and Adaptation (German: Kompetenzzentrum Klimafolgen und Anpassung)
KRITIS	Critical Infrastructures (German: Critical Infrastructures)
LÜKEX	Transnational Crisis Management Exercise (German: Länderübergreifende Krisenmanagement Übung)
MHP	Auxiliary Service of the Order of Malta (German: Malteser Hilfsdienst)
MunichRE	Munich Reinsurance Company Incorporated Company
NATO	North Atlantic Treaty Organization (German: Organisation des Nordatlantikvertrags)
NPSI	National Plan for Information Infrastructure Protection (German: Nationaler Plan zum Schutz der Informationsstrukturen)
PIK	Potsdam Institute for Climate Impact Research (German: Potsdam-Institut für Klimafolgenforschung)
PPP	Public Private Partnership (German: Öffentlich-Private Partnerschaft)
ROG	Federal Regional Planning Act (German: Raumordnungsgesetz)
StA AFK	Standing Committee for the Adaptation to Climate Change Impacts (German: Ständiger Ausschuss zur Anpassung an die Folgen des Klimawandels)
SFDRR	Sendai Framework on Disaster Risk Reduction (German: Sendai Rahmenwerk zur Reduzierung von Katastrophenrisiko)
THW	Federal Agency for Technical Relief (German: Bundesanstalt Technisches Hilfswerk)
TRAS	Technical Rules on Installation Safety (German: Technische Regeln für Anlagensicherheit)
UBA	Federal Environmental Agency (German: Umweltbundesamt)
UFZ	Helmholtz Centre for Environmental Research, Leipzig (German: Helmholtz-Zentrum für Umweltforschung)
UMK	Conference of Environment Ministers (German: Umweltministerkonferenz)
UNFCCC	United Nations Framework Convention on Climate Change (German: Klimarahmenkonvention der Vereinten Nationen)
UNISDR	United Nations Office for Disaster Risk Reduction (German: Sekretariat der Vereinten Nationen für Risikominderung)
VOST	Virtual Operation Support Teams
WFD	Water Framework Directive (German: Wasser-Rahmenrichtlinie)
WHG	Federal Water Act (German: Wasserhaushaltsgesetz)
ZSKG	Federal Protection and Disaster Assistance Act (German: Zivilschutz und Katastrophenhilfegesetz)

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1 Introduction

1.1 Context: The EU Project ESPREssO

This report is part of a larger synthesis to collect data across six EU countries and produce reports on the specific national approaches regarding policies, legislation and research frameworks addressing natural hazards and climate change adaptation within the framework of the project "Enhancing Synergies for disaster PRevention in the EurOpean Union" (ESPREssO). These national reports will feed into a synthesis of such approaches, both on the EU and global level.

In order to guarantee a comprehensive approach that allows for consolidating the data from national reports, a conceptual framework was developed based on a literature review regarding the project's three main challenges:

1. To propose ways to create more coherent national and European approaches on Disaster Risk Reduction (DRR), Climate Change Adaptation (CCA) and resilience strengthening;
2. To enhance risk management capabilities by bridging the gap between science and legal/policy issues at local and national levels in six European countries;
3. To address the issue of efficient management of transboundary crises.

The key areas identified within the framework support the analysis of potential issues and gaps within the three mentioned challenges. The identified categories were governance, risk, scientific frameworks and communication. Within each category, potential gaps and challenges were proposed to guide the data collection and analysis (see figure 1) for this report on Germany, whose hazard profile is presented in the next section.

Chapter 2 further elaborates the research methodology, Chapter 3 summarizes the status quo regarding institutions and procedures in relation to DRR and CCA and the three ESPREssO challenges in Germany. Chapter 4 then presents the analysis and findings of challenges and gaps within these areas. Finally, chapter 5 outlines conclusions and recommendations to address these challenges.

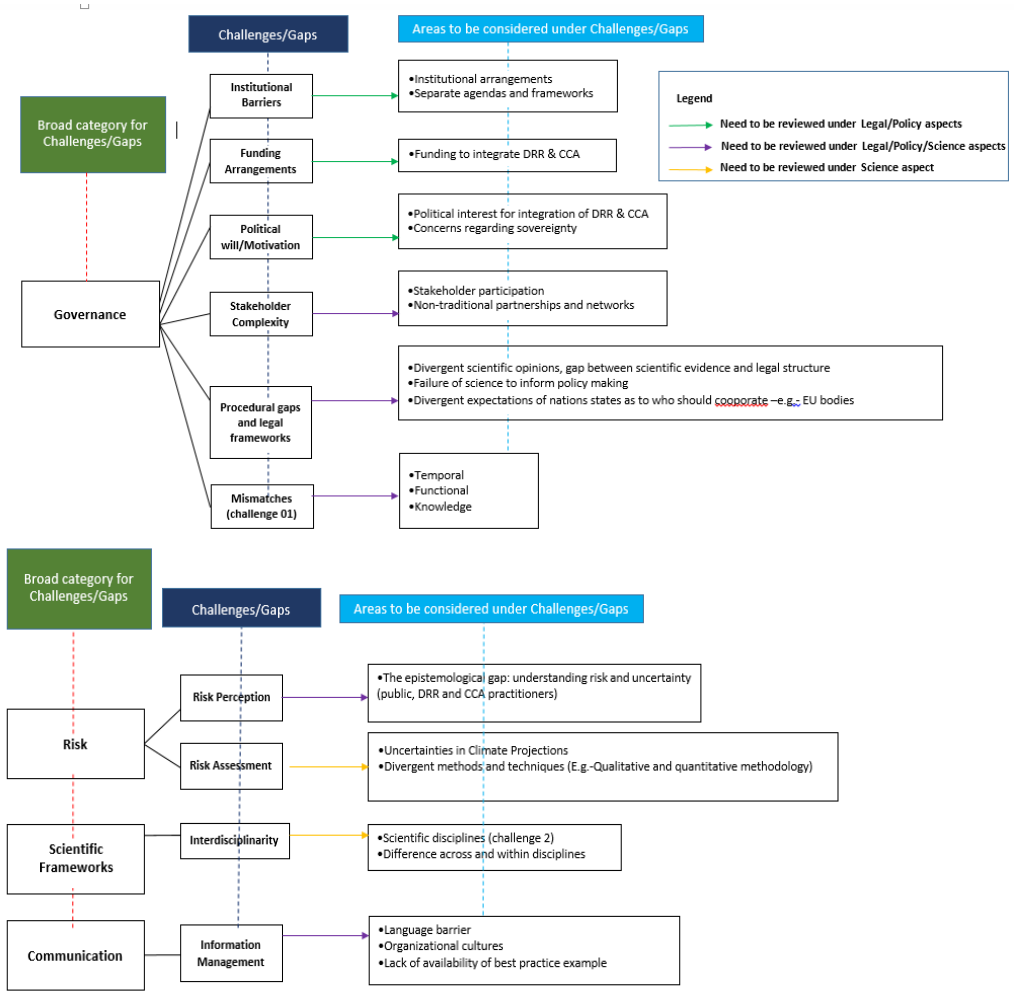

Figure 1: *Conceptual Framework*

1.2 Natural Hazards in Germany

Compared to many countries in the world, Germany is not heavily affected by natural disasters. Nonetheless, this does not mean that it is free from the adverse impacts of such events. Since Germany has no national disaster loss database, statistics on disaster frequencies and impacts are rare and have to be retrieved, e.g. from the global and publicly accessible database EM-DAT[1], in which, however, biases of recording might occur due to certain entry thresholds, temporal changes in the coverage due to increasing media reports on disasters or political changes etc. (see Gall et al., 2009). For Germany, 94 natural events were recorded in EM-DAT between 1900 and 2016, whereof 73 events have occurred since 1990, indicating a temporal bias (at least for the period before 1990). Figure 2 (left) reveals that the main hazards that have affected the country are storms (winter and summer), floods and extreme temperatures, particularly cold waves, while heat waves, earthquakes, epidemics, avalanches and wildfires occur occasionally.
This picture changes dramatically when it comes to disaster impacts. While the death tolls arising from natural disasters in Germany are, fortunately, usually relatively low (although very significant on occasion; see Fig. 2 right, approximately 9730 fatalities from 1990 to 2016), the economic losses may be considerable. For example, the worst loss of life from a natural extreme event arose from the August 2003 heatwave which cost the lives of over 9000 people in Germany.

Furthermore, storm surges and windstorms caused comparatively high numbers of fatalities: for example, the February 1962 storm surge saw the loss of 347 people at the North Sea, thereof 315 in the City of Hamburg. Apart from the heatwave in 2003, winter storms continue to be the deadliest hazard in the recent past with more than 200 fatalities between 1990 and 2016, followed by floods and cold waves (see figure 2, right).

With regard to economic losses, floods have resulted in the greatest economic losses in the recent past, with the "centennial" August 2002 flood being the worst event causing total losses of EUR 11.6 billion. Already in May/June 2013, another severe and widespread river flood occurred leading to total losses of around EUR 8 billion (Thieken et al., 2016). In May/June 2016, severe surface water flooding occurred at several locations and was partly accompanied by flash floods and debris flows, resulting in overall losses of EUR 2.6 billion (Munich Re 2017), an unprecedented amount caused by surface water flooding. In addition, storms are frequently causing damage. The most recent and expensive examples are the winter storm "Kyrill" in January 2007 causing an interruption of almost the entire railway network in Germany and losses of EUR 4.2 billion (Munich Re, pers. comm.) and hailstorms in July 2013 that hit some cities in Baden-Wurttemberg and Lower Saxony causing total losses of EUR 3.1 billion (GDV 2014).

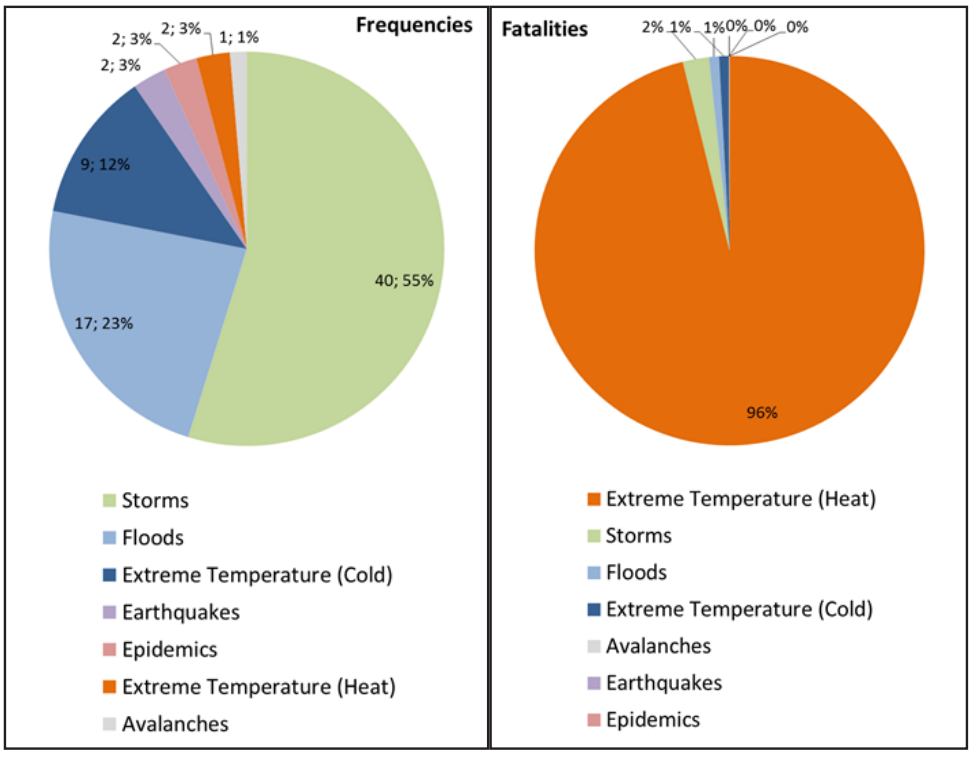

Figure 2: *Frequency of different natural hazards of Germany (absolute number of events and percentage of all 73 events; left) and associated mortality (right) for the period 1990 to 2016 (based on EM-DAT, last access 23 April 2017).*

[1] www.emdat.be

The main hazards that have recently affected the country are storms (winter and summer), floods, and extreme temperatures. It is expected that these hydro-meteorological hazards will increase in intensity and frequency due to climate change (Kreibich et al., 2014). In the following we outline some of the main features of these more important hazard types within the context of Germany. However, there are others that have the potential to inflict significant losses, for example, earthquakes, landslides (which may be triggered by earthquakes, heavy rains or both), wild fires, and magnetic storms (see Merz and Emmermann, 2006, for a comprehensive listing of potential natural hazards). Only some of these will be discussed below.

1.2.1 Storms

Storms are the most frequent of the natural hazards in Germany, and have caused approximately 45% of economic and 7% of human losses since 1990 (Kreibich et al., 2014). Nevertheless, it is worth mentioning that storm surges, which are composed of both storms and coastal floods, and thus are multi-hazard events (http://www.ecapra.org; Dyke et al., 2011)., are classified in EM-DAT and other peril classifications as storms. In Europe, storms may be subdivided into winter storms and convective (summer) storms, both of them associated with extreme winds, heavily precipitation and at times, particularly in summer, significant hail. Winter storms or storm cyclones usually develop over the North Atlantic due to high baroclinity between October and March. Severe convective storms, on the other hand, are usually confined to the summer season (May to September) and are the result of thermal instabilities and are relatively short lived (Kreibich et al., 2014).

Winter storms are amongst the more known events that occur in Germany, for example storms Kyrill in January 2007 and Lothar in December 1999, which can lead to damage losses of the order of billions of euros (e.g., Hofherr and Kunz, 2010). As they usually form over the North Atlantic, they decrease in number and intensity from west to east and north to south. The area affected by such storms may cover thousands of kilometres, although the actual intensity depends upon both the maximum gusts (e.g., storm Lothar saw local gusts of 259 km/hr) and the extent. There is also considerable spatial variability, given how wind gust velocities are strongly dependent upon local topography and features (Hofherr and Kunz, 2010).

Severe convective storms are much more localized and frequent events, with some 10 to 40 thunderstorm days per year over Germany. Their probability in Germany decreases from south to north, with several areas showing greater frequency, such as areas south of Stuttgart and Munich (Kreibich et al., 2014). Most damage is caused by large hail, a factor itself dependent upon wind speed and the actual size of hailstone, although Kreibich et al. (2014) comment that local-scale variability and lack of observational systems hinders the analysis of their distribution and probability.
In recent years, some exceptionally damaging summer storms have occurred. For example, in 2013, a number of hailstorms hit the cities of Hanover in the north of Germany as well as Stuttgart and Villingen-Schwenningen in the south, leading to a total loss of EUR 3.1 billion (GDV, 2014). One year later, the wind storm Ela caused damage of EUR 600 million in North Rhine-Westphalia (GDV, 2015).

1.2.2 Floods

Flood events, which involve a temporary rise in the water level, hold the greatest share of economic losses, making up some 50% of losses since 1990 and are the second most frequent natural hazards occurring in Germany (see Fig. 2 and Kreibich et al., 2014). Floods affecting Germany may be divided into inland events (pluvial and fluvial floods), caused by extraordinary rainfall (and snow melt) and coastal flooding resulting from storm surges. Inland floods affect mainly the western areas (Rhine and Weser catchment areas) during winter (triggered by westerly cyclone events), the eastern region (Elbe and Oder catchments) which also show considerable winter flooding but also spring and summer floods, and the southern region (Danube catchment) which sees flooding during periods of snow melting and summer due to southwest cyclonic activity (Beurton and Thieken, 2009).

Storm surges, which affect the North and Baltic Sea coastlines mainly during winter, arise from sudden abnormal rises in sea-level which are due to the combination of onshore winds and lower atmospheric pressure. The fetch, wind velocity, duration of the storm and water depth define the severity of the emerging storm surge (Kreibich et al., 2014). The specific atmospheric conditions causing these events to differ greatly between the Baltic and North Seas. In the North Sea, the surges are induced by cyclones that develop along the northern North Sea. There are in turn different types of these which lead to different durations and specific areas of impact. For the Baltic Sea, storm surges arise from strong high pressure zones over Scandinavia and a cyclone over central Europe whose influence may extend

as far as the Baltic Sea coast. The characteristics of storm surges, high waves, high velocity water flow, and the fact it is salt water, lead to different damage processes when compared to fluvial flooding (Kreibich et al., 2014).

1.2.3 Extreme Temperatures

As mentioned above, extreme temperature events, in the form of heat and cold waves, have been the cause of the deadliest natural hazard since 1900 (2003 heatwave, 9355 fatalities, EUR 1.2 billion damage). For Germany, a heat wave is defined often as 5-7 days of temperatures above 30° C (Kreibich et al., 2014). A cold wave in turn is defined as a rapid decrease in temperature within one day that requires increased protection against cold for agriculture, industry and commerce and the general population, which is understood to have durations of days to weeks (American Meteorological Society 2012). Heatwaves are also one of the natural hazards that will increase in intensity and frequency as a result of climate change (e.g., Meehl and Tebaldi, 2004), which in turn would have an influence on urban planning. For example, during the two main heatwaves between 1990 and 2006 in north-eastern Germany, the highest rates of mortality were from the more densely built up areas of Berlin (Gabriel and Endlicher, 2011).

1.2.4 Earthquakes

Although Germany experiences a relatively low level of seismic activity, it is still affected by some of the highest levels of seismicity north of the Alps (Kreibich et al., 2014). There are several regions that have experienced earthquakes of magnitude Mw > 6, leading to macroseismic intensities (EMS-98) of VIII-IX (Tyagunov et al., 2006).

The main region of concern is along much of the River Rhine, from Upper Rhine Graben taking in Basel in Switzerland to Frankfurt am Main, and the Lower Rhine Embayment which includes Cologne, and continues to the Netherlands and Belgium. In fact, the largest earthquake in this zone occurred near Basel in 1356 with an estimated magnitude of Mw=6.6. Another area of enhanced seismicity is Saxony-Thuringia (Vogtland) in the east. While the north of the country shows lower levels of seismicity, no part may be considered to be aseismic (see figure 4).

The last most significant earthquake that affected German territory was the 13 April 1992 Roermond (the Netherlands) event, with a magnitude of Mw = 5.3, with total economic losses of EUR 36 million (Tyagunov et al., 2006). Again, around the heavily populated and industrialised area of Cologne, very long return period events of Mw > 6 may occur (~500 years), leading to losses of the order of 10's of billions of euros, not to mention the loss of life and disruption to the nation´s economic and transport infrastructure (Grünthal et al., 2006; Kreibich et al., 2014).

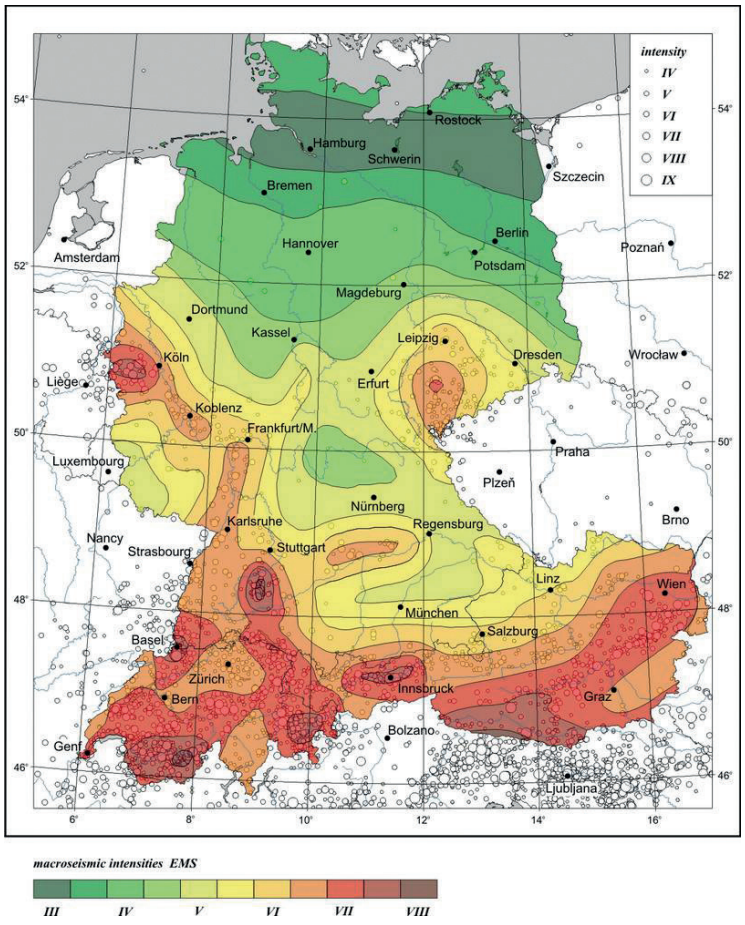

Figure 4: *Seismic hazard map for German, Switzerland and Austria in terms of macroseismic intensity (EMS-98 scale) with a 10% probability of exceedance over 50 years (Grünthal et al., 1998).*

[2] Data available at: http://www.preventionweb.net/countries/deu/data/

2 Research Methodology

2.1 Data Collection

In addition to the conceptual framework depicted in figure 1 (see chapter 1), a guideline for semi-structured interviews was prepared by the ESPREssO consortium that was to be used for all national reports with the possibility to modify questions according to the national context. Following this framework, both a literature review and expert interviews were employed to collect qualitative data in form of written and oral texts fitting to the identified categories. Finally, a quantitative analysis was conducted on scientific publications, aiming to find insights on research topics in Germany. This analysis was not exhaustive, given the fact that only a small portion of relevant publications could be included, as explained in the next section.

2.1.1 Literature Review and Semi-Structured Interviews

The qualitative analysis is based on a thorough review of existing scientific literature, agency reports and websites as well as legislative texts. Special attention was paid to grey literature in order to capture the developments within governmental structures, legislative frameworks and institutions related to CCA and DRR. With respect to the scientific literature, on top of the technical reports reviewed, over 40 research projects featured in governmental publications and official websites were used as source material for determining research methodologies commonly used in DRR and CCA. Each project provided information in the form of proposals, final reports and informal communications on web pages that were later aggregated in a single description per project.

Semi-structured interviews were conducted with experts from both CCA and DRR in order to capture their perspectives on progress and gaps of harmonising both fields in the German context. Experts were chosen in order to represent both the CCA and the DRR communities at different levels and from different disciplines. Interviews were conducted with representatives from governmental agencies at federal level (BBK, UBA) as well as federal state level (Conference of the Ministers of the Interior), municipal level (flood protection), different scientific backgrounds (social sciences, hazards, economics) and the private sector (Siemens, GDV). A detailed list of interviewees is provided in the annex.

2.1.2 Data for Quantitative Analysis

Two sources of data were used for the quantitative analysis: Google Trends and Google Scholar. The first source provided information regarding online-search trends for the general German population, which proves relevant when assessing public interest in Climate Change Adaptation and Disaster Risk Reduction. The second source was used for gaining insights specifically on scientific research aiming to back up the results from the qualitative analysis.

