



Climate change adaptation of major infrastructure projects

Country report for Germany

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Note for the readers of the printed version: the present country report links to a large number of resources via hyperlinks, which by nature are only active in the electronic version. In order to find the identified resources, an online search will usually deliver the right result; but otherwise it is also possible to make use of Annex II of the main report where all the identified resources and their hyperlinks are presented.

Disclaimer: The identified resources are non-exhaustive and present a snapshot of the readily available and accessible material during 2017. This information was collected through finite web-based desk research, and through questionnaires and interviews aimed at the relevant national competent authorities (ESIF managing authorities, research institutes, ministry officials, etc.). Further resources might be available but not accessible due to privacy restrictions, or a lack