The query to Google Trends was limited to Germany-specific online searches, using two-keyword combinations, namely "Disaster Management" and "Climate Change", as aggregators of DRR and CCA respectively. In the context of this work, "aggregators" are synonym of "topics", and can be understood as groups of similar words that are semantically related. The results obtained were time series depicting the popularity of each topic through the years.

Regarding the query to Google Scholar, the search terms: <"disaster risk reduction""Germany" „BMBF"> and <"Climate Change Adaptation" "Germany" „BMBF">³ were used and the results were ordered by relevance. While these terms were empirically found to provide the most results, even for research not funded by the BMBF, it should be taken into account that certain bias may exist in the analysis towards projects funded by that source.

Taking a small representative sample from the enormous number of available documents required careful analysis. To reduce the potential bias, characteristics of the data to be included need to be defined to enable a meaningful selection of documents. For this particular approach, two characteristics were considered when surveying papers.

A. **Temporal dimension:** scientific documents published longer than ten years ago were not considered.

B. **Relevance in the field:** this characteristic was assessed through the number of citations each paper possesses. A minimum threshold of five citations was set for papers to be accepted in this review. This criterion implies that recent papers were not considered in the analysis, not due to lack of relevance, but lack of citations, and is a challenge that remains open for further analysis.

Furthermore, and since the analysis focused on Germany-based research, other characteristics

such as degree of contribution per country were considered. This was easily assessed by aggregating authors according to the country where that particular research was carried out, and selecting only those papers where German contributions represented the majority of the work. These criteria resulted in a corpus of 16 documents for Disaster Risk Reduction and 38 documents for Climate Change Adaptation (see Annex 2). These papers were later aggregated in three specific documents, corresponding to CCA, DRR and approaches combining both. All documentation was acquired as PDF files that were later converted to plain text files.

2.2 Data Analysis

2.2.1 Qualitative Analysis

Thematic analysis (cf. Guest, 2012; Gibbs, 2007) was employed throughout the report as the primary qualitative research method (Braun & Clarke, 2006) to identify and organize key themes from qualitative data according to the conceptual framework. Since the conceptual framework for analysis was already developed, the coding process was concept-driven (cf. Gibbs, 2007, p. 44ff), but codes were amended throughout the analysis to include new categories that were derived from the texts. The program used for this analysis was coded in R and included the following collection of R libraries: topicmodels[4], tm[5], pdftools[6] and wordcloud[7].

2.2.2 Quantitative Analysis

In addition to the qualitative analysis, two automated techniques were employed to gain insights on scientific research in Germany, with special attention to its relation to DRR and CCA. This analysis was conducted using the previously acquired scientific articles as text data input.

The first step required to convert all PDF files into plain text data using the pdftools library, and merge all individual documents into one single text file. After applying an automated algorithm for cleaning this data from common words that provide no relevant information (such as "the", "a" or "some", to name a few), a simple analysis of frequency was employed to find the most relevant keywords in the scientific documents previously acquired.
This part of the analysis used the tm package, and consisted basically on keyword indexing according to the frequency in which they are used throughout these texts. The outcome of this methodology is the form of an ordered list with the most popular keywords used throughout the texts. While this analysis provides little added value by itself, it finds its stronger contribution when paired with a stronger analysis, such as topic modelling.

Topic Modelling was used to identify patterns within the selected articles. This technique aims at identifying "topics" which would normally generate similar keywords[8] : "Topic modeling algorithms are statistical methods that analyze the words of the original texts to discover the themes that run through them, how those themes are connected to each other, and how they change over time" (Blei, 2012).

The goal of Topic Modelling is discovering the abstract "topics" that best describe a document or a collection of documents. Such a technique is used in this report as a mean to find structured information from high volumes of text data, a task which would have required significantly more time or resources than available, if a traditional literature review had been used. The approach of Topic Modeling in text analysis can be better understood with an example: if a document frequently uses the keywords "Temperature", "Water Levels" and "Ozone" for similar sentences, then a theme or topic might be identified in the document. While the algorithm would not be able to assign a name to this topic, this task falls on the user. In this case, the user possibly would name this topic "Climate Change". On the other hand, keywords such as "Catastrophe", "Critical Infrastructures" and "Prevention" frequently used together, may determine a topic such as "Disaster Management". In both cases, the algorithm just clusters the words together, and the user names the cluster. The insights obtained through this technique should not be considered as truth in itself but a support of the approach used for the qualitative analysis, which always takes precedence in this report.

[3] BMBF stands for Bundesministerium für Bildung und Forschung, the Federal Ministry of Education and Research

3 Institutions in Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) in Germany

The definition by UNISDR declares disaster risk reduction (DRR) to be "the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events" (UNISDR, 2009). Therefore, DRR "refers to a wide range of opportunities for risk abatement and disaster management. Risk reduction includes prevention, preparedness, and part of the recovery process, and it gives particular emphasis to the reduction of vulnerability" (Ammann, 2013). Different strategies/measures can be distinguished and combined. With regard to flooding, Hegger et al. (2014) distinguished five risk reduction strategies: 1) loss prevention by an adapted use of flood-prone areas, 2) risk mitigation by flood-adapted design and use of buildings; 3) flood defence with structural protection measures, 4) preparedness for response, e.g. by flood warning and adaptive behaviour; and 5) risk transfer mechanisms such as flood insurance to compensate flood losses.

In this understanding, DRR is no longer framed as "a post shock-oriented tool to restore communities affected by disasters to their pre-disaster condition" (Birkmann et al., 2009, p. 6) but rather as a set of useful instruments for adapting to changes before events occur. Arising from this, potential synergies with Climate Change Adaptation (CCA) in terms of similar aims and mutual benefits could lead to an increased effectiveness and sustainability of both approaches.

While the DRR concept allows for a rather inclusive and broad classification of potential measures, actors, structures and institutions, in a national context the term itself is hardly used to describe the responsible official structures dealing with disasters. Rather, structures are classified according to the departmental portfolios under which they fall.

Most of DRR is therefore coined as e.g. civil protection, water management, land use planning or urban planning. In order to narrow down the topic of DRR within this report, special attention will be paid to civil protection, corresponding to the national structures. DRR in terms of civil protection has a long tradition in Germany. While civil protection before World War II usually meant civil defence in the event of war, today the institutional structures of civil protection mainly come into operation in case of natural disasters. The terminology and history of civil protection in Germany and its unique architecture as well as the most important institutions will be described in section 2.1.

Likewise, with the German Strategy for Adaptation to Climate Change („Deutsche Anpassungsstrategie an den Klimawandel" (DAS)) that was passed in 2008 and the several follow-up frameworks, CCA can now be understood as a policy field of its own in Germany (Bubeck et al., 2016). The most important institutional structures and policies in relation to CCA will be described in section 3.2. After looking at both fields separately, section 3.3 will describe the existing harmonisation of both fields in the German context.

3.1 Legal Structures and Institutions in Relation to DRR in Germany

3.1.1 Understanding the German Context: Terminology and a brief History of DRR in Germany

Often used as synonyms in public debates and media, the German terminology regarding DRR has many qualitative distinctions including different legal implications that need to be understood when talking about the policies and laws of German disaster risk reduction. The most common terms are civil protection („Zivilschutz"), disaster control („Katastrophenschutz") and the protection of the population („Bevölkerungsschutz"). While the last is usually not used in English and rather translated with civil protection, the distribution of tasks between different governance levels within Germany makes such a distinction useful. While civil protection ("Zivilschutz") is considered as part of national defence policies, for which

[4] https://cran.r-project.org/web/packages/topicmodels/index.html
[5] https://cran.r-project.org/web/packages/tm/index.html
[6] https://cran.r-project.org/web/packages/pdftools/index.html
[7] https://cran.r-project.org/web/packages/wordcloud/index.html
[8] For further information on the methodology of topic modelling cf. Jordan 2003; Griffiths, Steyvers 2002,2003,2004; Hofmann 1999,2001

the Federation in form of the Federal Ministry of the Interior is responsible under German constitutional law (Article 73, paragraph 1, German Constitution (Basic Law, "Grundgesetz" (GG)), disaster control ("Katastrophenschutz") is under the responsibility of the federal states ("Länder") (Article 30, and 70, paragraph 1, GG). However, both are interlinked and – under certain conditions - can call upon each other`s resources. When talking about both, civil protection and disaster control, hence referring to the general protection of the population regardless of the administrative level of responsibility, "Bevölkerungsschutz" would be the right term – following the definition of the Federal Office of Civil Protection and Disaster Assistance (cf. Geier 2013: 28)[9]. Bevölkerungsschutz includes all non-military and non-police measures taken by any administrative level to protect the population from disasters, other severe crises and emergencies as well as from the impacts of any armed conflict. It also includes measures to prevent, reduce and manage such events, i.e. the term contains measures of disaster risk reduction (ibid). Figure 5 provides an overview of the German terminology.

Measures of prevention and preparedness in terms of peacetime disasters were not a priority of German policies until the late 1960s. Disaster control as a task of the federal states was not organized, structured nor standardized. Fire protection and the organization of fire brigades were considered as the responsibility of municipalities (as a result of the allies` politics), while the Emergency Medical Services were entirely in the hands of private relief organizations. This is one major reason for the strong position of private relief organisations, fire brigades and other volunteer-based NGOs within the German DRR system (ibid) as will be explained further in sections 3.1.7 and 3.1.8.

Despite the nuclear threat of the 1970s and 80s, civil protection in Germany remained very much conventionally oriented and underfinanced. The German reunification process brought about more cutbacks in civil protection budgets and many programmes were given up without having an overall concept for the restructuring. There was not much professional debate about how to address new threats and challenges in civil protection and disaster control until September 11, 2001 and the massive Elbe flooding in the summer of 2002.

As a reaction to these events that came as a "wake-up call", in 2002, the Federal Government as well as the federal states agreed on a "New strategy for the protection of the population in Germany" (BBK, 2010a) which emphasizes emergency preparedness and disaster prevention. It underlines the joint responsibility of the Federal Government and the federal states in situations which threaten serious damage to the welfare of the nation. One important contribution of the Federal Government to this new strategy for the protection of the population in Germany was the establishment of the Federal Office of Civil Protection and Disaster Assistance (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe; BBK) in 2004. The BBK is a supreme federal office within the portfolio of the Federal Ministry of the Interior (Bundesministerium des Innern; BMI) which - together with the Federal Agency for Technical Relief (Technisches Hilfswerk; THW), takes measures in the field of civil protection and disaster assistance and supports the BMI, i.e. the responsible federal ministry, in these areas (BBK, 2010b). BBK has, among others, the statutory obligation for the development of national risk analysis, warning and informing the population[10], education, further education and training, support of municipalities to prepare for emergencies as well as technical and scientific research.

Today, the protection of the population i.e. "any civilian measure taken to protect the population and its livelihood from the impact of wars, armed conflicts, disasters and other major emergencies as well as any measure taken to prevent, mitigate the impact of and cope with these events" (BBK, 2012: 1) is a key component of Germany`s national security architecture. In general, the non-police aversion of danger in Germany is built upon a vertically structured, subsidiary system that heavily relies on volunteers (Weinheimer 2008: 135). This system is rather complex since it involves both state actors (on national level, state level as well as municipal level) and non-governmental organizations. The different levels of operative responsibilities as well as the vertical collaboration between both state actors and non-state actors will be described in the following sections.

3.1.2 National Level: Relevant Institutions and Legislative Frameworks for DRR

As mentioned above, according to the Basic Constitutional Law (GG, Article 73 Paragraph 1 Number 1), the federation is responsible for the protection of the population against war and other military conflicts. In all other cases the federal states (Länder) are responsible. As

[9] Usually translated as "civil protection"

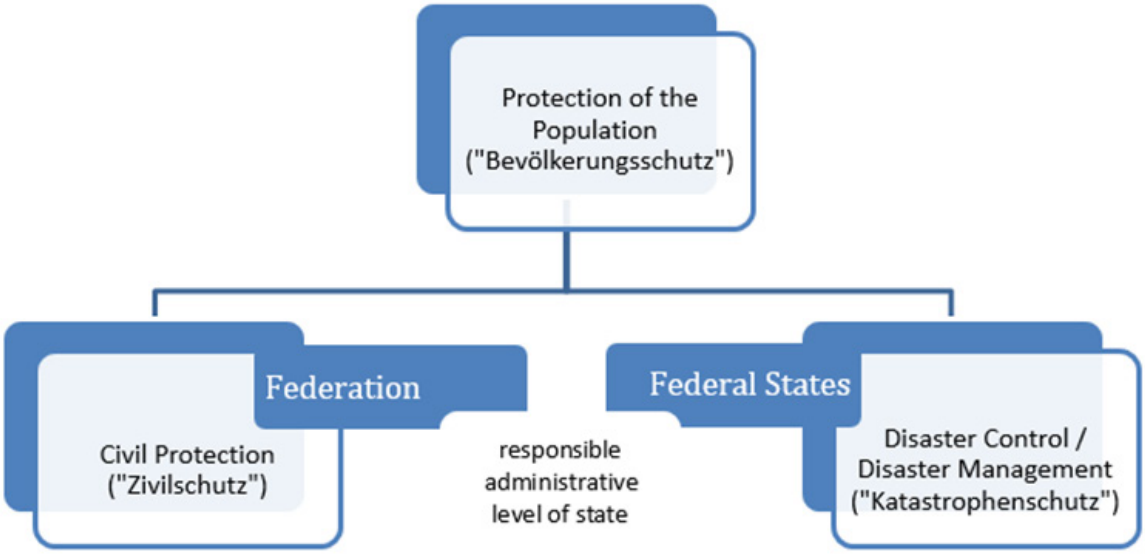

Figure 5: *German Terminology around Disaster Risk Reduction*

a reaction to the terrorist attacks of 9/11 and the massive Elbe flood in 2002, the Standing Conference of the Federal and State Interior Ministers adopted the "New Strategy for Protecting the Population" („Neue Strategie zum Schutz der Bevölkerung in Deutschland") the same year. This strategic framework was to strengthen the collaboration between federation and federal states in dealing with extraordinary, large-scale or nationally significant threats and damage. With this framework, the German government intended to review and renew the system of civil protection to prepare the system for current challenges - including climate change:

"[…] the existing systems at the federal and at the state level were developed further so as to give special priority to the synergetic deployment of resources by the various players in national crisis management in view of threats such as international terrorism, proliferation of weapons of mass destruction, epidemic and pandemic diseases, man-made disasters and the growing number of natural disasters (climate change)" (BMI 2015: 5).

The new strategy was to create a win-win situation for federation and federal states with assisting the Länder in dealing with disasters in times of peace while the federation's staff and material are used and trained to be fully operational in case of defence (BBK & DKKV, 2009, p. 122). By setting up the Federal Office of Civil Protection and Disaster Assistance (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe) in 2004, the federal government increased its coordinating role and shifted the federal focus away from Civil Defence more towards the subsidiary task of administrative assistance in disaster management.

The responsibilities at federal level have since then been constantly revised and were formalized in the Federal Civil Protection and Disaster Assistance Act (Zivilschutz- und Katastrophenhilfegesetz; ZSKG (Bundestag der Bundesrepublik Deutschland, 2009)) which - for the first time - established a legal basis for the fact that the whole of society shares responsibility in case of large scale damage that crosses the borders of federal states (Meyer-Teschendorf 2008, p.4).

Further, in 2016 the government adopted a new concept for civil defence („Konzeption Zivile Verteidigung") (BMI, 2016) which elaborates especially the tasks of the federation when averting severe threats regarding four main fields of responsibility, i.e. 1. maintaining the functions of the state, 2. civil protection, 3. supplying to the population, 4. supporting the armed forces. The concept is therefore the basis for taking concerted action at inter-departmental level and might necessitate an update of the ZSKG.

3.1.2.1 Ministries and Agencies

3.1.2.1.1 Federal Ministry of the Interior

Among the federal ministries, the Ministry of the Interior (Bundesministerium des Innern (BMI)) is responsible for security matters (public security, data security, internal security, protection against disasters and terrorism). It plays a central role in managing crises taking place within the country and hosts the Standing Committee of Interior Ministers. The ministry's crisis task force may be called on in case of serious threats to internal security to manage the situation and to coordinate measures taken by the BMI and its agencies. It also coordinates between the federal ministries and the Länder and provides advice for political actors. The crisis task force is called upon by the Communications, Command and Control Centre at the BMI (BMI 2015).
Within the ministry, the Directorate General Crisis Management and Civil Protection functions as Crisis Management Coordination Centre and Communications, Command and Control Centre of the ministry. It also has the administrative supervision of the two major institutions within the remits of the Ministry of the Interior that are dealing with civil protection, i.e. the Federal Office of Civil Protection and Disaster Assistance (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK)) and the German Federal Agency for Technical Relief (Bundesanstalt Technisches Hilfswerk (THW)). Both agencies are described in more detail below.

3.1.2.1.2 The Federal Office of Civil Protection and Disaster Assistance (BBK)

The Federal Office of Civil Protection and Disaster Assistance (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK)) was established as a contribution of the federation to the New Strategy for Protecting the Population within the portfolio of the BMI in May 2004 to create a central organisational element working to ensure the safety of the population.

The work of the BBK includes carrying out the tasks of the Federation especially with regard to the:

- Development of a national risk analysis (see section 3.1.5.3),
- Development of standards and framework concepts for civil protection,
- Warning and information of the general public,
- Development of a modular warning system with the core element of satellite-based warning information by including the existing and future alert and warning media,
- Information of the population about protection and support possibilities,
- Promotion of training measures for the general public,
- Education, further education and training of decision makers and managers from the sector of civil security measures (see also section 3.1.2.1.3) and
- Support of municipalities with regard to self-protection measures.

Therefore, the office is supposed to bundle all major activities in civil protection and connect them where they are interlinked. Some of the BBK´s departments and activities will be discussed in more detail below.

3.1.2.1.3 Academy for Crisis Management, Emergency Planning and Civil Protection (AKNZ)

The Academy for Crisis Management, Emergency Planning and Civil Protection (Akademie für Krisenmanagement, Notfallplanung und Zivilschutz (AKNZ)) forms Division IV of the BBK and is the central educational institution of the federation regarding risk and crisis management as well as civil protection. The aim is to develop the academy into an educational institution for civil safety precaution with a national and international network, within the framework of a strategic educational alliance. The seminars and courses target at all five pillars that constitute civil safety precaution on a national level (civil protection, police, the armed forces, services, critical infrastructure providers). Annually, around 10.000 staff from federal and federal state level as well as from the relief organisations are trained within the AKNZ (BBK 2013b).

3.1.2.1.4 German Federal Agency for Technical Relief

The German Federal Agency for Technical Relief (Bundesanstalt Technisches Hilfswerk (THW)) was founded in 1950 as the federal civil protection agency on behalf of the Federal Ministry of the Interior. On a national level, the THW provides technical relief under Section 1 (2) of the Act on the Federal Agency for Technical Relief (THW-Gesetz) in accordance with the Federal Civil Protection and Disaster Relief Act. Being a Federal agency, THW belongs to the department of the Federal Ministry of the Interior. However, the agency`s structure is unique: Only one percent (ca. 1000 individuals) of the staff is employed full-time by the authority. 99 percent of the THW-members work on a voluntary basis. Nationwide more than 80,000 volunteers provide professional assistance during their leisure time in 668 local

[10] However, weather warning is the responsibility of the DWD, hence, a close cooperation between both institutions is essential, cf. section 3.2.1.1.3 on the DWD

sections where the volunteers are also trained for operations[11]. According to THW (2016) "volunteers worked for about 1.3 million operational hours in 2015 at the request of different parties (e.g. police, fire brigade, civil protection authorities, municipalities, district presidents, Länder governments, federal government or European Union)". This basis of volunteers is very typical for the overall German civil protection system and will be discussed further in section 3.1.8.

In terms of operational units, the THW has at its disposal around 1,440 rescue groups and 1,000 specialist units in 722 technical platoons as well as more than 8,400 vehicles. Furthermore, it can provide specialised Rapid Deployment Units and Modules for foreign operations, e.g. in case of supporting EU or UN missions as well as a special training center (THW-Bundesschule) (THW 2016).

3.1.2.2 German Laws on Flood Protection

The overall regulatory law for water management in Germany stipulates that water bodies are subject to state management. The most important federal law is the Federal Water Act (Wasserhaushaltsgesetz, WHG) which was originally adopted in 1957. The major flood in August 2002 induced legislative changes so that a substantially revised versions entered into force in 2005 as well as in 2010 after transposition of the EU Water Framework Directive (WFD) into German national law. It was again updated in 2016. Regarding DRR, particularly the German Flood Protection Act of 2005 (Artikelgesetz zur Verbesserung des vorbeugenden Hochwasserschutzes) and the European Floods Directive (2007/60/EC; EC 2007) introduced important changes which marked a shift towards a more integrated flood risk management system in Germany that also considers non-structural measures to minimize adverse effects of flooding (DKKV, 2015b; Thieken et al., 2016; Hartmann and Albrecht 2014).

Furthermore, the EU Floods Directive requires that member states prepare flood hazard and risk maps for areas with (potentially) significant flood risk and establish flood risk management plans that outline plans for the implementation of prevention, protection and preparedness measures. Above all, the Floods Directive demands a review of such instruments in an iterative optimisation process every six years. A thorough analysis of the flood in 2013 (DKKV, 2015b) shows that considerable improvements have been made on many levels that deal with flood risk reduction and disaster response in Germany, in particular in 1) increased consideration of flood hazards in spatial planning and development, 2) comprehensive private precaution and self-provision, 3) more effective early warning and improved coordination of disaster response and 4) a more targeted maintenance of flood defence systems.

However, the implementation of the aforementioned changes to the WHG was still dominated by structural flood defences. It is rather after the flood in June 2013, that "bigger strategic changes are discernible. The systematic search and creation of retention space seen in the National Protection Program is one example of a further rejection of a purely protective concept, even if this is not always reflected in the terminology" (Thieken et al., 2016).

3.1.2.3 National Strategy to Protect Critical Infrastructure

The strategies regarding Critical Infrastructure Protection (CIP) are among the few national strategies regarding DRR, showing the importance of CIP for an industrialized country like Germany. The National Strategy to Protect Critical Infrastructure (2009) summarizes the aims and strategic approach of federal policy in this area. The CIP Strategy defines Critical Infrastructure as "organizational and physical structures and facilities of such vital importance to a nation's society and economy that their failure or degradation would result in sustained supply shortages, significant disruption of public safety and security, or other dramatic consequences" (BMI, 2009). The document lists several work packages that are to be jointly implemented by the Federation, the federal and local governments to enhance CIP in their respective areas of responsibility:

1. Definition of general protection targets
2. Analysis of threats, vulnerabilities, and management work packages capabilities
3. Assessment of the threats involved;
4. Specification of protection targets, taking account of existing protective measures as well as analysis of existing regulations and, where applicable, identification of additional measures contributing to goal attainment; if and where required, legislation.

„These work packages are implemented primarily by the public sector, with the collaboration of the companies and operators concerned. Responsibility for coordination at the federal level lies with the Federal Ministry of the Interior" (BMI, 2009). According to interviewed experts, the National Strategy to Protect Critical Infrastructure was revised in 2016 / 2017. Consultations between the involved government departments have taken place and comments are being incorporated as of April 2017.
Another action within this field is the initiative

[11] More specialised advanced training is conducted in a federal training center (THW-Bundesschule) with two locations. About 6.000 people are trained here each year (THW, 2017)

UP KRITIS, a Public-Private Partnership for Critical Infrastructure Protection which was institutionalised in 2007 (UP KRITIS, 2014) as a result of the Federal Government's "National Plan for Information Infrastructure Protection" (Nationaler Plan zum Schutz der Informationsstrukturen (NPSI)) from 2005, out of which the CIP Implementation Plan emerged in 2005 and 200612.

3.1.3 Federal State ("Länder") Level

Since the responsibility for disaster management in terms of civil protection lies with the "Länder", each federal state`s government has the right and responsibility for policy formulation in the area of civil security, typically through its Ministry of the Interior. The departments of the interior on federation and federal state level meet regularly to coordinate their activities in the Permanent Conference of Interior Ministers[13] („Ständige Konferenz der Innenminister und -senatoren der Länder", short: Innenministerkonferenz (IMK)) under the lead of a rotating presidency.

Working group V of the IMK (Arbeitskreis V - Feuerwehrangelegenheiten, Rettungswesen, Katastrophenschutz und zivile Verteidigung/ Fire Fighting Issues, Rescue Services, Disaster Prevention and Civil Defense) brings together professionals and lead officials in the areas of civil protection and disaster relief. The working group has written plenty of position papers and recommendations to harmonize operational doctrine and civil protection structures across the Länder and local authorities. It also "served as the key negotiation forum for the legislative reforms to the German emergency management system from 2002-2009" (Hegemann & Bosong, 2013, p. 12).

The federal states are especially responsible for legislation on rescue and emergency services, fire protection and disaster management. They support the districts and municipalities with their tasks and take over the overall coordination in case of large-scale hazards, damage or disasters. On the basis of the states' laws, some divergent structures regarding management, education and equipment have evolved over the years (BMI 2017). Depending on the respective laws of the respective federal state, the first authority in charge during a peacetime disaster is either the cognizant rural district, county or the municipal authority. The local response is managed by the director of administration for the respective authorities. If necessary, a staff is established consisting of members from his or her own administration, as well as other authorities, services and organisations involved in disaster management to assist with administrative duties. When several districts are affected by an event or a local government cannot handle an event on its own the next highest hierarchical authority takes over the coordination. According to the Basic Constitutional Law (GG, Article 36) federal authorities render legal and administrative assistance to the federal states in cases of especially large scale impacts or natural disasters and accidents affecting more than one state. The federal government supports local and regional authorities and the states with information, coordination, and advice as well as with their own operational forces (e.g. with services provided by the BBK, the THW, the federal police, and, with certain limitations (with regards to the use of weapons) the Armed Forces) when asked for assistance (BMI 2015: 6). In this case, an inter-ministerial coordination group may be set up within the BMI which together with other federal ministries and the other states, ensures the coordination of assistance to the affected federal state. However, the right of initiative and the disaster management remains with the federal states (German Red Cross 2010).

3.1.4 Municipal Level

Even though the federal states have the legislative and executive power according to the Basic Constitutional Law (GG, Article 83), disaster relief is to a large extent planned and implemented on a local level (following the subsidiarity principle): while e.g. the legal responsibility concerning fire brigades lies with the Länder, the fire brigades are run by municipalities which together with the relief organizations make up the core of non-military and non-police civil protection staff. The fire brigades and relief organizations undertake operative and tactical measures for disaster reduction and response under the lead of the responsible operational command of the respective civil protection authority (Katastrophenschutzbehörde). 95% of this emergency personnel serve on a voluntary basis (BBK & DST:10) as explained in more detail in section 3.1.8. In case of an event, the district chiefs or chief mayors are politically responsible managing the crisis. They are supported by a management staff

12 With regards to IT security, see also the Germany's Cyber Security Strategy 2011 and 2016 (BMI 2011, BMI 2016)

to be established in case of an emergency as well as by a command staff/operational command post (BBK 2013) – both on the level of municipal districts and autonomous cities as well as on the level of the federal states[14].

3.1.5 Vertical Cooperation

Since the New Strategy for the Protection of the Population in Germany was passed in 2002, there is a close cooperation between federation and federal states to make effective use of personnel and equipment. The BBK has several activities directly targeting vertical cooperation that will be described below.

3.1.5.1 Interministerial Coordination Group of the German Government and the German States

The Interministerial (Crisis Management) Coordination Group (Interministerielle Koordinierungsgruppe des Bundes und der Länder (IntMinKoGr)) coordinates between the Länder and the federal level. It plays an important role alongside the existing federal and state crisis management system, dealing with the limited number of threats or emergencies which affect more than one state over a longer period of time (e.g. accidents at nuclear power plants in Germany and abroad, pandemics and major natural disasters). In such cases, the IntMinKoGr focuses on the necessary coordination and consultation to deal with complex situations (BMI 2015).

3.1.5.2 Joint Information and Situation Centre of the Federal Government and the Länder

The Joint Information and Situation Centre of the Federal Government and the Länder (Gemeinsames Melde- und Lagezentrum von Bund und Ländern (GMLZ)) is to guarantee that the Federal Government, Länder and relief organisations have the same information about a certain event. As a central component of restructuring the German civil protection after 2002, the GMLZ was already set up in October 2002 - two years before the establishment of the BBK itself. Since the ZSKG came into force, the basis of the GMLZ`s tasks is § 16 ZSKG with the following three main tasks:

1. Situation management:

   One of the central tasks is the creation of a constantly updated and extensive situation assessment of issues relevant to civil protection in Germany and abroad. The focus hereby is not on observation alone buton evaluation and analysis of situational developments. These are incorporated into certain products that are shared with the relevant partner organisations on a regular basis (such as a daily situation report). The aim is to comprehensively inform all partners such as federal states, ministries, relief organisations, THW, neighbour states, EU and NATO about relevant events at an early stage.

2. National-Contact-Point (NCP)

   The GMLZ is the central contact point for around 20 national and international information and alert mechanisms. Since the centre can be reached 24/7, the GMLZ is responsible for informing and alerting the responsible ministries and agencies outside of normal business hours. Furthermore, the GMLZ exchanges information with the situation centres of other EU member states and the EU commission`s Emergency Response Coordination Centre (ERCC) in Brussels. In international disaster control missions with German participation the GLMZ coordinates the sending of units, aid supplies or experts in international disaster relief (BBK 2017).

3. Resource Management

   Resource management includes the procurement and distribution of bottleneck resources (e.g. during the Elbe and Danube floodings in 2013 the GLMZ obtained 1.25 million sandbags from neighbouring countries to the affected federal states).

3.1.5.3 National Risk Analysis

According to the Civil Protection and Disaster Assistance Law (ZSKG, Section 18, Paragraph 1), the federal government and the federal states have to jointly generate a national risk analysis for civil protection. The national risk analysis is key to the advancement of the German System of National Security and part of the "New strategy for the protection of the population in Germany". Therefore, the BBK has developed a risk assessment method for civil protection which has been made available to the federal states. The findings of the national risk analysis

[14] For a detailed account of the command structures in case of emergency as well as in the everyday administration of municipalities see German Fire Brigade Service Regulation FwDV 100 (1999) as well as Ehl & Wendekamp (2013, p. 133ff)

[13] This governance structure is quite common in Germany. Similar "conferences" exist e.g. with regard to the environment (Conference of Environmental Ministers, Umweltministerkonferenz; UMK) including all water issues such as floods and droughts as well as in the justice department (Conference of the Ministers of Justice, Justizministerkonferenz; JuMiKo). The JuMiKo discussed for example the possibilities of a compulsory insurance covering losses caused by natural hazards.

serve as a basis for informed decision making and a risk-based planning of prevention and preparedness activities. Aim of the analysis is to come to a comprehensive overview of potential risks and events regarding the probability of occurrence and the extent of damage that is to be expected. This way, the government can also use the risk analysis to capture hazards of national importance. The outcome, the "Joint Hazard Estimation of the Federals States and the Federal Government", compiles hazards which exceed day-to-day events and identifies risk hotspots and means to reduce vulnerability. To systematically improve the assessment, BBK also engages in a regular exchange on risk management methods and results both within and outside Europe (DKKV, 2015a).

The analysis is carried out in an abstracted, generic manner and does not attempt to prioritize specific scenarios or to conduct a political evaluation of risks. The following risk analyses have been carried out since 2012: flooding, extraordinary epidemic event, winter storm, storm surge, release of radioactive materials from a nuclear power plant and release of chemical substances. The analysis that is currently ongoing will deal with a massive gas shortage (Deutscher Bundestag 2016).

On the basis of the developed and examined scenarios, risk assessment procedures that were accordingly adapted for the respective administrative levels were applied already at the district and independent town level, in order to carry out detailed analyses as part of pilot projects. In early 2016, the BBK developed a guideline for the implementation of risk analyses, including the steps for risk assessment and risk management, available to the public agencies in the affected administrative levels as well as publicly accessible online (BBK 2015). Using scenario-based risk analyses, the existing abilities and coping capacities in disaster protection as well as the general danger defense were subjected to a stress test (Fekete & Hufschmidt, 2016). The German parliament is regularly informed about the progress and the outcomes. The national risk analysis process is listed as a contribution to CCA in Germany in the progress report of the German adaptation strategy (as a couple of the scenarios are particularly relevant in that context).

3.1.5.3.1 Exercises on crisis management: LÜKEX

The so-called LÜKEX (Länderübergreifende Krisenmanagementübung (EXercise)) is an interministerial and interstate crisis management exercise involving both the Federal Government and the Federal States to prepare for (exceptional) crises and threats to provide them with an opportunity to test existing crisis management plans and mechanisms. While the overall responsibility for the exercises lies with the Federal Ministry of the Interior (BMI), they are prepared, implemented and evaluated by a project team within the Federal Office of Civil Protection and Disaster Assistance (BBK). The aim of LÜKEX is to enhance the cooperation between all actors in the political-administrative system who bear responsibility in the area of civil defence. Focusing on the crisis committees on the federal and the state level, operators of critical infrastructure and other safety-relevant facilities have to be involved in the exercise (BBK 2014: 7). LÜKEX are also supposed to determine the need for action where there are no established or no sufficient procedures for collaboration or consultation channels in place. The exercises usually take place every two years which corresponds with the approximate time of completing one exercise. Since 2009 LÜKEX has been part of the Federal Civil Protection and Disaster Assistance Act (ZSKG § 14). The next exercise is planned for 2018 and - in line with the current national risk assessment - will deal with a massive gas shortage event[15].

3.1.6 Implementing International DRR Frameworks in Germany

The Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) was adopted at the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan, in March 2015 and is the successor instrument to the Hyogo Framework for Action 2005-2015 (HFA). The German Delegation in Sendai consisted of representatives from BMZ, AA, BMI, BBK, DKKV as well as other experts and "during the negotiations, Germany was one of the countries that called for the development of indicators to enable progress on the goals agreed under the Framework to be measured against established global benchmarks for the first time" [16].
The Sendai Framework focuses on comprehensive risk management. Its priorities are to improve understanding of disaster risks, to strengthen local, national and international steering mechanisms

[15] In 2015, the planned LÜKEX (with the scenario of an extreme storm surge) was cancelled due to the degree of capacity utilisation of the federal states in tending to the higher numbers of refugees.
[16] http://www.auswaertiges-amt.de/EN/Aussenpolitik/HumanitaereHilfe/2_Katastrophen/HuHi_Preparedness_node.html

for managing disaster risks, to invest in disaster risk reduction in order to enhance resilience, to improve preparedness for disasters in order to ensure an effective response to them and to facilitate preventive reconstruction ("building back better"). The national focal point for the Sendai Framework and UNISDR is going to be within the remit of the BMI. The German Secretariat is based at the BBK from summer 2017 onwards.

3.1.7 International Cooperation: Transboundary Disaster Management

The European Civil Protection Mechanism (CPM) is the main framework for cross border cooperation on disaster relief within the EU[17]. This mechanism was put in place to improve the coordination of the work carried out by civil protection and relief services in the event of a major emergency extending to all 28 EU Member States in addition to Iceland, Montenegro, Norway, Serbia, the former Yugoslav Republic of Macedonia and Turkey. Any country affected or likely to be affected by a major disaster – within or outside the EU – may call upon the Member States for assistance. According to the German Red Cross (2010), "Germany has not yet requested assistance via this mechanism and thus has not gained any practical experience in this area". However, cooperation on disasters between Member States is often based on geographic proximity or on similar hazards that countries face. Likewise, Germany has signed bilateral agreements on mutual disaster assistance with all its neighbour states as well as with Russia, Hungary and Lithuania.

Therefore, agreements with the following countries are in place:

- Austria
- Belgium
- Denmark
- France
- Hungary[18]
- Lithuania
- Luxembourg
- Poland
- Russia
- Switzerland
- The Czech Republic
- The Netherlands

A study by the German Red Cross that was published in 2010 as a country report within the project "Analysis of Law in the EU Pertaining to Cross-Border Disaster Relief" provides a comprehensive overview of the laws and regulations as well as the operational practicalities in terms of transboundary disaster management from a German perspective[19]. The most important institutions are summarized in the following.

Besides bilateral agreements of the federation, the states (Länder) also have the right to enter into agreements with other countries. According to Art. 32, paragraph 3 of the Basic Constitutional Law, the federal states can conclude agreements with foreign countries with consent of the federal government if the matter concerned by the agreement falls within their legislative power. Since this is the case regarding disaster relief, some of the federal states have concluded agreements with their neighbouring states or regions (German Red Cross, 2010, p. 7). Also, both official and unofficial agreements exist at the local level, e.g. between German municipalities and their direct neighbours[20].

Corresponding to this complex horizontal distribution of responsibilities, no exclusively responsible national focal point has been defined for requesting international disaster relief and liaising with international aid providers. Rather, various contact points exist whose responsibilities are determined according to the legal basis of the international request.

Regarding the operational process in terms of German assistance in foreign countries, the responsibility for humanitarian assistance (which from a German perspective refers to measures in third countries outside the EU) lies with the Federal Foreign Office (Auswärtiges Amt (AA))[21], while disaster relief and management within Germany (and in view of the cross-border disaster relief as regards the EU) the Federal Ministry for the Interior is the leading responsible institution. Regarding the CPM, the procedure starts with an international

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17 http://ec.europa.eu/echo/what/civil-protection/mechanism_en

18 Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich Belgien über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen v. 6. November 1980 (BGBl. 1982 II, p. 1006) („German-Belgic Agreement"), Abkommen zwischen der Bundesrepublik Deutschland und dem Königreich Dänemark über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen v. 17. März 1988 (BGBl. 1988 II, p. 286) („German-Danish Agreement"), Abkommen zwischen der Bundesrepublik Deutschland und der französischen Republik über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen v. 3. Februar 1977 (BGBl. 1980 II, p. 33) („German-French Agreement"), Abkommen zwischen der Bundesrepublik Deutschland und der Schweizerischen Eidgenossenschaft über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen v. 28. November 1984 (BGBl. 1987 II, p. 75) („German-Swiss Agreement"), Abkommen zwischen der Bundesrepublik Deutschland und der Republik Österreich über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen v. 20. März 1992 („German- Austrian Agreement"), Abkommen zwischen der Bundesrepublik Deutschland und der Russischen Förderation über die gegenseitige Hilfeleistung bei Katastrophen und schweren Unglücksfällen v. 16.

19 www.ifrc.org/Global/Publications/IDRL/country%20studies/IDRL-Report_GerRC_May2010.pdf

20 e.g. the agreements on mutual assistance in cases of disasters between the City of Aachen and the Cities of Heerlen, Kelmis, Kerkraade and Vaals respectively

21 In November 2011, the Federal Foreign Office and the Federal Ministry for Economic Cooperation and Development (BMZ) concluded an inter ministerial agreement, redefining the government departments` responsibilities regarding humanitarian assistance (https://www.bmz.de/en/issues/transitional-development-assistance/index.html). The AA is now in charge of the government's entire portfolio of humanitarian aid; the BMZ is responsible for transitional development assistance.

request for disaster relief within the framework of the CPM. If Germany is to assist, the situation centre (Lagezentrum) of the Federal Ministry of the Interior is contacted. The request is then passed on to and carried out by the German Joint Information and Situation Centre (GMLZ) of the Federal Office of Civil Protection and Disaster Assistance (BBK). The GMLZ communicates between the requesting state(s) and the potentially assisting organizations in Germany.

Since the procedures agreed upon bilaterally have precedence over the CPM, foreign countries that have concluded bilateral agreements with and seek disaster relief from Germany have to interact with the contact point or with the institution designated within the respective agreement (German Red Cross, 2010, p. 11). While this is typically the Federal Ministry of the Interior, requests can also be directed at the Ministries of the Interior of the federal state(s) that are located at the border to the requesting country, at the district president (Regierungspräsident) who has been authorized by the Ministry of the Interior of the respective federal state or can even be directly filed with the local fire brigades, the situation centers of the police departments or the authorities of the municipality. Annexes to agreements on the federal state or municipality level often contain precise contact information. By 2011, Germany has not officially requested assistance through CPM but contributed assistance 14 times between 2007 and 2011 alone.

3.1.8 Non-Governmental Organizations

3.1.8.1 German Committee for Disaster Reduction (DKKV)

With the beginning of the United Nations` International Decade for Natural Disaster Reduction (IDNDR) in 1990, the German IDNDR Committee was set up. After the decade`s end, the association German Committee for Disaster Reduction (Deutsches Komitee Katastrophenvorsorge e.V.; DKKV) was established as a non-governmental organization, non-profit association under private law and seamlessly took over the IDNDR`s tasks in 2000. The DKKV was designated by the German Government as National Platform (NP) for Disaster Risk Reduction (DRR) in the framework of the UNISDR (United Nations International Strategy for Disaster Reduction). In this function, DKKV served as the German focal point institution for the 10-year international disaster risk reduction plan, the Hyogo Framework for Action 2005-2015 (HFA). As such it promoted the implementation of the HFA which ended in 2015. The successor instrument to the HFA, the Sendai Framework for Disaster Risk Reduction 2015-2030, will be implemented and managed through governmental bodies (see section 3.1.7) as recommended in the framework itself. Since the end of the HFA, the DKKV mainly serves as a network and information hub for organizations and initiatives involved in DRR and as a centre of expertise in all matters relating to national and international disaster reduction issues. DKKV consists of a consolidated network of key stakeholders within the disaster reduction domain at the national, European and international level, including European civil protection authorities. The network`s interdisciplinary and multi-sectoral character enables a broad and targeted dissemination of initiatives, knowledge and methodologies within the DRR community. Among the focus areas of DKKV is linking science and practice, linking national and international aspects and initiatives as well as linking public-sector and private-sector structures. Members of DKKV range from governmental agencies (including the BBK, the THW and the UBA), scientific institutes and organizations, media, humanitarian and development cooperation organizations.

3.1.8.2 Relief Organisations

In Germany, non-governmental relief organisations are part of the so-called "Behörden und Organisationen mit Sicherheitsaufgaben" (BOS), i.e. authorities and organizations that perform security tasks (such as law enforcement, fire brigades, emergency medical services and other emergency and rescue services) in those cases when they provide assistance within civil protection. The German Federation, States (Länder) and municipalities are working together with the large relief organisations in a vertically structured emergency aid system. The following organizations belong are relevant for civil protection:

- Workers' Samaritan Federation Germany (German: Arbeiter-Samariter-Bund; ASB)
- German Lifeguard Association (German: Deutsche Lebens-Rettungs-Gesellschaft; DLRG))
- German Red Cross (German: Deutsches Rotes Kreuz; DRK)

- Hospitaller Emergency Service (German: Johanniter-Unfall-Hilfe e.V.)
- Auxiliary Service of the Order of Malta (German: Malteser-Hilfsdienst e.V.)
- Union of the German Fire Departments (German: Deutscher Feuerwehr Verband; DFV; the DFV represents the interests of the German fire brigades national-wide and abroad).

Through these organisations alone, around 500,000 supporters are put at the disposal of the civil protection system (Lange & Endreß, 2013, p. 18).

3.1.9 The Role of Volunteers in german DRR

There is no doubt that the German civil protection system would not be functional without volunteers. 1.7 million volunteers (from which around 1.2 million volunteers come from the fire brigades and another 76,000 from the THW (BMI 2012)) form the backbone of civil protection in Germany with almost 90 % of relief organizations' staff consisting of volunteers (Hielscher and Nock, 2014). This is why demographic change (with a decrease in the overall population and an overall aging society) poses a major challenge for the future of the German civil protection system (Lange & Endreß, 2013, p. 19). Studies[22] on voluntarism in DRR in comparison with other fields show that civil protection is especially affected by this development. While fire brigades and THW have already lost substantial numbers of members within the last years, projections predict a decline in numbers of volunteers within DRR by nearly a quarter from 2006 to 2025 (Hielscher & Nock, 2014, p. 9). It is not clear, however, whether the number of 1.7 million volunteers is actually operational for civil protection needs. Surveys among relief organisations showed that most do not have concrete figures on their active and trained supporters (Lange & Endreß, 2013, p.18).

Since civil protection is dependent on volunteers like no other sub-system of the German internal security, the success in recruiting new supporters will be crucial for its future (Geier 2013: 21). As a result, a number of conferences, workshops and studies on this topic have been conducted from both governmental and non-governmental institutions active in DRR within the last years[23]. One of the objectives is to better integrate migrants, women and senior citizens into DRR institutions since they were found to be heavily underrepresented (BBK 2012a, 2012b, 2012c, 2012d).

3.1.9.1 Private Sector

Besides insurance companies, the private sector is involved in DRR first and foremost as operator of critical infrastructures, e.g. in the fields of energy and water supply, transportation, telecommunications and information technology. Critical infrastructures are especially vulnerable to hazardous events due to their interdependence and the associated cascading effects. The privatization of critical infrastructure in Germany began in the 1960s so that today 80 % of the German critical infrastructure facilities (as in most other countries) are operated and owned by private or privatized enterprises (Schneider, 2014), which are thus also responsible for the functioning of the facilities. In cooperation between the Federal Ministry of the Interior, its subordinate authorities and CI operators, guidelines, protection concepts and Public Private Partnerships (PPPs) have been established that have resulted in national legislation (see section 3.1.2.2).

Since Critical Infrastructures are rather vulnerable industries due to their interconnectedness, the IPCC has argued in its Fourth Assessment Report on Climate Change (2007) that these need to adapt to climate change impacts such as extreme weather events, changing mean temperatures and precipitation patterns in order to prevent major damage or outages in the future. A case study of Germany`s critical infrastructure and CCA by Schneider (2014) shows that - in contrast to the publications of the BMUB and its agencies - the German CIP Strategy "does not differentiate between climate change impacts and other natural hazards and, therefore, does not account for climate change as a special societal issue [...]".

3.2 Legal Structures and Institutions in Relation to CCA in Germany

Since it is very unlikely that the negative impacts of climate change can still be avoided even by the most ambitious climate mitigation goals (IPCC, 2013), climate change adaptation (CCA) has gained increasing importance in debates about climate change within the last few years. Therefore, CCA processes have been initiated on international, European as well as national levels. On the European level, the EU strategy on adaptation to climate change was adopted by the European Commission in April 2013 with one of the aims being to encourage Member States "to adopt

comprehensive adaptation strategies" (European Commission, 2013).

Germany has taken a leading role in climate change mitigation and adaptation since the 1980s and adopted its Strategy for Adaptation to Climate Change (DAS) already in 2008, followed by the Adaptation Action Plan of the German Adaptation Strategy in 2011. A number of legislative frameworks regarding CCA have been adopted at the federal level while the majority of adaptation measures have to be taken at the level of federal states and municipalities. Both will be summarized in the following sections.

3.2.1 National Level: Relevant Institutions and Legislative Frameworks for CCA

3.2.1.1 Ministries and Agencies

3.2.1.1.1 Environment and transport portfolio

Government policies regarding climate protection and climate change adaptation fall mainly under portfolio of the Environment Ministry (BMUB) and its agencies: the Federal Environment Agency, the Federal Agency for Nature Conservation, the Federal Office for Radiation Protection and the Federal Office for Building and Regional Planning[24]. Out of these four the Federal Environment Agency (Umweltbundesamt (UBA)) and the Federal Office for Building and Regional Planning (Bundesamt für Bauwesen und Raumordnung (BBR)) are the agencies mostly involved with climate change issues. The German Strategy for Adaptation to Climate Change (see section 2.2.1.3) and subsequent framework documents were passed by the German government under the lead of the BMUB. The agencies and their functions will be described in more detail in the following.

3.2.1.1.2 Federal Environment Agency and Competence Centre for Climate Impacts and Adaptation

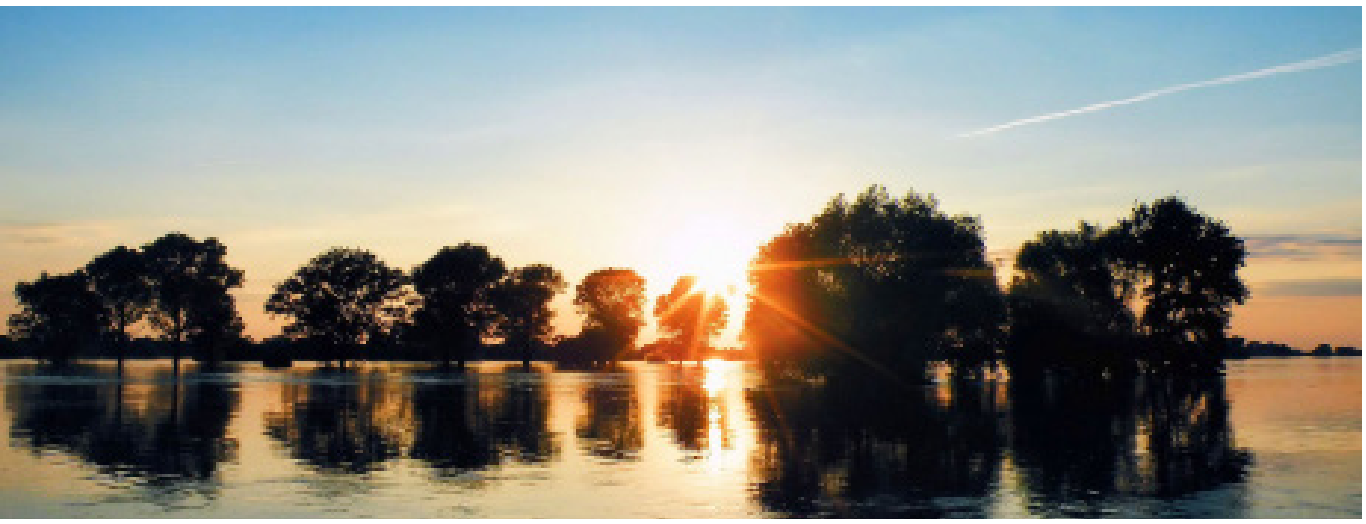
The competence centre for climate impacts and adaptation (Kompetenzzentrum Klimafolgen und Anpassung (KomPass)), based at the federal environment agency (Umweltbundesamt (UBA)), wants to link expertise on climate change effects and to convey this expertise to decision makers and the public. KomPass was set up at the end of 2006 and supported the development of the National Adaptation Strategy. It offers a wide range of tools in CCA that are described in detail below (see section 3.2.6).

3.2.1.1.3 Federal Institute for Research on Building, Urban Affairs and Spatial Development

The Federal Institute for Research on Building, Urban Affairs and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR)) within the Federal Office for Building and Regional Planning as a departmental research institution advises the Federal Government with sectoral scientific consultation in the policy fields of spatial planning, urban development, housing and building. The institute supervises several initiatives on climate change adaptation[25].

3.2.1.1.4 National Meteorological Service - Deutscher Wetterdienst

Germany's National Meteorological Service, the Deutscher Wetterdienst (DWD) as an agency



22 cf. Hielscher & Nock 2014; Krimmer & Priemer 2013

23 e.g. the symposium „Ehrenamt im Bevölkerungsschutz" (DRK, 2012), the studies published by BBK (2012a, 2012b, 2012c, 2012d) or the research project „Professionelle Integration von freiwilligen Helfern in Krisenmanagement und Katastrophenschutz" (INKA) (BBE, 2015)

under the remit of the Federal Ministry of Transport and Digital Infrastructure is responsible for meeting meteorological requirements arising from all areas of economy and society in Germany. The area of responsibility is defined by the statutory tasks of providing information and performing research as laid down in the Law on the Deutscher Wetterdienst (DWD 2015), among them:

- provision of meteorological services,
- meteorological safeguarding of aviation and shipping,
- issuing of official warnings about potentially dangerous weather phenomena,
- short and long-term recording, monitoring, and evaluation of meteorological processes in the atmosphere, its structure and composition,
- recording of interactions between the atmosphere and other environmental spheres,
- forecasting of meteorological processes,
- operation of the necessary measuring and observation systems, and
- provision, storage, and documentation of meteorological data and products.

A cooperation agreement between the BBK and the German Meteorological Service (Deutscher Wetterdienst; DWD) was established in 2008 to better integrate the services of the DWD into civil protection. Data on weather and climate are provided by the DWD which the BBK uses for risk mapping and analysis, especially with respect to the GLMZ and the warning of the population[26].

3.2.1.2 The German Strategy for Adaptation to Climate Change

The German Strategy for Adaptation to Climate Change (Deutsche Anpassungsstrategie an den Klimawandel (DAS) (Bundesregierung, 2008)) was established in 2008 as a framework for a medium-term national adaptation process:

"Even with a limited temperature rise of this magnitude, the environmental, social and economic consequences of the climate change that is already taking place will make their effects felt. If the 2°C target is met, it is expected to be possible to mitigate the consequences by means of appropriate and timely adaptation measures and thereby avoid serious consequences." (Bundesregierung, 2008, p. 5)

The DAS was also a first step of the federal government in order to meet its obligations under Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC). The DAS highlights areas likely to be affected by climate change or which already show evidence of impacts as well as requirements for action for adaptation in various sectors in 14 fields of action including so-called crosscutting issues of which civil protection is mentioned as one.

The aim of the strategy was to create a national framework for action in order to avert dangers to the public, the environment as well as the national economy. The framework was intended to make it easier for the various levels of the Federation, Länder, local authorities and for individual citizens to identify impacts and adaptation needs, and to plan and implement measures. The DAS was developed in close cooperation with the federal states by a working group comprised of representatives from most of the federal ministries and under the lead responsibility of the Federal Environment Ministry.

3.2.1.3 Adaptation Action Plan I and II

In 2011, the Adaptation Action Plan (Aktionsplan Anpassung (APA)) (Deutsche Bundesregierung, 2011) followed to supplement the strategy with concrete objectives and activities and to establish links to other national strategic processes. It was the result of an inter-departmental discussion and coordination process. The APA I is underpinned by the objectives and options for action, defining specific activities as detailed in the DAS and linking it with other national strategy processes. The APA mainly presented federal activities while also relating to joint activities with the federal states. According to the progress report of 2015, 43 of the 150 activities and measures that were defined in the APA I were finalized by the time

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[24] In December 2013, the Chancellor issued a decree transferring the responsibility for building (including urban development, housing, rural infrastructure, public building law, the construction industry and federal buildings) from the former Federal Ministry for Transport, Building and Urban Development (BMVBS) to the BMUB (BMUB, 2016).

[25] With the research programme "Experimental Housing and Urban Development" (Experimenteller Wohnungs- und Städtebau (ExWoSt)) the federation supports innovative planning and measures on climate change such as StadtKlimaExWoSt (Urban Strategies for Adapting to Climate Change). With the action programme „Demonstration Projects of Spatial Planning" (MORO) and especially the project "Raumentwicklungsstrategien zum Klimawandel" (KlimaMORO) that is also supervised by the BBSR, the Federal Ministry of Transport and Digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur (BMVI)) supports practical trials and implementations of innovative action approaches and instruments for spatial planning in co-operation with science and practice.

the report was published. Another element of the Progress Report is an updated APA, the „Adaptation Action Plan II". This plan presents future actions of the federal government as well as a concrete time and financing plan.

All activities of APA II are organized along specific fields of action or clusters, e.g. "water", "infrastructures", "land", "health", "business" and "spatial planning and civil protection (Bevölkerungsschutz)". The same clusters were also used in the vulnerability assessment (see section 3.2.2.2) and are an agreed concept for CCA in Germany.

3.2.1.4 Indicator and Monitoring Reports

In September 2015, the first report to evaluate the DAS was published. According to the Federal Environmental Agency (UBA), the indicators "[...] underlying the Monitoring Report and the overall report itself were created and agreed politically in an inter-departmental process with the participation of numerous experts from the competent sectors of agencies at Federal and Länder level and from scientific and private institutions. This painstaking theme-specific process took nearly six years" (UBA, 2015c).

On the basis of defined indicators, the monitoring report aimed to describe the current state of development and implementation of climate change adaptation in Germany. In cooperation with federal and state authorities, NGOs, the private sector and science, the UBA developed a system of indicators for the 15 fields of action of the German Adaptation Strategy. These indicators demonstrate how Germany is affected by climate change and where adaptation measures have already been taken. The indicator system for the DAS is primarily an instrument of the federal state, which is meant to accompany the process of implementing the DAS.

In terms of DRR, the report states that data about the number, duration and causes of the THW's operations show no significant trend towards a permanent increase in operational strain but that singular extreme events, especially recent record floodings, do have a significant impact on operations (UBA, 2015a, p.222).

3.2.2 Horizontal Cooperation

3.2.2.1 Interministerial Working Group on Adaptation to Climate Change

Led by the Federal Environment Ministry, the Interministerial Working Group on Adaptation to Climate Change (Interministerielle Arbeitsgruppe Anpassungsstrategie der Bundesregierung (IMA)), previously an informal working group, was formalised after the adoption of the DAS. Nearly all federal ministries are represented in the IMA[27] (UBA 2015a).
The working group`s purpose is to coordinate the cooperation among the participating ministries and further develop the DAS. In 2015, the IMA submitted the first Monitoring Report on the German Strategy for Adaptation to Climate Change, summarizing climate change impacts and adaptation measures in Germany (UBA 2015a). This Monitoring Report is planned to be submitted every four years to track further developments (ibid).

3.2.2.2 Vulnerability Network and Vulnerability Assessment for Germany

In the Adaptation Action Plan (APA) it was stated that„Germany needs an up-to-date cross-sectoral vulnerability assessment prepared in line with uniform standards". Such an interdisciplinary task required the cooperation of different research institutions and authorities as well as the integration of regional and action field-specific expertise. Therefore, in 2011 the „Vulnerability Network" was established by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the German Environment Agency.

From 2011 to 2015 a network of 16 federal agencies and institutes supported by a scientific consortium, has assessed the vulnerability of Germany to climate change. The purpose was to prioritize the risks of climate change and the need for action at the federal level. For that purpose, existing regional and sectoral evaluations of climate change impacts and vulnerability studies were analyzed. Furthermore, a methodology for a new cross-sectoral, nation-wide standardized vulnerability assessment was developed. Using the vulnerability methodology, an interdisciplinary screening procedure identified those regions and systems across Germany that are particularly

[26] http://www.bevoelkerungsschutz-portal.de/BVS/DE/Zustaendigkeiten/DWD/dwd_node.html

threatened by climate change. The results were discussed at the conference "Germany's vulnerability to climate change" in June 2015 and published in November 2015 (UBA, 2015b). The report does however not present any detailed results regarding the crosscutting issue of „civil and disaster protection". It only states that: "It has not been possible to identify indicators that would allow us to come to any conclusions on civil protection's contribution to the adaptive capacity towards climate change over the entire country. This would require a nationwide uniform data collection exercise that would have to include a cross-organisational approach. Since, however, civil protection has high overall standards, it can be expected that it is prepared for the challenges of climate change adaptation" (ibid: 45).

3.2.3 Vertical Cooperation

3.2.3.1 Standing Committee for the Adaptation to Climate Change Impacts

As part of the federal government's and federal states` working group on climate, energy, mobility and sustainability (Bund-Länder-Arbeitsgemeinschaft Klima, Energie, Mobilität und Nachhaltigkeit (BLAG KliNa)), in 2009, the Conference of Environmental Ministers (UMK) established a standing committee for the adaptation to climate change impacts (Ständiger Ausschuss zur Anpassung an die Folgen des Klimawandels (StA AFK)). The committee's task is to provide information to the federal government and the federal states and to coordinate and link their respective climate adaptation activities in an interadministrative cooperation. One of the committee`s main tasks was the development of the APAs together with the IMA (BLAG KLINa, 2012).

3.2.3.2 Expert Discussions on Climate Change Impacts and Adaptation (Fachgespräche Klimafolgen)

The expert discussions on climate change impacts and adaptation (Fachgespräche Klimafolgen) are a cooperation between federal state authorities and the Federal Environment Agency (UBA). The discussions are focussing on information exchange regarding running projects on climate change issues. The UBA is coordinating the interstate discussions to identify mandatory political tasks around climate change issues and improve and ensure data provision as well as enable technical cooperation and exchange of information to support political actors and institutions such as the Conference of Environmental Ministers of the Länder (Umweltministerkonferenz; UMK).

3.2.4 Legislative Integration of CCA

Since law as an instrument for steering the actions of individuals and institutions plays a central role for adaptation policies, integrating CCA into federal legislation (i.e. climate mainstreaming) is essential for progress on this matter. Accordingly, the Adaptation Action Plan I (2011) elaborates on the way forward regarding the inclusion of climate related issues into federal legislation:

"The federal ministries are called upon to examine whether it is objectively necessary and appropriate to include climate change impacts or adaptation requirements as target, principle or even trade-off aspect in relevant legislation that is being introduced, particularly in the fields of planning and environmental law" (APA, 2011, p.29f).

In a study on climate mainstreaming in federal legislation Bubeck et al. (2016) evaluate the degree and effects of legislative climate mainstreaming in Germany. The authors come to the conclusion that CCA has only been explicitly integrated into very few laws, i.e. the Federal Regional Planning Act (Raumordnungsgesetz (ROG)), the Federal Building Code (Baugesetzbuch (BauGB)) and the Federal Water Resources Act (Wasserhaushaltsgesetz (WHG)). The authors however remark that these are very relevant legislations for CCA.
When the Federal Regional Planning Act was revised in 2008, adaptation to climate change was introduced into the legislation as one of the principles of spatial planning (Paragraph 2, Section 2, No. 6) (APA, 2011, p.29f) but when looking at the actual implementation, climate change issues are integrated rather selectively. There is quite a regional variation, with CCA issues being especially considered within pioneering pilot regions (e.g. within the KlimaMORO initiatives).

Generally, Bubeck et al. (2016) conclude that

[27] Auswärtiges Amt (AA), Bundeskanzleramt (BK), Bundesministerium der Finanzen (BMF), Bundesministerium des Innern (BMI), Bundesministerium für Arbeit und Soziales (BMAS), Bundesministerium für Bildung und Forschung (BMBF), Bundesministerium für Ernährung und Landwirtschaft (BMEL), Bundesministerium der Verteidigung (BMVg), Bundesministerium für Familie, Senioren, Frauen und Jugend (BMFSFJ), Bundesministerium für Gesundheit (BMG), Bundesministerium für Verkehr und digitale Infrastruktur (BMVI), Bundesministerium für Wirtschaft und Energie (BMWi), Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ). Ständig beisitzende Oberbehörde ist das Umweltbundesamt (UBA).

the lack of clear objectives and thresholds in CCA (as they exist for climate protection) is a barrier for implementing CCA on the ground. Defining these for the adaptation to climate change is however more complicated due to the greater dependence on context and location (Bubeck et al., 2016, p. 303). The gaps and barriers regarding the integration of CCA and DRR into legislative frameworks will be discussed further in section 4.1.4.
Another result of the German Adaptation Strategy was the development of rules related to Natech (Natural Hazard Triggering Technological Disasters) risks by the Commission on Process Safety (Kommission für Anlagensicherheit (KAS)). The KAS developed two Technical Rules on Installation Safety (Technische Regeln für Anlagensicherheit (TRAS)) that take into account the effects of Climate Change (Krausmann et al. 2016, p.60):

on the basis of Article 51a of the German Federal Immission Control Act, the BMUB promulgated

- TRAS 310 "Precautions and Measures against the Hazard Sources Precipitation and Flooding"[28] and the

- TRAS 320 "Precautions and Measures against the Hazard Sources Wind, Snow- and Iceloads"[29].

These Technical Rules on Installation Safety (TRAS) apply to implementing the obligations of the Major Accidents Ordinance as well as the EU Seveso-Directive (Krausmann et al., 2016, p.60).

Both TRAS introduce the same systematic approach for Natech Risk Management by operators related to the natural hazards within their scope. They include a short characterization of the relevant hazards and offer recommendations for a simplified and detailed hazard source analysis, the determination of safety relevant parts of installations that may be at risk, specification of protection aims, elaboration of protection concepts, measures for mitigation, and emergency management. The chapters on the characterization of the relevant natural hazards include some information about the expected effects of climate change in Germany on these natural hazards (as known by the time of publication). The parts on hazard source analysis include the recommendation to consider effects of climate change in this analysis. The specification of protection aims considers climate change in some aspects.
The TRAS 310 requires operators to consider climate change by the application of a "climate change factor" of 1.2 (a) on the 100-year runoff of riverine systems and (b) on the 100-year precipitation rate. New installations and installations to be operated until 2050 or later have to comply with this requirement.
The TRAS 320 introduces no "climate change factor" as there was no reliable knowledge on the effects of climate change on top speeds of winter storms, snow- and iceloads in Germany by the time of elaboration of the rule. Nevertheless, the TRAS 320 includes the requirement for operators to consider data on extreme snow loads in the lay-out of their installations (before this was required in the north of Germany only and has been extended to the whole country by the TRAS). This requirement considers possible present effects of climate change on extreme snowfall events. For both TRAS recommendations and explanations as well as background information are available.
Krausmann et al. (2016, p. 139) suggest that TRAS 310 "may be one of the first technical rules considering the expected consequences of climate change. This was possible due to enormous work carried out in Germany, especially on projections of climate change at the regional level". Moreover, the TRAS 310 will be evaluated every five years in terms of needed updates in order to be able to integrate new research results regarding climate change impacts (Bundesregierung, 2015, p.21).

The German water legislation which was updated in 2010 as a result of the EU Floods Directive also foresees an update of hazards and risk maps as well as of management plans every six years because of climate change (see also section 3.1.2.3).

3.2.5 Implementing CCA at Local Level

Municipalities are among the central actors when looking at CCA since many of the impacts of climate change become effective on the local level. Despite that, integrating adaptation measures into urban and spatial planning is still in its infancy.

The report on progress in implementing the German Adaptation Strategy DAS includes an evaluation of regional pilot projects on climate change adaptation (Bundesregierung, 2015, p.26f). The results suggest that a number of climate change relevant measures are taken that are not explicitly termed as such (e.g. flood protection, green areas, avoiding conventional pavement (sealing) by asphalt, concrete or closed stone areas). The report also points out that smaller municipalities do not necessarily have the

financial and human capacities to initiate proper adaptation measures[30] which is further complicated by the fact that there is no ideal adaptation process in terms of „one size fits all" when looking at regional and local levels since the underlying conditions and parameters are so diverse. However, guidelines based on best practices should be created and communicated. In some fields like flood protection and coastal management such examples have been systematically collected and published with a special focus on municipalities and local actors. The evaluation nevertheless showed that climate change adaptation in regional and urban planning often remains within the scope of pilot projects while playing a minor role in practice. This is underlined by the vulnerability assessment`s results: "Actual local-level adaptation activities are generally rather sparse and concentrate on a few urban centres. For this reason, according to the Vulnerability Network estimate, increased technical and financial support is needed in particular in small and medium municipalities" (UBA, 2015b).

3.2.6 CCA Platforms and Tools

Quite a number of different tools and guidelines regarding climate change adaptation on different administrative levels have been developed over the last years. A comprehensive and systematic overview of tools and guidelines for the German context can be found in Gebhardt et al. (2017). In the following, only a selection is presented. Among the most relevant CCA services provided by the scientific community is the Helmholtz Association (Helmholtz-Gemeinschaft) of German Research Centres and its Climate Service Center Germany (GERICS).

3.2.6.1 Climate Service Center Germany (GERICS)

GERICS was initiated by the German Federal Government[31] in 2009 as a fundamental part of the German hightech-strategy for climate protection. In June 2014, GERICS has become a scientific organizational entity of the Helmholtz-Zentrum Geesthacht. It functions as a think tank for climate services and develops prototype products in cooperation with science and practice partners from politics, economy and administration. Two of these tools (Adaptation toolkit for cities (Stadtbaukasten) and Klimanavigator) are described in the info box below.

On a governmental level, the following two organisations have been or are planned to be established to institutionalize the needed services for the implementation of the German Strategy for Adaption to Climate Change:

3.2.6.2 Deutscher Klimadienst

The Deutscher Klimadienst (DKD) is Germany's network of agencies and offices[32] which, on a regular, operational basis, is to provide reliable long-term climate information and climate services. The Deutscher Klimadienst (DKD) was officially launched in October 2015. The DKD`s task is to ensure that climate information and climate services at the national level are scientifically sound, tailored to the users' needs, coherent and reliable, while duplication of work is to be avoided to make best use of existing resources.

3.2.6.3 Klimadapt (planned)

A similar structure with the DKD is planned that provides information and recommendations regarding adaptation measures on the basis of DKD`s climate information together with other parameters. KlimAdapt[33] together with the DKD are supposed to form a comprehensive two-pillar model that represents the overall climate services of the federation[34]. KlimAdapt marks the transition of project-based CCA support to an institutionalized format. A selection of other climate services is listed in the info box on pages 30 and 31.

3.3 Scientific Approaches, Institutions and Programmes on DRR and CCA in Germany

Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) have a closely intertwined trajectory in research. This can be effectively observed in Annex 2, where several research projects and publications address both DRR and CCA related issues. Additionally, both domains are not isolated from each other; the effects of climate change can potentially have a significant impact on the risks faced by the population, on multiple levels (Venton & La Trobe, 2008). This synergy found between DRR and CCA calls for joint efforts capable of providing a systemic perspective, instead of compartmentalized research.
From a general perspective, this report focuses on three fundamental aspects whose description may help characterizing the scientific research in Germany: funding institutions, research centres and scientific

28 http://www.kas-bmu.de/publikationen/tras/TRAS_310end.pdf
29 http://www.kas-bmu.de/publikationen/tras/tras_320.pdf
30 This is supported by recent findings such as the master thesis of Dierck (2016)

Tools of „KomPass - Climate Impacts and Adaptation in Germany“

- **Climate Navigator**

  https://www.umweltbundesamt.de/en/topics/climate-energy/climate-change-adaptation/adaptation-tools/project-catalog/climate-navigator

  The Climate Navigator (“Klimalotse”) supports decision makers in developing their own strategy for climate change adaptation. It is tailored to the information needs of local authorities as well as companies. The platform contains specific information and examples for both target groups and does not require any prior knowledge. The Climate Navigator is guiding users in detail through the process of integrating adaptation measures into existing instruments and involving stakeholders. Adaptation measures are divided into short, medium and long term planning and responsibilities, communication methods, synergies and conflicts are described for each measure. The Climate Navigator is in German language; a short version is available in English.

- **Tatenbank**

  https://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/werkzeuge-der-anpassung/tatenbank

  The “Tatenbank” (deeds bank) introduces exemplary adaptation measures of different stakeholders. It provides all interested parties with a forum for an independent registration of adaptation projects and to receive suggestions for effective action. The database focuses on local and regional measures that have already been carried out or are currently being implemented in Germany. The filter allows for displaying those which somehow relate to civil protection or, more general, DRR. The Tatenbank is only available in German language.

- **Project Catalogue**

  https://www.umweltbundesamt.de/en/topics/climate-energy/climate-change-adaptation/adaptation-tools/project-catalog

  An extensive project catalogue regarding climate change impacts and adaptation documents scientific projects in Germany and Central Europe, which generate basic knowledge on climate change adaptation. It informs stakeholders from research and research sponsors by collecting existing knowledge about climate impacts and adaptation. The Project Catalogue is available in German and English.

- **Klimanavigator**

  www.klimanavigator.de

  The web portal contains portraits of German academic institutions working on issues of climate change and provides an overview of their key research areas. A multifunctional search makes it easy to find institutions and their specific areas of expertise.

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31 Jointly by BMBF, BMU and BMVi
32 Led by BMVi, the DKD`s Secretariat is based at the DWD
33 Led by the BMUB, the KlimAdapt`s Secretariat is planned to be based at the UBA / KomPass
34 Further information and an organigram can be found at: http://www.deutschesklimaportal.de/DE/Themen/4_DKD/DKD.html

Tools for municipalities

- **Stadtklimalotse**
  http://www.stadtklimalotse.net/
  The research programme KlimaExWoSt developed the Stadtklimalotse (city climate guide), a tool that supports medium-sized and smaller municipalities in their decision-making processes. It enables municipalities to assess their own concern in ten fields of action. The core of the tool is a data base that contains approximately 140 adaptation measures that intend to support the user when selecting appropriate, context-specific measures. The Stadtklimalotse is in German language.

- **Climate Scout**
  http://www.klimascout.de/
  The Climate Scout is run by the Climate Alliance and accompanies municipalities and communities in the development of a suitable adaptation strategy. The platform is designed in form of an Internet encyclopaedia and is divided into four modules. It provides incentives for the development of own solutions. The Climate Scout is in German language.

- **Adaptation Compass**
  http://www.future-cities.eu/project/adaptation-compass/
  The adaptation tool was developed in the context of the European cooperation project "Future Cities". With the help of a workbook and numerous interlinked documents, it provides employees of local authorities with information enabling them to determine their own issues and identify cross-sectoral adaptation measures. The Project Catalogue is available in German and English.

- **Adaptation toolkit for cities (Stadtbaukasten)**
  http://www.climate-service-center.de/products_and_publications/toolkits/stadtbaukasten/index.php.en
  In contrast to web portals and other best-practice solutions that can be found on the web, all activities in the Stadtbaukasten are done in close cooperation between city representatives and the Climate Service Center Germany (GERICS). This is supposed to support the development of customized solutions according to the local situation on a case-by-case basis[35].

[35] For a detailed description of the scientific background and the content of the Stadtbaukasten, cf. Cortekar et al., 2016

methodologies frequently used to address research challenges in relation to CCA and DRR.
Funding institutions contribute not only by financial resources, but also shape the horizon regarding research directions and interests through exhaustive selection processes and open calls for specific topics. While Germany offers a wide range of financial support possibilities both for individual applicants and research projects, the economic source can usually be traced to a few, mostly public, entities which are the focus of this report.
It is also worth noting that Germany is the European country with the highest expenditure on research and development and ranked fourth in the world after USA, China and Japan (DFG, 2015).

Germany has also a strong presence and support of well-known research centers, providing the structural capital required for conducting quality research on multiple fields, as described in the next sections for each domain. On a general basis, the organization of research in Germany can be briefly summarized as in the following five pillars:

Higher Education Institutions (Universities): Not only preparing students for a potential research career, but also with a broad offer of research opportunities. Funding for these institutions comes mainly from state level and the DFG (on a project level and after a review process of proposals).

Max-Planck Association: Highly specialized institutes dedicated on fundamental research topics, such as meteorology in the Max-Planck Institute in Hamburg. This association is equally funded by the Federal Government and the States.

Fraunhofer Association: Association of institutes dedicated on applied research. Given its strong cooperation with industry partners, their funding comes mainly from contract research (70%) and the rest from public sources.

Helmholtz Association: Research on big societal challenges. This association is jointly funded by the Federal Government (BMBF) and the respective state (small share). Examples of institutes in this association dealing with earth-related research are GFZ, UFZ, DLR and others.
Institutes of the Leibniz-Association: Smaller research institutions on dedicated topics. This association is equally funded by the federal level (BMBF) and the respective state.

The next sections expand on the differences in scientific approaches, institutional and funding structures between the research communities dealing with DRR and CCA in Germany.
The identified differences are based on the compilation and analysis of several German research projects (the list of research projects taken into account can be found in Annex 2).

3.3.1 Research Support Institutions and Scientific Approaches in Relation to DRR and CCA

Research on DRR and CCA is funded by multiple institutions in Germany. The main contributor is the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung (BMBF)) with a budget for institutionalized research of almost 6 billion Euro annually[36] (cf. figures 6 to 8).

BMBF expenditures on civil security research accounted for 65,8 million euros in 2016 and 71,6 million in 2017 while the German federal government at the same time spent108,2 million and 106,3 million euros respectively (cf. figures 7 and 8).

While funding individual researchers directly is explicitly excluded from the responsibilities of the BMBF[37], it still does so in cooperation with other institutions, being two of the most renowned the German Academic Exchange Service (Deutscher Akademischer Austauschdienst (DAAD))[38] and the Alexander von Humboldt Foundation[39]. In addition to several satellite programmes, the BMBF has two main programmes in place for DRR and CCA. The Framework Programme "Research for Civil Security 2012-2017" (Forschung für die zivile Sicherheit) (BMBF, 2012a) is the reference programme that the BMBF has in place for funding research in association with Disaster Risk Reduction issues. Regarding Climate Change Adaptation, the Framework Programme "Research for Sustainable Development" (Forschung für Nachhaltige Entwicklung (FONA 3)) is the most representative programme addressing Climate Change related issues with funding from the BMBF (BMBF, 2016).

Other financial support institutions for DRR and CCA are the German Research Foundation (Deutsche Forschungsgemeinschaft (DFG)), the largest European organization for funding research, and the Federal Foreign Office (Auswärtiges Amt (AA))[40]. The DFG provides research funds through a variety of grant and funding programmes for scientists in Germany, with a budget of approximately 3 billion Euro annually[41]. The AA aims to improve the quality of Germany's research mainly through international cooperation and scientific exchange support.

Major research centres working on topics related to both CCA and DRR include the institutes of the Helmholtz Association, such as the Centre for Materials and Coastal Research (Helmholtz-Zentrum Geesthacht (HZG))[42], the Helmholtz Centre for Environmental Research (Helmholtz-Zentrum für Umweltforschung(UFZ))[43], the German Research Centre for Geosciences (GeoForschungsZentrum (GFZ))[44], the Jülich Research Centre (Forschungszentrum Jülich (FZJ))[45], the Karlsruhe Institute of Technology (KIT)[46], the Alfred Wegener Institute for Polar and Marine Research (AWI)[47], the Helmholtz Centre for Ocean Research Kiel (GEOMAR)[48] and the German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR))[49].

In the case of DLR, research adopts a highly technological perspective involving mainly applied science. In the case of Geosciences (GFZ Potsdam) and Environmental Research (UFZ Leipzig), these institutes follow lines of integrated research in special fields within their five-year programmes of research (POF).

Qualitative and Quantitative Research Methods

The concept of qualitative and quantitative research is frequently used throughout this document. Hence, it is important to clarify what these concepts mean and how they are used in this context.

Given the complexity of the concept, this document adopts a division between both concepts considering the type of data used (Given, 2008). According to this division, **Qualitative Methods** are a type of scientific research concerned with understanding unstructured descriptive data, normally not in numerical form. These methods are mainly exploratory, and frequently rely on expert's knowledge to interpret the available data.

Quantitative Methods, on the other hand, are those interested in numerical data susceptible of measurement or order. These methods are approached through statistical, mathematical or computational techniques.

In the context of this work, examples of qualitative methods are interviews, case studies, and thematic analysis, among others. Examples of quantitative research are computational simulation, cluster analysis and other computational or mathematical techniques.

3.3.2 Research Support Institutions and Scientific Approaches in Relation to DRR

Scientific knowledge plays a pivotal role in Disaster Risk Reduction, geared at presenting accurate, unbiased insights on catastrophes, and the development of new technology for preventing or mitigating the impacts of such catastrophe. Furthermore, the Sendai Framework on Disaster Risk Reduction 2015-2030 (SFDRR) explicitly recognizes the relevance of science-based methodologies for Disaster Risk Reduction, and sets the goal of strengthening these approaches in the upcoming years (UNISDR, 2015).

Besides the aforementioned funding of scientific research, the Federal Office for Population Protection and Disaster Aid (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe - BBK) carries out

36 https://www.bmbf.de/en/education-and-research-priority-areas-of-federal-government-policy-1410.html
37 https://www.bmbf.de/en/research-funding-1411.html
38 https://www.bmbf.de/de/deutscher-akademischer-austauschdienst-daad-427.html
39 https://www.bmbf.de/de/die-alexander-von-humboldt-stiftung-426.html
40 http://www.auswaertiges-amt.de/EN/Startseite_node.html
41 http://www.dfg.de/en/dfg_profile/facts_figures/statistics/finances/index.jsp
42 https://www.hzg.de/index.php.de
43 http://www.ufz.de/index.php?en=33573
44 http://www.gfz-potsdam.de/en/home/
45 http://www.fz-juelich.de/portal/EN/Home/home_node.html
46 https://www.kit.edu/english/index.php
47 https://www.awi.de/en.html
48 http://www.geomar.de/en/
49 http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10002/

Expenditure area			2005	2012	2013	2014	2015
A+B	Education[2]	billions of euros	143.3	181.4	186.5	192.1	195.1
		share of GDP	*6.2%*	*6.6%*	*6.6%*	*6.6%*	*6.4%*
C	Research and development[3]	billions of euros	55.9	79.1	79.7	84.2	90.0
		share of GDP	*2.4%*	*2.9%*	*2.8%*	*2.9%*	*3.0%*
D	Other education and science infrastructure	billions of euros	4.1	5.4	5.5	5.6	5.8
		share of GDP	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*
A+B+ C+D	**Total expenditure on education, research and science[4]**	**billions of euros**	**193.9**	**251.9**	**257.4**	**267.0**	**275.8**
		share of GDP	***8.4%***	***9.1%***	***9.1%***	***9.2%***	***9.1%***

Explanation of abbreviations/symbols:
GDP = gross domestic product;
OECD = Organisation for Economic Co-operation and Development.
1) Expenditure pursuant to the performance concept. Demarcation pursuant to concept 2012. 2015 figures are preliminary.
C) was calculated using research and development (R&D) statistical methods (Frascati Manual / OECD report).
The budget for education, research and science has been consolidated by the higher education expenditure on research and development, because this position is included in both, A and C.

The BMBF publication „Education and Research in Figures 2017" has been compiling selected data and facts about Germany's education and research system and comparative international statistics since 2011. All are also available in English. The latest one includes the updated overviews and structural data of the past years: https://www.bmbf.de/pub/Education_and_Research_in_Figures_2017.pdf

More detailed analyses are available from www.datenportal.bmbf.de, where one can download current and time-series data, some of which goes back to the 1960s.

Figure link: www.datenportal.bmbf.de/fig-3
Source: Federal Statistical Office (Budget für Bildung, Forschung und Wissenschaft 2014/2015)

Figure 6: *Budget for education, research and science, by expenditure areas, in billions of euros and by share of GDP (2005/2012-2015)*

Figure 7: *German Federal Government expenditure on science, research and development, by funding areas, in millions of euros (2016/2017)*

Funding area[1]	2016 (TARGET)[2,3]		2017 (TARGET)[2]	
	Total	R&D	Total	R&D
A Health research and health industry	2,523.6	2,273.8	2,657.2	2,419.1
B Bioeconomy	245.5	245.4	270.7	270.6
C Civil security research	108.2	102.6	106.3	100.6
D Nutrition, agriculture and consumer protection	914.5	786.9	1,058.2	923.5
E Energy research and energy technologies	1,733.6	1,307.2	1,936.7	1,482.9
F Climate, environment, sustainability	1,507.7	1,294.4	1,647.6	1,429.9
G Information and communication technologies	858.5	820.4	977.7	879.3
H Vehicle and traffic technologies including maritime technologies	487.5	386.4	479.1	374.3
I Aerospace	1,648.4	1,646.0	1,671.0	1,668.5
J Research and development to improve working conditions and in the service sector	153.5	95.1	165.8	107.3
K Nanotechnologies and materials technologies	684.8	655.7	727.3	697.8
L Optical technologies	209.6	205.3	214.0	209.6
M Production technologies	242.0	239.8	260.4	258.2
N Regional planning and urban development; construction research	148.5	115.3	176.4	123.2
O Innovations in education	950.9	464.2	1,068.1	564.2
P Humanities; economics and social sciences	1,407.3	1,082.2	1,529.4	1,170.7
Q Innovation funding for SMEs	1,140.9	1,130.8	1,214.5	1,204.2
R Innovation-relevant underlying conditions and other cross-cutting activities	496.9	388.4	574.2	460.8
T Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes	3,884.7	762.7	4,194.2	793.0
U Large-scale equipment for basic research	1,252.5	1,252.2	1,281.4	1,281.1
Z Global reduced expenditure; budget reserve	-260.2	-260.2	-384.4	-384.4
Total of civil funding areas	**20,338.7**	**14,994.6**	**21,825.9**	**16,034.2**
S Military scientific research	840.2	775.8	1,249.5	1,182.5
Total expenditure	**21,178.9**	**15,770.4**	**23,075.4**	**17,216.7**

Figure 8: *BMBF expenditure on science, research and development, by funding areas, in millions of euros (2016/2017)*

Funding area[1]	2016 (TARGET)[2]		2017 (TARGET)[2]	
	Total	R&D	Total	R&D
A Health research and health industry	2,063.6	2,063.6	2,186.3	2,186.3
B Bioeconomy	245.3	245.3	270.4	270.4
C Civil security research	65.8	65.8	71.6	71.6
D Nutrition, agriculture and consumer protection	53.5	53.5	57.5	57.5
E Energy research and energy technologies	968.9	652.1	1,033.4	716.5
F Climate, environment, sustainability	1,068.9	1,068.9	1,143.3	1,143.3
G Information and communication technologies	679.6	667.4	720.1	657.4
H Vehicle and traffic technologies including maritime technologies	25.5	25.5	28.8	28.8
I Aerospace	93.7	93.7	98.8	98.8
J Research and development to improve working conditions and in the service sector	53.3	53.3	62.8	62.8
K Nanotechnologies and materials technologies	589.7	589.7	630.9	630.9
L Optical technologies	199.1	199.1	203.2	203.2
M Production technologies	229.7	229.7	247.9	247.9
N Regional planning and urban development; construction research	22.5	22.5	24.0	24.0
O Innovations in education	725.1	409.9	808.5	493.3
P Humanities; economics and social sciences	838.4	838.4	885.1	885.1
Q Innovation funding for SMEs	187.3	187.3	210.5	210.5
R Innovation-relevant underlying conditions and other cross-cutting activities	346.1	276.4	448.4	374.6
T Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes	3,719.8	734.1	4,000.5	760.3
U Large-scale equipment for basic research	1,251.8	1,251.8	1,280.7	1,280.7
Z Global reduced expenditure; budget reserve	-260.2	-260.2	-384.4	-384.4
Total expenditure	**13,167.4**	**9,467.8**	**14,028.4**	**10,019.6**

departmental research related to DRR ("Ressortforschung"), both receiving and awarding funds for research .

Some research centers relevant for DRR that were showing up in scientific literature and expert interviews[52] include the Free University of Berlin (Freie Universität Berlin) hosts the Disaster Research Unit (Katastrophenforschungsstelle (KFS))[53], a renowned institution specialising in interdisciplinary disaster research, and the Interdisciplinary Security Research Working Group (AG Interdisziplinäre Sicherheitsforschung)[54], a very prolific group with several high-profile projects in the field of DRR. Other well-known research centers are the Center for Disaster Management and Risk Reduction Technology[55] (CEDIM) part of the Karlsruhe Institute of Technology (founded in 2002 as a common undertaking with the Helmholtz-Zentrum Potsdam), the Institute of Rescue Engineering and Civil Protection[56] (Institut für Rettungsingenieurwesen und Gefahrenabwehr) from the Cologne University of Applied Sciences and the German Center for Geosciences (GFZ) from the Helmholtz Association, with significant presence on the DRR research landscape, holding a high citation/papers ratio on Disaster Management topics in Germany, with particular focus on flood-related research, as well as seismic risk and Tsunamis, as can be seen in Annex 3. The University of Bonn, with the Master of Disaster Management and Risk Governance (Masterstudiengang Katastrophenvorsorge und Katastrophenmanagement (KaVoMa))[57], the United Nations University, in particular with the Institute for Environment and Human Security (UNU- EHS)[58], and the University of Potsdam, with the Research Training Group NatRiskChange (Natural Hazards and Risk in a Changing World)[58], have also a strong presence in the DRR landscape in Germany.

With respect to research methodologies and given the relevance of social factors present in almost any disaster, DRR-associated research is characterized by a combination of quantitative and qualitative methodologies, mainly related to natural sciences while social sciences are rather underrepresented. A review exclusively of DRR research (projects used as source can be found in the annex) showed that expert interviews, scenario analysis, indicator development and questionnaires are some of the techniques most commonly seen in research projects in this field. Other hard-science associated approaches are certainly used too, with a strong emphasis on technical solutions to concrete problems, with a strong presence of engineering departments in higher education institutions in several cities across Germany, such as Aachen, Brunswig (Braunschweig), Hamburg, Hanover, Karlsruhe, Munich [59], among several others. Examples of these solutions are mainly on the field of Communications, Geographical Information Systems and Remote Sensing Technologies. The usage of past data was also present and in the form of case studies and content analysis mainly. High level simulations are also frequent in DRR research, mainly for scenario analysis, „what-if"-studies and other qualitative techniques.

3.3.3 Research Support Institutions and Scientific Approaches in Relation to CCA

On a national level, and besides the funding institutions already mentioned in section 3.3.1, such as the Ministry of Education and Research (BMBF) with the FONA3 Programme, other relevant sources of funding are the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB))[60] (see Info Box), the Hans Ertel Center for Weather Research (Hans-Ertel-Zentrum für Wetterforschung (HErZ))[61] and the Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ))[62].

Due to the transnational nature of Climate Change Research, funding for this topic can also be found from international institutions and programmes, such as the Framework Programmes for Research and Technological Development from the European Commission, being the "Horizon 2020" its latest iteration[63].

In the field of CCA, "Ressortforschung" is also present as in the case of DRR. Several

51 http://www.bbk.bund.de/DE/AufgabenundAusstattung/Forschung/Forschung_node.html
52 http://www.polsoz.fu-berlin.de/en/ethnologie/forschung/arbeitsstellen/katastrophenforschung/index.html
53 http://www.sicherheit-forschung.de/index.html
54 https://www.cedim.de/
55 https://www.th-koeln.de/anlagen-energie-und-maschinensysteme
56 https://www.kavoma.de/
57 https://ehs.unu.edu/
58 http://www.uni-potsdam.de/natriskchange/
59 https://www.tu9.de/tu9/1473.php

governmental agencies, both at national and federal levels, have direct involvement in research, such as the German Federal Institute of Hydrology[64] (Bundesanstalt für Gewässerkunde (BfG)), the Federal Maritime and Hydrographic Agency[65] (Bundesamt für Seeschifffahrt und Hydrographie (BSH)) or the National Meteorological Service[66] (Deutscher Wetterdienst (DWD)), among others[67].

Two important institutions in German climate research that bring together leading scientists in the field are the German Climate Consortium (Deutsches Klima-Konsortium e.V.; DKK) and the Helmholtz Association (Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGF)). The DKK represents leading players of German climate and climate impact research encompassing more than 20 renowned research organisations. The HFG has also a strong presence in Climate Research in Germany, with among others the GERICS Climate Service Center[68], a think-tank for innovation on Climate Science, and the "Climate Service Science" Institute[69] in cooperation with the University of Hamburg, complementing research tasks of the former.

Environment Ministry`s Research Plan 2017

The BMUB's latest departmental research plan (BMUB 2017) outlines the key research areas that the ministry will cover in 2017. Besides the establishment of the KlimAdapt Platform (see section 3.2.6), the department`s priorities in terms of CCA are among others the vulnerability assessment 2021, operationalizing the indicators of the German Adaptation Strategy (DAS) with remote sensing data, institutionalizing best practices in CCA through standardization processes and supporting municipalities and regions with controlled settlement contraction in particularly affected or endangered areas.

It is not uncommon to observe strategical cooperation and alliances between renowned research centers in Germany. The Cluster of Excellence "Integrated Climate System Analysis and Prediction", for example, reunites around 250 scientists from Hamburg University, the Max Planck Institute for Meteorology, the Institute for Coastal Research at the Helmholtz-Zentrum Geesthacht, and the German Climate Computing Centre (DKRZ)[70]. With regard to common research methodologies and unlike Disaster Risk Reduction, a review on Climate Change Adaptation research shows that CCA frequently deals with past data mainly through quantitative analysis. The development of numerical models and methods is a key element of this research, characterized by high volumes of numeric data, sometimes spanning hundreds of years of measured variables. The development of technologies is mostly observed for environmental impact mitigation and more accurate measurement of variables, it does not constitute, however, the main research of this domain. Research on social and legal aspects is also present, although not a pivotal attribute of CCA research, focusing mainly on optimal policies for impact mitigation and societal behavioural changes. Another common aim of Climate Change research is "Vulnerability Assessment" as shown on the website for European Climate Adaptation Platform concerning selected research[71]. This last methodology provides a common ground with Disaster Risk Reduction research.

3.3.4 Interdisciplinary approaches

Throughout the analysed scientific papers and project descriptions, a consistency is found in the usage of the word "interdisciplinary". In this context, interdisciplinarity is introduced as a key element to deal with complex issues that could not be addressed by only one single knowledge domain.

The concept of interdisciplinary research is not only relevant from the scientific perspective, but also from other stakeholders' perspectives, being frequently pushed by governmental funding agencies.

60 http://www.bmub.bund.de/ministerium
61 https://www.herz-tb4.uni-bonn.de/index.php/hans-ertel-centre-for-weather-research
62 https://www.bmz.de/en
63 https://ec.europa.eu/programmes/horizon2020/
64 http://www.bafg.de/EN/Home/homepage_en_node.html
65 http://www.bsh.de/en/index.jsp
66 http://www.dwd.de/EN/Home/home_node.html
67 Information taken from the projects described in the German Climate Change Adaptation Strategy, found in http://climate-adapt.eea.europa.eu/countries-regions/countries/germany
68 http://www.climate-service-center.de/
69 http://www.climate-service-center.de/science/hicss/index.php.en
70 https://www.uni-hamburg.de/forschung/forschungsprofil/exzellenzcluster/clisap.html

In the preface of BMBF's Framework Programme for Civil Security (BMBF, 2012a), Prof. Dr. Johanna Wanka links inter- and transdisciplinarity with the perspectives from multiple stakeholders in research, business and industry. Furthermore, the importance of interdisciplinary research is implicitly made clear throughout the document, and explicitly frames Civil Security as an interdisciplinary and transdisciplinary issue, being the former defined as the integration of efforts from different disciplines, and the later as efforts creating a unity of intellectual frameworks beyond the disciplinary perspectives (Stember, 1991). Another relevant example of how this push strategy is implemented from governmental agencies is the Excellence Initiative from the German Research Foundation (DFG). This Initiative adopts a strong focus on interdisciplinarity through the promotion of Clusters of Excellence, an interdisciplinary network of research centres and graduate education institutions. However, this programme is completely open for all topics. There is one cluster that explicitly addresses CCA (Integrated Climate System Analysis and Prediction; CliSAP[72]) while no cluster on DRR is in place.

3.4 Legal and Policy Approaches Combining CCA and DRR

The need to harmonize CCA and DRR activities in order to guarantee a functioning civil protection system under changing conditions - especially with regard to increased extreme weather events - has been identified by the relevant agencies several years ago:

The working group "Klimawandel und Anpassung im Katastrophenschutz" ("climate change and adaptation in disaster control") was founded in 2008. The working group includes a wide range of institutions active in DRR in Germany, among these the federal level of relief organizations (ASB, DLRG, DRK, JUH, MHD), the Federal Agency for Technical Relief (THW), fire brigades and the BBK (BBK, 2016, p.10f).

Also, the German Strategy for Adaptation to Climate Change deals with the relation of CCA and DRR. Under the heading "Cross-sectional topics: Spatial, regional and physical development planning and civil protection" it states that:

> "Civil protection has only recently started to address the topic of climate change, which means that there has so far been little investigation on the possible impacts of climate change on this sector. Essentially, civil protection is already geared to deal with extreme events and major damage situations. If weather and climate-induced disasters occur more frequently in future, this can present state-managed civil protection with new challenges relating to its resources, crisis and emergency management and operations planning. At the same time these challenges have impacts on the individual protection and self-help measures of the general public. In the centre of attention is the future frequency and intensity of extreme events such as storms and floods, which threaten human life and cause heavy losses and damages" (DAS 2008: 42).

The Federal Office of Civil Protection and Disaster Assistance (BBK) has put quite some effort into the topic of harmonizing CCA and DRR according to their own statement: "The topic has been worked on in the BBK for about ten years now by a full-time employed staff position. Additionally, the BBK has been involved in the funding of research activities in the framework of the so-called Behördenallianz. The research projects carried out jointly with other federal institutions aimed at broadening the information basis specifically with respect to the potential developments of extreme weather events" (interview BBK, 13th January 2017).

This "Strategische Behördenallianz", i.e. a Strategic Governmental Agencies Alliance for adaptation to climate change, exists since June 2007. Members of the alliance include the Federal Agency for Technical Relief (THW), the Deutscher Wetterdienst (Germany's National Meteorological Service (DWD)), the Bundesinstitut für Bau-, Stadt- und Raumforschung (Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR)) and the Umweltbundesamt (Federal Environmental Agency (UBA). The alliance is also motivated by the fact that civil protection was defined as an important crosscutting issue in both, the Deutsche Anpassungsstrategie an den Klimawandel (DAS) of 2008 and the Aktionsplan Anpassung (APA) of 2011. The agencies closely cooperate within the alliance with joint preparation of events such as workshops and seminars, regular exchange of information as well as jointly conducted research (DKKV, 2015a: 13).

The Behördenallianz supports the federal ministries in identifying and implementing strategies, instruments and measures for reducing vulnerability to climate change

71 http://climate-adapt.eea.europa.eu/countries-regions/countries/germany
71 https://www.clisap.de/de

effects. The main aim is to cooperate towards an improved approach in dealing with the effects of climate change, especially regarding extreme weather events - from long-term strategic planning to short-term operative measures. Therefore, the alliance has implemented various joint projects, e.g. on extremes in temperature, wind and precipitation. Similar holds for the UBA project „Bördenkooperation Klimawandel und -anpassung“ (cooperation network of state authorities on climate change adaptation)where DRR aspects are also discussed.

4 Analysis of Challenges and Gaps in DRR and CCA in Germany

After describing the status quo of the institutional set-up regarding CCA and DRR in Germany, the following sections will analyze the challenges and gaps that result from the literature review and interviews. These are described according to the categories defined within the conceptual framework as explained in the introduction to the report.

4.1 Challenges and Gaps: Governance

4.1.1 Institutional Barriers and Stakeholder Complexity

As mentioned earlier, the German governmental system in general is federally organized and follows the department(al) principle ("Ressortprinzip") which means that - within the boundaries set by the Chancellor's political directives - every minister is responsible for his or her own ministry and policy field independently. These two general principles of German politics also have a substantial influence on the institutional arrangements regarding CCA and DRR as well as their integration. In terms of challenges and gaps, the division of tasks between the Federation and the federal states (and the municipalities) as well as between different governmental departments interferes both with the implementation of DRR and CCA respectively as well as with the harmonisation of both.

The vertical cooperation within DRR is complicated by the distinction between civil protection (with respect to international conflicts ("Zivilschutz")) with administrative responsibility at the federal level and civil protection with respect to all other kinds of hazards and threats ("Katastrophenschutz")) that falls under the responsibility of the federal states (see section 3.1.1). As Martin Voss points out, „in other countries with a more centralised system, it is often expected that the BBK could take the lead in transboundary situations that involve several federal states which is not the case" (interview with Voss, January 5th, 2017). Therefore, in view of disasters that cross the borders of federal states or even nations, some actors such as Jens Lattmann of the Association of German Cities (Deutscher Städtetag; DST) call for an institutional restructuring that abolishes the separation of "Zivilschutz" and "Katastrophenschutz" and the affiliated administrative separation (BBK & DST 2010: 4). Also, the distribution of power and legislative frameworks at the different levels is not the same for CCA and DRR, since no document comparable to the National Adaptation Strategy for CCA exists for DRR. Reimund Schwarze calls this a "mismatch of responsibilities" as there is a limited charge to the national level in terms of German DRR in comparison with CCA (interview with Schwarze, January 7th, 2017). Some interviewees speculate that this might change when governments rearrange their DRR structures to comply with the Sendai Framework (cf. UNISDR, 2015)

Regarding horizontal cooperation, the fact that DRR and CCA are not based within the same ministerial portfolio (CCA is mainly within the responsibility of the Environment Department, while DRR falls under the area of competence of the Department of the Interior) is the case for most sectors mentioned as relevant for CCA in the National Adaptation Strategy:

> "With respect to CCA the administrative structure not only encompasses different administrative levels, but also different government departments at all levels. At federal level the department of environment has the lead, but the list of the different fields of action given in the national strategy of adaptation to climate change at first glance reveals that other ministries are in charge of implementing the strategic goals. Accordingly, constant information exchange and coordination between the different government departments is central" (interview BBK, 13th January 2017).

While initiatives focusing on such information exchange and coordination between the different government departments do exist (such as the working group on "Climate Change and Adaptation in Civil Protection" or the agency alliances and cooperation described in section 2.3) interviewees mentioned a rivalry between the ministries and the associated agencies. While interviewees usually referred to this rivalry in a way that each department is eager to keep as many responsibilities as possible, unclear distributions of responsibilities can also lead to the opposite case such as in the case of critical infrastructure providers:

> "Given the inadequate approach of the various relevant federal ministries (for example, the Federal Ministry for Economics and Technology, and the Federal Ministry of the Interior) to incorporating responsibility for climate change adaptation by private-sector critical infrastructure providers into their respective domains, this responsibility should be delegated to an agency" (Schneider 2014).

When looking at the harmonisation of CCA and DRR, most initiatives aiming at cooperation between the DRR and CCA communities mainly involve federal level stakeholders and institutions while the actual implementation of measures falls under the responsibility of the federal states and municipalities. The UBA is aware of the fact that federal cooperation is quite mature but when looking at the departments on the Länder-level, everyday administration of the ministries runs rather parallelly: "There is awareness on both sides that CCA and civil protection have to come together especially in terms of extreme weather events but the structures that are decisive for taking measures are separated" (interview UBA, January 16th, 2017, own transaltion). Moreover, stakeholders active at the Länder-level such as Herbert Trimbach who is leading working group V on Fire Fighting Issues, Rescue Services, Disaster Prevention and Civil Defence within the Permanent Conference of Interior Ministers of the Federal States, stress the point that from a short to mid-term perspective, the harmonisation of DRR and CCA is not likely going be a priority for administrations dealing with civil protection at both federal states and municipal levels since these are rather busy with implementing the concept for civil protection (KZV)[73] which is legally binding while the integration of CCA in many cases is not.

Besides this, some of the interagency mechanisms have been described as "predominantly characterised by the features of negative coordination: The 'lead' ministry assumes a steering role, information is collected rather than shared, consensus is based on the veto-right of single ministries and the coordination output (‚Aktionsplan Anpassung', APA) does neither reflect a shared concept of adaptation policy nor joined policy measures. The coordination process as well as the APA reflect the selective perceptions and single organisational interests, which become manifest in defending individual areas of competence, the veto-rights based on the departmental principle as well as in the dominance of single departmental projects in the APA" (Hustedt, 2014).

The German Strategy for Adaptation to Climate Change also focuses on the federal level, however, explicitly targeting other administrative levels as well (Bundesregierung 2008: 4). This is essential in order to be relevant for civil protection with its competencies distributed at different levels. Especially DRR related to extreme weather events, which dominates the discussion on the relevance of CCA for civil protection, traditionally falls into the responsibility of the federal states and municipalities (BBK 2016: 9). Wolfram Geier, Director of the Department of Risk Management and International Affairs at the Federal Office of Civil Protection and Disaster Assistance (BBK) underlines the differences of CCA measures between federal and Länder level:

> "The range of possible measures taken at the federal level to a certain degree reflects the (limited) responsibilities of the respective administrative structures in the risk management of natural hazards: the federal institutions mainly engage in overarching, basal questions such as providing information and advice, coordinating working groups, advancement of the information basis for all other actors by way of research or the identification of general recommendations for adaptation options at other levels. The National Adaptation Strategy has counterparts at the Länder level. The actions to be taken in order to implement the strategy in the area of civil protection (here, accordingly, in the sense of Katastrophenschutz) necessarily differ at Länder level in that they are clearly more to the operative side"
> (interview BBK, 13th January 2017).

Therefore, the federal states` climate adaptation strategies are of special importance. When looking at these strategies, the topic of civil protection is dealt with in very diverse ways (see also section 2.2.1.8): while some explicitly mention the topic and elaborate on relevant actors, potential or existing adaptation measures, formulate objectives and responsibilities while others rather do not mention civil protection as a separate point (BBK, 2016, p. 25). Even though this diversity of approaches makes an integrated approach more complex, it reflects the overall stakeholder complexity within the German DRR system.

As Wolfram Geier (BBK) remarks:

> "Even if the responsibility for civil protection is clearly situated at the ministries of the interior both at federal and Länder level, there is a strong need for constant discussion and reconciliation with the administrations under the responsibilities of other

73 https://www.bmi.bund.de/SharedDocs/Downloads/DE/Broschueren/2016/konzeption-zivile-verteidigung.pdf?__blob=publicationFile

> government departments as, for instance, questions concerning flood protection or risk management in the context of hazardous facilities, are shared with the departments of environment and/or economy at all administrative levels. This situation clearly is not one specifically influencing the cooperation between DRR and CCA but a general condition of the administrative system of Germany as a federal state - yet, it is a condition that constantly needs to be kept in mind when seeking for cooperation with DRR: the abbreviation "DRR" in Germany does not relate to a monolithic entity or at least a homogenous structure, but to a variety of actors with highly differentiated responsibilities"
> (interview BBK, 13th January 2017).

On the other hand, stakeholder complexity has – according to interviewees – the great advantage that the German system allows for solutions tailored to local circumstances. While Germany's decentralised structures retain strong benefits (fast response, deep local knowledge and support), the question remains whether the system will function adequately when exposed to increasingly challenging situations, such as large-scale power and infrastructure failures (Reichenbach et al., 2008). Most interviewees mention the political and administrative complexity to be one of the most important challenges related to the harmonisation of CCA and DRR.

Nevertheless, interviewees (as well as policy-makers and security professionals interviewed in other studies) continue to regard Germany's historically grown and decentralised structures for civil security as exemplary with comparatively high levels of public trust and legitimacy (cf. German Red Cross, 2010; Hegemann & Bosong, 2013). The strong involvement of volunteers in Germany's civil protection system contributes to maintaining the link to the general public. However, wider social and economic changes including demographic changes and the suspension of military subscription in 2010 (which before regularly provided a great number of conscientious objectors that would serve in relief organizations instead) negatively influence the number volunteers that are at the disposal of Germany`s civil protection system. Therefore, institutions such as the THW seek new ways of voluntary involvement that do not require long-term commitment but are less formalized and more task and event-related. Forms of engagement that rely on social media can also support relief organizations such as Virtual Operation Support Teams (VOST) that are currently being tested in the German context[74].

4.1.2 Funding Arrangements

Earlier assessments of the linkages between CCA and DRR identified structural difficulties in funding arrangements, since the objectives usually reflect the issuing institution`s scope of interest (Birkmann & Teichmann 2010). Likewise, most interviewees stated that a growing popular interest (and accordingly political relevance) in climate change issues within the last years has resulted in a shift of funding in favour of climate change issues. This complies with an analysis of search-term popularity in Germany. Using Google Trends, we compared "Emergency Management" and "Climate Change" as aggregators of DRR and CCA respectively.

The results that can be seen in Figure 6 indicate that "Climate Change" has been a topic with increasing presence, particularly after 2006, coinciding with the publication of the Stern Report and the release of Al Gore's movie on the impact of Climate Change, "An inconvenient truth". Averaging from 2004, the topic "Climate Change" is almost three times more relevant than "Emergency Management", with an interesting seasonal fluctuation that may be due to the annual UNFCCC conferences (COP). The peaks in emergency management in 2013 and 2016 could be related to the flood disasters in Germany that occurred in the respective years (described in section 1.1.2). However, climate change obviously covers more than CCA (e.g. mitigation) and „emergency management" does not fulfil the aggregation function for DRR as „climate change" does for CCA.

In general, interviewees perceive an overall trade-off between CCA and DRR regarding funding structures. As Martin Voss, sociologist and Head of the Disaster Research Unit at the Freie Universität Berlin, puts it:

> "One can say that it is precisely because of CCA that there is little willingness to run DRR.Everything is framed in terms of climate change. This is, of course, also visible in the funding structures. All of the classical topics that one could apply for 20 or 30 years ago are only funded today if one also includes the words 'climate change' 20 times"
> (interview with Voss, January 5th, 2017).

This is however not necessarily a disadvantage per se. Most interviewees understood the increased availability of funds related to climate

74 http://vostde.de/

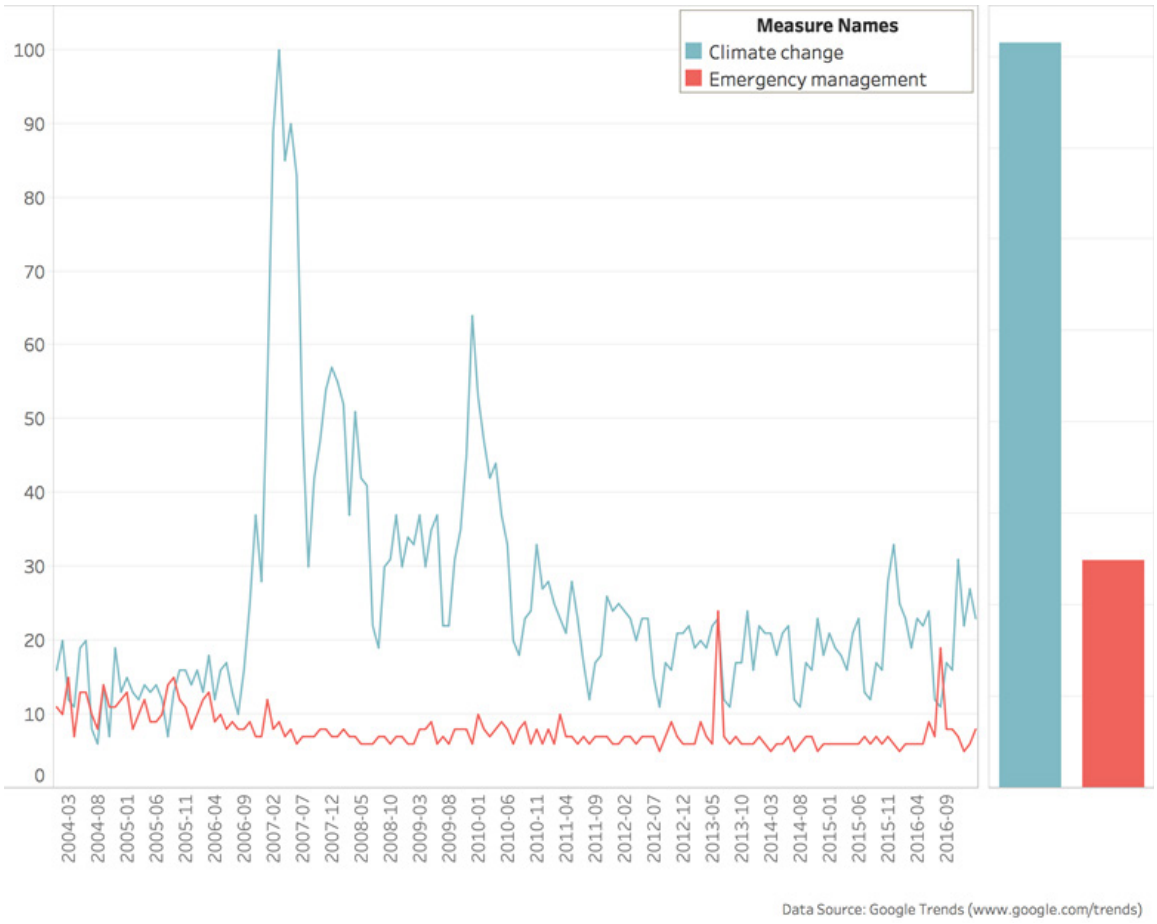

Figure 6: *Population Interests through the years for DRR and CCA, based on online searches*

change research as a possibility of cherry-picking: projects can simply be reformulated according to the funding requirements so that e.g. a climate change element would be included into a DRR project to become eligible for funding under a certain scheme.

International studies stress the temporal mismatch of funding schemes in DRR and CCA to be "a major drawback for further integrating the fields of disaster risk reduction and climate change adaptation. Especially problematic were the differences between a rather short-term funding for disaster response by humanitarian donors and the necessity of long-term financial support for adaptation strategies" (Birkmann et al., 2009, p. 7). While this is not perceived as very relevant to the German context, as funding for DRR in Germany does not typically come from "humanitarian donors", but from within the federation and from research-oriented funding institutions, especially experts from the scientific arena suggest a lack of vertical and / or horizontal cooperation in the allocation of funding between the different departments.

As Geier explains, "the general funding of the institutions/organisations involved in the civil protection system in Germany lies with the respective administrations. That is, the federal level has to financially support all institutions within its responsibility, such as the Federal Office of Civil Protection and Disaster Assistance (BBK) as well as the Technical Relief Organisation (THW, the operative organisation held by the federal level). The federal level does also give additional funding to the Länder for sustaining the operative forces the federal level relies on in order to fulfil its tasks in terms of Zivilschutz. The Länder delegate the organisation of the operative forces at the communal level – accordingly the general funding of day-to-day emergency management that involves the local fire brigades and the relief organisations

generally is in the hands of the communal level. More closely to the idea of "initiatives" are the funding schemes of the ministry for the environment at federal level (BMUB). It provides project based funding for initiatives at communal level in all fields of action of the German adaptation strategy"
(Interview BBK, 13th January 2017).

Accompanying the Adaptation Action Plan, since 2011 through the program „Förderung von Maßnahmen zur Anpassung an die Folgen des Klimawandels" the BMUB finances measures to adapt to climate impacts. As the programme intends "multiplier effects", especially measures with a societal model function and high public visibility are targeted. The programme has three key areas: 1) adaptation strategies for businesses, especially within SMEs and municipal companies, 2) development of educational programmes on climate change and adaptation and 3) municipal lighthouse projects and local as well as regional cooperation.

A first evaluation of the funding programme (Huschit el al., 2014) shows that, 35 projects were funded through the programme from 2011 to 2014 with almost EUR 7 million in total of which 5.6 million went into the third pillar "municipal lighthouse projects and local as well as regional cooperation"(ibid: 8). The analysis of project topics also shows that civil protection as a crosscutting issue was not among the fields of action that received funding until 2014 (ibid: 13). However, the number of projects had risen to 70 in April 2016 (BMUB, 2016) now also including a project in the field of DRR. Also, the field of action with most activities by 2014 was "water" including projects on flood protection, coastal protection etc. which are obviously strongly related to DRR. Further, the statistics regarding recipients of funds shows that universities and research institutions are overrepresented in relation to municipalities, NGOs, businesses and others (ibid:17).
This underlines the statements of interviewees that municipal actors often might not have the same experience in applying for funds as university staff and researchers. It also underlines statements and studies such as Birkmann et al (2007, 2009) that the most well-developed issues related to CCA and DRR are water issues.

Another funding scheme of the BMUB that also includes the funding of CCA activities is the National Climate Initiative (Nationale Klimaschutzinitiative). It more generally aims at funding activities at different levels and not only in CCA but to an even higher proportion in mitigation. Since its start in 2008 until the end of 2014 around 19,000 projects were financed with a total budget of more than 555 million Euros (BMUB 2015). The National Climate Initiative's programmes especially promote

- climate mitigation in municipalities, and in social and cultural institutions,
- innovative projects in industry and in the consumer, education and municipal sector,
- highly efficient small combined heat and power (CHP) systems and
- commercial cooling and air-conditioning plants.

As one can see from the above, there is quite a diversity in funding for both scientific research on and implementation of climate change adaptation, in some cases also explicitly related to disaster risk reduction. However, as several interviewees pointed out, for "every day" operational activities of civil protection institutions, municipalities or businesses, funding is not available to the same extent. The problem is not necessarily that funding is not available per se, but that funding programmes do not reach the relevant target groups on the ground.

There are several reasons for this phenomenon. According to Wolfram Geier, the feedback from individuals, working groups and discussions with stakeholders at the Federal Office of Civil Protection and Disaster Assistance (BBK) suggests that one reason is a deficient awareness of "other" departments` activities, namely the funding available for CCA by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB):

> "The funding schemes named above are all provided by the environmental department but give funding to initiatives from all kinds of different contexts including civil protection. But: the institutions of the civil protection system might possibly not be looking for funding here and the BMUB as a potential donor might not be known to the respective target group. There might be a lack of awareness that the everyday task of the civil protection organisations, such as, constantly improving the operations in emergencies caused by weather conditions, might also be considered an important CCA activity. The activity then is not "framed" as a CCA activity by those who perform them every day and, accordingly, the idea of seeking for funding schemes under this headline does not come into play"
> (Interview BBK, 13th January 2017).

Another reason is that many funding programmes ask for an own financial contribution from the applicant, often amounting up to 25% of the total costs ("Eigenfinanzierungsanteil"). A lot of cities and communities are not able to provide the necessary amount of financial resources. Accordingly, these programmes might not be appropriate for every community who would like to engage in CCA via applying for funding.

On top of financial resources, many funding programmes also require human resources in order to obtain funding, simply because of the capacities needed to write a proposal or application:

> "Writing a promising application for funding can be a demanding task which requires well-informed, experienced staff members. For communities which do not have the personnel resources needed the application process might be challenging and, at times, disappointing. This aspect is particularly relevant against the background of the predominantly voluntary organisation of the German civil protection system. There is a need for comprehensive `helpdesk services` in the funding institutions that is approachable for those who are thinking about applying" (Interview BBK, 13th January 2017).

In other cases, however, there seems to be a lack of available funding especially when it comes to adaptation on the ground, e.g. when talking about the impacts of climate change on the working conditions of safety and security personnel (both in public and private enterprises) or on those of small and medium-sized enterprises (SMEs). As an example, Marc Knoppe, head of the Masters Programme Security & Safety Management and Vice Dean at the Technical University Ingolstadt, describes a vivid situation in which the impacts of climate change are directly to be felt by operational staff:

> "When the protective clothing and equipment for the THW was designed, a certain maximum temperature was presumed. Today, when THW staff is on duty in summer, working on a highway at 35 °C above zero, those people have a high risk getting a heat stroke because of their thick suits. While the textile industry tries to improve the quality of protective clothing for relief units, adapting to the higher temperatures, very little public funding is made available for these research activities[75]
> (Interview Marc Knoppe, 18th January 2017)"

Likewise, little is known about the impact of climate change on SMEs` assets when comparing those SMEs that take preventive measures to those that do not, e.g. when looking at delivery failures due to climate induced events such as floodings[76].

4.1.3 Political Will/Motivation

Expert interviews reveal rather heterogeneous perspectives regarding political will to integrate or harmonize CCA and DRR. Stakeholders within the relevant ministries` associated agencies perceive political will to be existent within both the CCA and DRR communities, while "outsiders" (i.e. interviewees from academia, private sector and civil society) are more critical in this regard. Most of them agree that a general will can be observed but that there is a trade-off between political will and a) economic interests as well as b) political retention of power:

> „I would say that a political will exists in this country, but only to the extent that it fits within a certain economic perspective. Political will is there on a fundamental level – I think that is the German dogma – insofar as it is market-compliant so that it can occur in a more export oriented manner, and in that way connect other markets, support its own technologies. That is, it is present wherever its own benefit exceeds the adaptation and adjustment costs. Pure adjustment at one's own expense, that is, without additional benefits for the donor-country Germany became much more difficult over the last decade. This isn´t generally evil to look for win-win-solutions, but it excludes many ethical and humanitarian needs" (interview with Martin Voss, 5th January 2017).

Oliver Hauner from the German Insurance Association (Gesamtverband der Deutschen Versicherungswirtschaft (GDV) stresses the interest of political actors to be reelected:

> "Political will to integrate climate change adaptation measures into legislation depends on how well it fits the mainstream. If you have to communicate an inconvenient truth it becomes difficult and when it comes to natural hazards the messages are usually not too positive. It costs money to prepare for them and you talk about risk so you do not become more popular as a politician. When

[75] As part of their adaptation to climate change, the BBK has conducted a survey on the impacts of heatwaves on operational staff active in DRR. Results show that fire brigades and THW have not experienced relevant heat-related staff shortages while other relief organisations did have problems with this issue in the past (BBK, 2016, p. 44)
[76] Exceptions are e.g. Kreibich et al. (2007) and DKKV (2015b)

> you make a revision of the building act then this is fine but when you want to change something that has a real impact on citizens and municipalities then you encounter greater resistance"
> (interview with Oliver Hauner, 21st January 2017).

According to Hauner, this can lead to rather odd situations in particular cases: "Especially, if professionals within ministries, agencies and the like are aware of certain risks and are therefore willing to act preventively, while politicians are unsure about the public opinion or the impact of certain measures on the public finances respectively the overall economic development". Hauner points out that "politically influenced communication therefore tends to trivialize risks or tries to make sure, that the risk is identified and fully under control. But if the risk finally has materialized, every now and then the `blame game` is played by putting the blame on the administration or on others". When looking at studies regarding that topic, during and after the flood in 2002, climate change was made responsible; after the flood of 2013, the general public opposing to certain flood protection measures was blamed (by politicians) in the media (cf. Otto et al., 2016; Becker and Rexhausen (2015)). Experts in earlier studies have pointed out that a lack of knowledge, awareness and interest for crisis management among the wider population is related to missing day-to-day emergency management and relevant programmes for public education and popular exercises (Hegemann & Bosong 2013).

One example are natural hazards information systems that enable citizens to evaluate the exposure to different hazards at a certain location. Hauner points out that a nationwide information system[77] like in Austria would be necessary so that all citizens could take appropriate precautionary measures on the household level but that these are still politically unpopular as a better knowledge base on location-specific hazards might lead to a loss in value of affected properties, although the introduction of such a system was decided by the UMK after the flood of 2013.

Besides the mentioned barriers, interviewees criticize a general tendency of political will with regard to disaster prevention to be rather event-related, i.e. that political will to act is always present in the aftermath of a hazardous event but gradually decreases the more time elapses after the event. This is illustrated by the fact that most interviewees mentioned heavy rainfalls (such as the ones that occurred in Germany in May / June 2016) as a political motivator for the harmonization of DRR and CCA. In general, most interviewees mentioned the fact that both individual and institutional stakeholders have an interest in keeping as much political power and therefore responsibilities within their portfolios which sometimes hinders effective collaboration and harmonisation of CCA and DRR in terms of political will.

4.1.4 Legislative Integration of Frameworks

As discussed in section 2.2.1.10 there is only a partial integration of climate change impacts or adaptation requirements as targets, principles or even trade-off aspects in relevant legislation. For those regulations that are already climate-mainstreamed i.e. the Federal Regional Planning Act (Raumordnungsgesetz (ROG)), the Federal Building Code (Baugesetzbuch (BauGB)) and the Federal Water Resources Act (Wasserhaushaltsgesetz (WHG)), there is still little practical implementation on the ground. According to Bubeck et al. (2016), one reason is the short time since the new legislations came into effect and the resulting lack of methodological tools and protocols for implementation. He adds that Regional and Urban Development Plans have both long drafting procedures as well as duration of validity so that integration of climate change issues takes time.

Best practices regarding implementation of CCA issues on the municipal level have often evolved within pilot projects that were promoted and financially supported by the government and / or accompanied by scientific research. While there is quite a number of guidelines and tools that aim at distributing examples of best practices, Bubeck et al. (2016) point out that smaller municipalities with less resources to tackle a complex topic such as CCA should increasingly be targeted and supported.

When explicitly looking at an integration of CCA and DRR in legislation there is rather little progress besides the Technical Rules on Installation Safety (Technische Regeln für Anlagensicherheit (TRAS)) that take into account the effects of Climate Change as discussed in chapter 3.2.4. The same holds for the Floods Directive and its implementation in the Federal Water Act. Still, with regard to flood management, the 2013 event and the current legislation, "there is a chance that a more integrated flood risk management will become permanently implemented" (Thieken et al., 2016b).

Little progress in terms of legislation is perceived as a gap by interviewees and reflects earlier surveys on the topic of CCA and DRR in Europe such as the one by the

[77] such as the „Zonierungssystem für Überschwemmungsrisiko und Einschätzung von Umweltrisiken" (ZÜRS Geo)

European Forum for Disaster Risk Reduction (EFDRR, 2013) in which legislative integration has been pointed out as a major challenge. While the harmonization of policies on the federal level - despite the stakeholder complexity of the German system - is quite mature on the federal level, provisions for individual precautions are rather weak. As Oliver Hauner from the German Insurers points out, there is a need for mandatory provisions rather than for optional or advisory regulations. Reinhard Vogt, former head of the flood protection agency of the City of Cologne, adds that there is a clear lack of legal provisions for climate-relevant local protection of property. The lack of subsidies for property-level protection measures regarding floods was also highlighted by DKKV (2015).

4.1.5 Procedural and Legal Frameworks in Transboundary Disaster Management

Regarding transboundary disaster management interviewed experts and existing literature, both suggest that flood management on transboundary rivers is a best practice example. Procedural and legal frameworks have substantially improved over the last 15 years in particular in terms of flood warning, where clear regulations and agreements are in place in most of the regions – also as a result of large scale, transboundary hydro-meteorological events like the Elbe/ Labe floods in 2002 and 2013: "Comparison of DRR and CCA capabilities in 2013 vs. 2002 demonstrates substantial progress that has been made on transboundary and transnational exchange of critical information and resources to deal with such disastrous situations" (interview DWD, 6th Febraury 2017).
Explicitly mentioned as decisive for improved transboundary management of natural hazards by all interviewees were the Floods Directive and the Water Framework Directive. As a legal act, mandatory for EU members, the directive has been a crucial step towards cooperation and joint objective-setting across national borders. This is why most initiatives mentioned as best practices in transboundary management were related to riverine and coastal risks, such as the International Commissions for river protection (International Commission for the Protection of the Rhine (ICPR), International Commission for the Protection of the Elbe River (ICPER), International Commission for the Protection of the Danube River (ICPDR)) or the Coastal & Marine Union (EUCC) and the Wadden Sea Forum.
One of the main points of criticism regarding the German system for transboundary disaster management in the past was the lack of a national contact point (German Red Cross, 2010). This situation has been changed however: since June 2010 the GMLZ at the BBK has taken over the task of Germany`s National Contact Point and therefore functions as the official centre for alerting and informing the relevant actors in case of disastrous events.

The BBK is also active in other dialogue activities with Germany's neighboring states on issues concerning the efficiency and effectiveness of civil protection and emergency management to create synergies in cross-border cooperation such as the international high level expert meeting on the role of civil protection and emergency management in a changing security context in 2017.
However, in terms of legislation, the German law does not address the issue of international disaster assistance besides existing bilateral agreements. This does specifically apply to the case in which Germany itself would be in need for assistance from other countries:

> "This lack of relevant legislation can primarily be explained by the fact that so far there has not been a disaster on German territory resulting in a (true) need for international assistance. The general assumption among German authorities and organisations is that in hardly any case imaginable would Germany actually need to request international disaster assistance. Therefore, national stakeholders do not see any requirement to fill this legislative gap. While the system has indeed proven successful until now, the question remains open as to whether the complex and decentralised German system will be able to indeed coordinate and operate effectively, particularly in the occurrence of a disaster of a scale that would make Germany dependent on international assistance"
> (German Red Cross 2010).

4.1.6 Mismatches

Interviews point to the fact that there are very diverse perspectives on the meaning and relevance of the so-called mismatches among stakeholders, i.e. practical barriers in implementing an effective link of DRR and CCA that were described by Birkmann (2009, 2010). According to his classification, mismatches can be categorised into three key areas: scales, knowledge and norms.

While aspects of knowledge and norms are partly

covered in other sections of the report, within the applied conceptual framework, special focus was on scale issues. Scale mismatches cover three types of scales: spatial, temporal and functional. All of these are relevant for developing DRR and CCA strategies. The spatial mismatch refers to the fact that climate change issues have mostly been studied on a global scale while disasters are mainly analysed with a regional or local perspective. Spatial mismatches were mentioned by experts mainly in terms of incoherent databases that do not link CCA and DRR data in assessments of risks and vulnerabilities. Most experts underlined the relevance of temporal mismatches since long-term, slow onset climate risks are rarely considered in DRR practices. Also referring to the temporal scale, Voss emphasized that all solutions that seem functional within a certain context at a specific point in time are not evaluated according to their long term effects at all (interview with Voss, January 5th, 2017). Functional scale mismatches refer to the governance of DRR and CAA and have been described separately at length in section 4.1.1 since both interviewees and literature analysis suggested institutional barriers and stakeholder complexity to be a major gap in the German context.

4.2 Challenges and Gaps in Risk Perception and Assessments

4.2.1 Risk Perception

While the synergies and the need of bringing CCA and DRR together are discussed at length in many scientific articles, professional reports and policy papers, the relation of DRR and CCA and how this relation should be translated into collaborative structures remains unclear. As Birkmann et al. (2010) point out, it has been argued by some that CCA should be mainstreamed into DRR while others claim that DRR can be coined as a crosscutting topic within CCA: "These conceptual differences are indeed one of the factors that have so far prevented an effective linkage between both communities".

The German Adaptation Strategy to Climate Change defines DRR as a crosscutting issue within a general CCA strategy. Whether or not this makes more sense from a technical point of view than the other way around (in terms of enhancing synergies, effectiveness and efficiency of measures related to CCA and DRR), many interviewees voiced doubts about this conceptual approach. Some argued that climate change is only one driver of disasters among others and that many risks are not influenced by climate change at all, others pointed out that the issue is not about integrating one into the other but rather about harmonising the two in terms of cooperation.

It can be observed however that such epistemological gaps regarding the understanding of risk and the relation between DRR and CCA do not run between DRR and CCA communities but rather between different disciplines. Also, both the existence of any epistemological gap as well as the existence of CCA and DRR communities per se is rather stressed by researchers, much less by practitioners. Wolfram Geier from the BBK for example remarks that "the "labelling" of an activity or an institution as either one or the other seems counterproductive and is possibly missing the point. Of course, one can think of purely organisational or academic questions related to CCA. But mostly "doing" CAA in terms or application would not work without doing it in specific fields of activity." Disciplinary borders matter especially when looking at the differences between social and natural sciences. The field of climate change research is dominated by the IPCC-process and by the natural sciences per se with the resulting influence on risk perception. This is criticized by social scientists working on these issues, especially with regard to the dominance of quantitative data in risk assessments. Martin Voss, sociologist and Head of the Disaster Research Unit at the Freie Universität Berlin points out that "scientific approaches influence the risk, the assessment of risk, because they place more value on what can be quantified. It is always easier to push quantified aspects through. They are easier to fund, they can be displayed, they are easier to report, etc. While this can be quite productive, risks are social phenomena and can mostly not be evaluated through a technical formula" (interview with Voss, January 5th, 2017).

Besides this perspective of socially constructed risk there are already some divergent perspectives on risks even within those communities that work with technical and quantitative assessments of risk.

4.2.2 Risk Assessment

The assessments of risk and vulnerability in Germany described in chapter 3 differ in terms of methods and approaches: in DRR, risk is generally calculated according to the risk formula of the International Organization for Standardization (ISO 31000 and ISO 31010[78]), e.g. within the National Risk Analyses in

Civil Protection (cf. section 3.1.5.3). Within this methodology, risk is understood as the product of the potential occurrence of an extreme event ("hazard"), the propensity or predisposition to be adversely affected ("vulnerability") and the presence of people, livelihoods, environmental services and resources or economic, social, or cultural assets in places that could be adversely affected ("exposure"). In general, one can say that risk assessments in Germany generally focus on one hazard at a time and their strategies are developed on country, state and municipal levels (e.g., Kreibich et al., 2014). This means that multi-hazard risks are usually not considered, i.e. only considering one risk at a time and not more than one hazard type, also not considering how they may interact with each other.

For example, one hazard may trigger another (e.g., earthquakes triggering landslides) or may amplify another (e.g., heavy rains or floods may enhance the likelihood of earthquake induced landslides). One of the few studies dealing with this in the German context was to examine the multi-hazard environment of Cologne (Grünthal et al., 2006) which is threatened by wind storms, earthquakes and flooding, although again interactions between hazards are not dealt with.

In CCA, vulnerability is usually more broadly defined as the relationship of all these components, i.e. hazard, susceptibility, and exposure in relation to the capacity of human and natural systems to cope with a certain risk ("coping capacity"). In the Assessment Reports of the IPCC vulnerability is defined as "the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which the system is exposed, its sensitivity, and its adaptive capacity"[79]. This corresponds by and large to the German Vulnerability Assessment`s findings: the full version of the report (only available in German) includes an analysis of 155 studies on vulnerability assessments in Germany. The results underline the conceptual differences between the "risk" and the "vulnerability" approach: around 40 % of the studies were based on the IPCC`s vulnerability concept, while around 24% relied on the risk concept. The remaining studies either used a combination of both or completely different concepts (UBA, 2015b, p.136).

Regarding the conceptual differences between the National Risk Analysis in Civil Protection and the Vulnerability Assessment in Germany, involved experts pointed out that these were openly communicated and that the "translation" of methodological or conceptual terminology was largely unproblematic. According to interviewees, the remaining terminological ambiguities were not caused by the two (scientific) communities (CCA and DRR) using different terms or using the same terms differently but rather by the scientific challenges involved. In addition, interviewees pointed out that the differentiation between vulnerability and risk as such does not reflect the more recent IPCC approach (as in the AR5 terminology) and resulting scientific literature.

4.3 Challenges and Gaps related to Scientific Frameworks

The results of the analyses conducted in this report brought light to several challenges and gaps that are currently present in the relation between the scientific community and Disaster Risk Reduction and Climate Change Adaptation research topics. This section addresses, first, the insights directly obtained from the analyses of DRR and CCA research, and concludes with the challenges observed while conducting the analyses.

4.3.1 Analysis of DRR and CCA Research Topics in Germany

As described in section 2, text mining analysis was employed in order to get an impression of the content of scientific publications related to CCA and DRR in Germany and the most popular issues discussed within these publications. The keyword analysis assumes that there is a correlation between the frequency in which words are mentioned and their relevance for the studied area. The results of this analysis are depicted in the central cloud in figure 7 for DRR and figure 8 for CCA. The size of keywords in the figure corresponds to the frequency in which they were mentioned in the analysed texts.

4.3.1.1 Keyword Analysis

In the case of Disaster Risk Reduction, some of the most popular keywords are "FLOOD", "TSUNAMI", "WARNING", and "MEASURES" (among others of similar relevance). From this it can be assumed that natural disasters associated to floods are of high interest to the scientific community in Germany. The first keyword ("Flood") is coherent with the natural

78 https://www.iso.org/iso-31000-risk-management.html
79 https://www.ipcc.ch/publications_and_data/ar4/wg2/en/spmsspm-e.html

risk associated to the region. Also, "WARNING" and "MEASURES" are to be expected words regarding the topic, and relate to early warning procedures and security and mitigation measures aiming to reduce the impact of catastrophic events. "TSUNAMI" on the other hand, is a more surprising keyword that does not match the expected regional interests. The reason for this result is a rather prolific research project in cooperation with Indonesia (GITEWS: German Indonesian Tsunami Early Warning System)[80] that dominates the analysed text corpus. Since flood-related events are - next to wind storms - by far the most common in Germany, other regionally relevant hazards such as heat waves fall behind the scientific interest in major international disasters.

The analysis for Climate Change Adaptation holds less surprises than the one for DRR, with a predominant presence of "WATER" and "LAND" as main keywords extracted from the corpus. These two keywords show up consistently in most publications. "ADAPTATION" also features as one of the most frequent terms, ranking higher than "IMPACT" or "PROTECTION" corresponding to interviews and government reports stating that - with the increasing realization that climate change impacts are unavoidable - adaptation has gained more attention throughout the years.

4.3.1.2 Topic Modelling Analysis

Topic Modelling is a relatively recent approach to text mining, in which clusters of keywords are identified (as shown on the external grouped keywords in figures 9 and 10), aiming for keyword's associations that best describe the most relevant topics in the area. This analysis provided, compared to the previous keyword analysis, more detailed insights into the scientific community interests in Germany. The most popular topics in published research for DRR in Germany are:

1. Early warning systems for natural hazards (top-right of figure 9). This research topic is basically self-explanatory. One important note comes from the keyword local, in this context, this word indicates a small area of influence for the analysis. This remains coherent with the fact that different regions are exposed to different catastrophes and require specific approaches to face these challenges.

2. Population protection and vulnerability detection (bottom-right of figure 7). In this particular topic, there is a clear case study with the Indonesian capital of West Sumatra, Padang. Interestingly, this topic

[80] http://www.gitews.org/homepage/

Figure 9: *Results of Keyword Analysis and Topic Modelling for Disaster Risk Reduction Papers*

complements the previous one, suggesting that evacuation of urban areas is a highly researched strategy in the region.

3. Tsunami risk assessment, influence areas and response measures (bottom-centre of figure 7): another topic for which Germany is not the case study. One relevant insight to extract from this, is how important international cooperation is to German research.
4. Vulnerability detection and knowledge mapping (bottom-left of figure 7): this topic aggregates two common methodologies in DRR. Similarly to the first topic, the relevant presence of the word local suggest a small area of influence for the analysis, due to high regional specificity.

5. Flood related damage, with special focus on economic losses (top-left of figure 7): this is a topic perfectly characterizing research with Germany as case study. The presence of insurance companies in the keyword cloud relates to a clear stakeholder interested in this research.

Analogously to the results of the keyword analysis, the influence of the GITEWS project is made clear, with strong presence in the topic list, particularly with technical approaches for mitigation and early warning measures. For a Germany-specific context, flood related research is also on the spotlight, but research seems to lean more towards damage analysis and social aspects. Since the sample of papers used for this analysis is rather low, and given the facts that research on catastrophes such as wind storms and earthquakes are missing, the conclusions on this analysis need to be taken with care.
Regarding the analysis for Climate Change Adaptation research, the following five topics got the most attention:

1. Climate change models and data-driven modelling (top-right of figure 10): this cluster represents CCA analysis in two levels of aggregations:

    a. On the highest level, it brings forth the importance of modelling and data driven approaches in climate change research (quantitative methodologies where acquired numerical data is heavily used for modelling the analysed systems). Phenomena studied

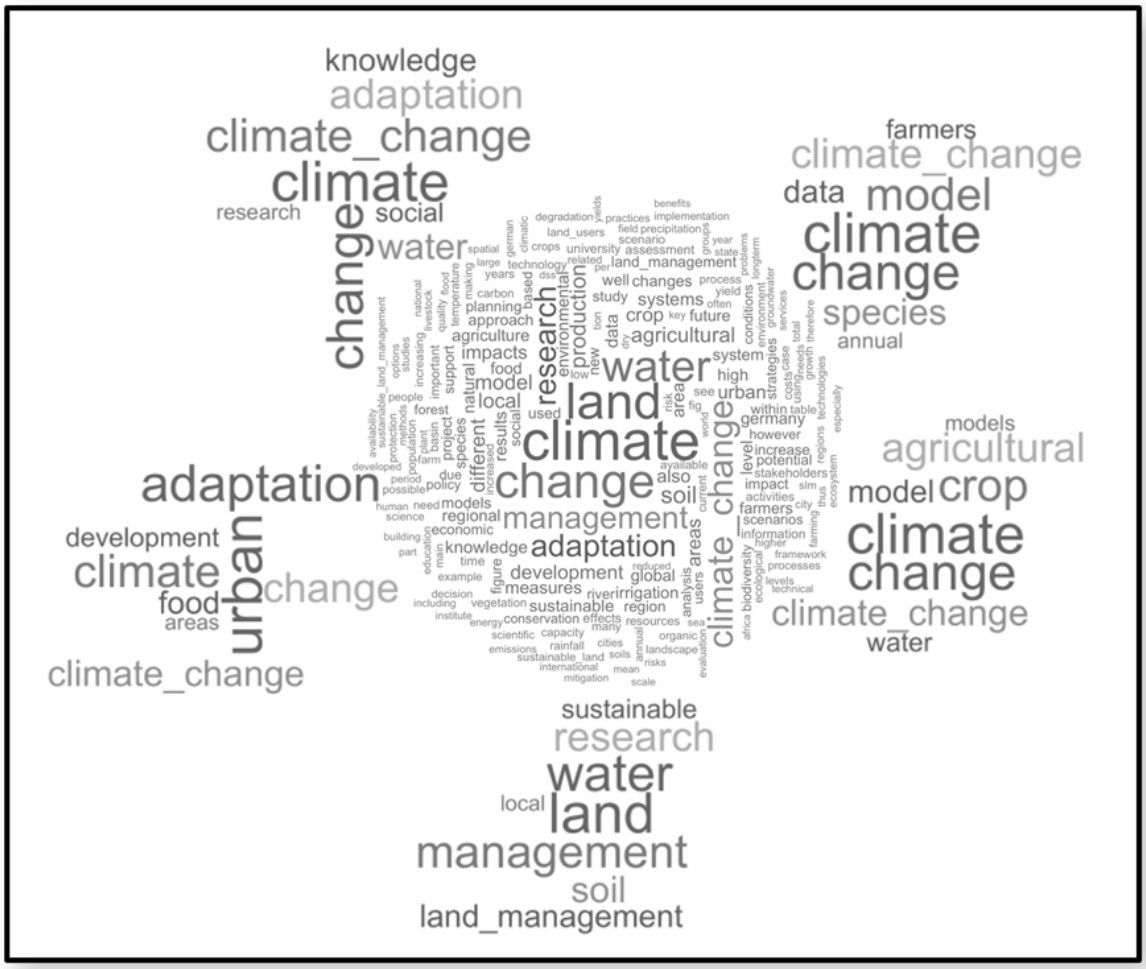

Figure 10: *Results of Keyword Analysis and Topic Modelling for Climate Change Adaptation Papers*

in this area usually present a high interplay between variables, and extend over significant periods of time.

b. On a low level, it also mentions species and farmers, possibly referring to the impact of climate change in agricultural biodiversity. This is still subject to the development of models to assess such impacts.

2. Agricultural development and climate change impact on crops (bottom right of figure 8): this topic overlaps with the previous one, and suggest that the number of topics selected was too high, i.e. there may be four main topics instead of five. The technique applied does not allow for this number to be automatically determined).

   Despite this drawback, some insight still can be found, given the presence of the word Water, suggesting a potential conditioning variable for the analysis.

3. Sustainable Resource Management (bottom-centre of figure 8): self-explanatory topic, where special attention is drawn to land and water management. Similarly to the previous case, this suggests high impact variables that need to be studied in the context of CCA research.

4. Urban and Social Development (bottom left of figure 8): in this case, food was a popular related term, frequently associated in the context of food scarcity.

5. Knowledge acquisition related to Climate Change Adaptation (top-left of figure 8): This topic describes generically the analysed domain, and sets two specific subjects of study: water and social aspects.

Throughout the five topics, some common inferences were made, such as the importance of water and land management, and the relevance of food and agriculture in some papers. Finally, it can be easily seen how impactful the combination of words "Climate Change" is, perfectly describing the domain, highly used in most research, and dominating four out of five topics in the analysis.

4.3.1.3 Conclusions

The results of the Keyword Analysis and Topic Modelling provide basic insights on the research landscape for both DRR and CCA, although by no means constitute an exhaustive analysis on the area. The three main issues that this approach could not address, were 1) the lack of access to more comprehensive body of scientific documents, 2) the lack of methodology transparency, where the keyword relations are not evident to the user and 3) the popularity of the term "Climate Change" in the field of CCA, is not mirrored in a specific term on Disaster Risk Reduction. In DRR, the scientific community seems to be more compartmentalized by hazards and disciplines. Hence, in several papers maybe only "flood" is mentioned as keyword, but not "disaster management" or "emergency management". Consequently, there is a tendency in this analysis to underrepresent work on Disaster Risk Reduction.

That being said, there are four main challenges that should be made explicit, and complement the previous findings:

1) Uneven popularity: Climate Change constitutes a more popular topic on research, compared to Disaster Management, with 16 papers for DRR and 38 papers for CCA found under the same criteria. While this finding supports the population trend presented before, it may also be related to the issue mentioned before, i.e. how DRR research presents a certain compartmentalization regarding the use of keywords.

2) Data availability: Scientific research in both DRR and CCA faces a challenge in the form of data availability.
The results of a 2015 DKKV-JPI Climate workshop81 on the role of loss data for climate change adaptation and disaster risk reduction in Europe clearly showed a lack of data on disaster losses in relation to climate change impacts. This hinders development and validation of reliable loss models, which are essential for risk analyses and efficient decision making. Disaster loss data are still scarce, incomplete or inaccessible and methods in their infancies compared to other scientific fields related to the climate system. The workshop however presented a vision where high public availability of data on social indicators and economic losses, coupled with the insights gathered from research, may be feasible by the year 2020. In this regard, several steps are outlined in order to accomplish this vision, including legislative, operative and institutional improvements and developments. In addition, the data collection efforts initiated by the implementation of the Sendai Framework for Disaster Risk Reduction could also help to gather more loss/impact data (DKKV, 2016).

3) Transnational research interests: due to the relatively low exposure of Germany to natural hazards, some centralization is seen in DRR research, focusing on floods (national risk) and tsunamis (international cooperation). While this holds true for the analyzed sample, its generalization on national level must include the research on earthquakes (GFZ, Potsdam University, KIT) and windstorms (Freie Universität Berlin, Cologne University, KIT), and concerning foreign regions other risk issues such as volcanism are deemed relevant for international cooperation. The situation is not so similar for CCA; while there is a tendency to water and land management research, this could be seen as a central theme for Climate Change, and not an issue arising from regional characteristics.

4) Bias towards natural sciences: The role of social sciences is still underrepresented in CCA as well as DRR, favoring natural sciences as the leading research domain. Furthermore, there is an observable gap on the initiatives concerning social sciences from authorities and main funding institutions.

4.3.2 Challenges/Gaps Related to COMMUNICATION in the Existing Legal Policy Aspects

In terms of communication between professionals, both practitioners and scientists, the perceptions of challenges and gaps differ

81 The workshop was organized by members of DKKV's scientific board from the Freie Universität Berlin (Prof. Dr. Uwe Ulbrich), Helmholtz Centre for Environmental Research (UFZ; Prof. Dr. Reimund Schwarze) and University of Potsdam (Prof. Dr. Annegret Thieken, Dr. Stephanie Natho) and funded by JPI Climate.

rather substantially between interviewees. As already outlined in section 4.2.1 on risk perception, potential communication barriers are rather stressed by scientists, much less by practitioners.

While researchers mentioned the need for a comparative catalogue on a national level to make terminological differences explicit and potentially streamline concepts, experts of governmental agencies rather underlined the fact that issues of terminology and concepts might be overrated. Wolfram Geier (BBK) puts it in a nutshell: "Everyone who works either in CCA or DRR should have noted, that we all agree to disagree on this point" (Interview BBK, 13th January 2017).

A certain pragmatism of this sort could be observed with most interviewees. According to them, communication between different actors within present dialogue platforms on DRR and CCA, such as the various interministerial working groups, works quite well despite these potential language barriers. Most experts pointed out that there are no clearly distinguished CCA and DRR communities but rather a very diverse spectrum of disciplines involved in both fields with accordingly different constructions of the problems. This complexity obviously involves misunderstandings and ambiguities. However, some interviewees also understood this situation as leaving space for collaboration that might not have been there if all concepts were clearly defined with indeterminacy disguising potential conflicts.

Another communication challenge that was mentioned more often is the effective exchange of information on best practices. While there is a substantial number of tools and guidelines (cf. section 3.2.6), the process of communicating these in a way so that applicable solutions reach the right target groups is a great challenge. This is especially the case when looking at the municipality level. Most actors stressed the lack of a central platform that integrates best practices on CCA and DRR. However, even a national overview of natural hazards and risks is missing. One exception is the platform "Wasserblick" operated by the BfG[82], where all flood hazard and risk maps that were created during the implementation of the Floods Directive by the federal states are summarized. The federal environment agency UBA is the major player regarding the communication of CCA measures and good practices in Germany. Its Competence Centre on Climate Impacts and Adaptation in Germany (Kompetenzzentrum Klimafolgen und Anpassung (KomPass)) provides a number of tools that were described in more detail in section 2.2.1.6 such as the Climate Navigator ("Klimalotse") or the Deeds Bank ("Tatenbank"). Representatives of the KomPass however remark that a task for the coming years will be to develop methods to measure the effectiveness: "How do ideas spread? Do they reach the relevant stakeholders? Do the good practices trigger action in other actors?
(interview UBA, January 16th, 2017)".

82 http://www.bafg.de/DE/05_Wissen/01_InfoSys/WasserBLicK/WasserBLicK.html

5 Conclusions

The German political system and with it the administrative responsibilities for both DRR and CCA are located at different levels within different departments and with a different allocation of responsibilities among those levels, i.e. both policy fields face multi-level governance challenges. Due to these fundamental institutional complexities and because both fields face many different tasks (e.g. slow onset disasters, geo-physical disasters), the results of interviews and literature review suggest that DRR and CCA in Germany cannot (and should not) be integrated as such on the federal level but rather need to cooperate and to be harmonised in overlapping policy areas with defined collaboration responsibilities. While vertical and horizontal cooperation could still be improved, the German Adaptation Strategy to Climate Change, defining DRR as a crosscutting issue within CCA, has initiated a substantial number of such collaborative initiatives.

Major gaps can rather be found when looking at implementation on the grounds. Municipalities often do not have sufficient resources to address CCA issues, even less so the complexities of bringing together CCA and DRR in a coherent manner. Both aspects need to be integrated in land use planning such as regional plans of the federal states and urban development plans. To help local and regional actors with the harmonization of DRR and CCA, the federal government needs to invest in capacity building and awareness raising activities, especially at the local level.

To enhance equal information on funding opportunities on CCA and DRR, information should be made available also to actors who might not belong to the respective community per se.

Since there is no one-size-fits-all solution for either CCA or DRR at the local level - not to speak of an integrated approach to both – the process of implementing these issues can be informed through best practices but will need to be individually tailored to the location under study and its specific challenges and problems at hand. The need for supporting local level actors with CCA has been identified by the federal government and is explicitly prioritized in several policy documents on that matter. However, the system of civil protection is mostly perceived as so well equipped and functional that its contribution to CCA (as well as in terms of Germany`s capacity to deal with disasters on its own) is taken as a given. This should be re-evaluated considering that the system is based on a shrinking number of volunteers.

To enable a better understanding of potential synergies and future trends in CCA and DRR, a better link and accessibility of data is needed that allows for a unified assessment of hazards, vulnerabilities and risks and takes into account multiple (climate) hazards that occur simultaneously or cumulatively over time and their potentially interrelated effects and impacts.

Finally, communicating potential synergies to relevant actors is a central task that could be improved, e.g. by better linking DRR and CCA measures within existing climate tools and guidelines.

Recommendations:

Governance

- Further institutionalize integrated structures dealing with DRR and CCA, especially on state and municipal levels

Risk Assessments

- Enhance the understanding of possible linkages and cascading effects of natural hazards and
- climate-related risks (multi-hazard approaches) in risk assessments for Germany
- Improve databases towards linking CCA and DRR in risk and vulnerability assessments in order to enable a unified assessment approach
- Improve data bases on disaster impacts (e.g. losses) as requested by the Sendai Framework

Transboundary Disaster Management

- Better prepare for the case of international assistance on German territory

Funding

- Make sure that local actors have the same access to funding opportunities, both in terms of access to information and regarding potential to receive funding

Communication

- Establish a central platform that links existing best practices in both DRR and CCA
- Establish a central platform that illustrates hazards and risks in all of Germany for the general public (and link it to information on adequate behaviour in risky situations)

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Annexes

Annex 1: List of interviews

Title	Surname, First Name	Position | Institution
Prof.	Bogardi, Janos	Senior Advisor to the Global Water System Project
Dr.	Bubeck, Philip	University of Potsdam
	Representative of KomPass	KomPass - Climate Impacts and Adaptation in Germany at the Umweltbundesamt (UBA) / German Federal Environmental Agency
Prof.	Fiedrich, Frank	Professor, University Wuppertal
Dr.	Geier, Wolfram	Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK) / German Federal Office of Civil Protection and Disaster Assistance
	Hauner, Oliver André	Gesamtverband der Deutschen Versicherungswirtschaft / The German Insurers
Dr.	Klaus Lützenkirchen	Vice President Corporate Environmental Protection, Siemens AG
Prof.	Knoppe, Marc	Professor, Technical University Ingolstadt
Prof.	Schwarze, Reimund	Professor, Helmholtz Zentrum für Umweltforschung (UFZ) / Helmholtz Centre for Environmental Research
Dr.	Trimbach, Herbert	leads working group V on Fire Fighting Issues, Rescue Services, Disaster Prevention and Civil Defense within the Permanent Conference of Interior Ministers of the Federal States
	Vogt, Reinhard	former head of StEB Köln / Flood Protection Agency Cologne
Prof.	Voss, Martin	Professor, Free University Berlin
	Representatives from DWD	Deutscher Wetterdienst (DWD) / German Meteorological Office

Annex 2: List of Climate Change Adaptation and Disaster Risk Reduction research projects considered in the analysis

Project Name	DRR	CCA	Scientific Approach / Methodology // Selected Techniques
BigWa: Civil Protection Within Societal Change.	X		Interdisciplinary - (Applied Social Sciences, Rescue Engineering, Communication Sciences and Informatics) / IT Technology Development
CIRmin/ KIRmin: Critical Infrastructure Resilience as a Minimum Supply Concept.	X		Scenario and Case Study Analysis, In-Depth Expert Interviews/ Workshops,
AtlasVR: Atlas of Vulnerability and Resilience.	X		Interdisciplinary Knowledge Management / Case Studies / Workshops / Scientific and Organizational Thematic Analysis / Expert Questionnaire / Communication
Push4DRS: Push for Disaster Resilient Societies.	X		Scientific and Organizational Thematic Analysis Analysis/ GIS And RS Methods / Data Usage for Disaster Risk Governance / Indicators Development
KritisF&E: Critical Infrastructures Research & Development.	X		Review of Previous Research on Critical Infrastructures / Thematic Analysis
Kophis: Care-dependent Persons in Disaster Situations	X		Qualitative Data and Document Analysis / Expert Interviews / Quantitative Surveys
WEXICOM: Weather warnings: from EXtreme event Information to COMunication and action.	X	X	Interdisciplinary - (Meteorology / Social Sciences / Psychology) // Statistical Modelling / Communicational Techniques / Assessment Indicators Development
FloodEvac: Vulnerability of Transportation Structures,Warning and Evacuation in Case of Major Inland Flooding.	X	X	Interdisciplinary // Risk Based Approach / Optimization Methods / Monte Carlo Simulations / Scenario Analysis / Modeling / GIS Modeling / Electronic Development / Software and Data
INVOLVE: INitiate VOLunteerism to counter VulnErability .	X		Interdisciplinary//Theoretical Social Model Development / Social Mechanisms Analysis
VERSS: Aspects of a more just distribution of safety and security in cities.	X		Statistical Evaluation / Indicators Development / Qualitative Dataset Evaluation

Project Name	DRR	CCA	Scientific Approach / Methodology // Selected Techniques
ENSURE: Enablement of Urban Citizen Support for Crisis Response	X		Literature Review / Scenario Analysis / Evaluations / System Analysis
Soft Parts: Social Factors of Airport Security.	X		Interviews / Surveys / Creative Problem Solving
ANiK: Alpine Natural Hazards in Climate Change	X	X	Interdisciplinary // Human and Social Sciences / Case Study
Kolibri: Communication of location information on population protection in an international comparison	X		Literature Review // Expert Interview / Content Analysis / Population Survey
REBEKA: Resilience of the forces involved in crisis situations	X		Case Studies / Emergency Processes and Measures Analysis and Improvement / Improvement of Organizational Measures
VVL-OECD: Comparative vulnerability assessment of food supplies in OECD countries in case of major damage events	X		Thematic Analysis / Expert Assessment / Case Studies / Literature Review / Expert Interviews / Questionnaires
WiSima: Cost-effectiveness of safety measures in public passenger transport	X		Literature Review and Case Studies / Thematic Analysis /Exploratory Study / Economic Analysis of Safety Measures
PRI-KATS: Prioritization of rescue measures	X		Interdisciplinary (Social - Emergency - Legal)// Scenario Analysis
ALARM: Adaptive solution platform for active technicalsupport when saving human lives	X		Data Acquisition and Exploration / Indicator Development / Exercises and Games
e-Triage: Electronic registration of disaster victims	X		Electronic System Design / Satellite - Based Communications / Database
EVA: Risks associated with major public events – Planning, assessment, EVAcuation and rescue concepts	X		Risk Assessment Tools / Databases / Simulation
EvaSim: Combined traffic and hydraulics simulation for controlling traffic in evacuation measures	X		Simulation / Optimization / Strategy Development

Project Name	DRR	CCA	Scientific Approach / Methodology // Selected Techniques
LAGE: Integration of existing information systems for joint crisis management	X		Data Standardization / Communication Technology
REPKA: Regional evacuation: Planning, control and adaptation	X		Mathematical Optimization / Simulation / Technology Development
Security2People: Secure IT-Based Disaster Management System to Protect and Rescue People	X		Simulation / Technology Development
SiKomm: Communication for Security: Preventive, proactive and reactive strategies for communications support in security and rescue operations	X		Interdisciplinary // Social / Psychology / Modeling
SoKNOS: Service-oriented architectures supporting public security networks	X		Data Management / Semantic Technology Development / Interactive Technology Development
Hermes: Study for an evacuation assistant for use in emergencies during large-scale public events	X		Simulation / Communication Technology / Field Study / Laboratory Trials

Project Name	DRR	CCA	Scientific Approach / Methodology // Selected Techniques
ACER: Developing Adaptive Capacity to Extreme events in the Rhine basin		X	Scenario Analysis / Modeling and Simulation
AMICA: Adaption and Mitigation - an Integrated Climate Policy Approach		X	Thematic Analysis / Expert Assessment / Communication
ARISCC: Adaptation of Railway Infrastructure to Climate Change		X	Case Studies // Data Management / Risk and Vulnerability Mapping / Risk Assessment /
AVEMAC: Assessing Agriculture Vulnerabilities for the design of Effective Measures for Adaption to Climate Change		X	Data Management / Modeling and Simulation / Vulnerability Mapping
IOACID: Biological impacts of ocean acidification		X	Modeling and Simulation / Thematic Analysis / Integrated Assessment/ Local Experimentation / Socio-Economic Impact Analysis / Domain Specific Experimentation
CC-LandStraD: Climate Change: Land Use Strategies in Germany		X	Scenario Development and Analysis / Integrated Assessment Modeling / Impact Evaluation
CLIMAWARE: Impacts of climate change on water resources management–regional strategies and European view		X	Scenario Analysis / Modeling and Simulation / Strategy Development /
ECODRIVE: Ecosystem Change in the North Sea: Processes, Drivers and Future scenarios		X	Spatial and Temporal Analyses / Thematic Analysis / Scenario Analysis / Indicator Development
ENHANCE: Enhancing risk management partnerships for catastrophic natural hazards in Europe	X	X	Case Studies / Scenario Analysis / Indicator Development / Risk Assessment / Expert Assessment / Participatory Processes
EU-Circle: A pan-European framework for strengthening critical infrastructure resilience to climate change	X	X	Case Studies / Reliability Analysis / Impact Assessment / Modeling and Simulation
KRIM: Climate Change and Preventive Risk and Coastal Protection Management on the German North Sea Coast	X	X	Vulnerability Assessment / Scenario Analysis / Adaptation Measures, Strategies and Actions // Interdisciplinary
TIDE: Tidal River Development		X	Quantitative Resilience Assessment / Indicators Development / Literature Review / Thematic Analysis / Data Analysis / Expert Assessment / Framework Development
WEAM4i: Water & Energy Advanced Management for Irrigation		X	Domain Specific Technology Development / Data Acquisition and Management

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Annex 3: List of Publications used for Keyword Analysis and Topic Modeling

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Technisches Hilfswerk

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

DLR

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand
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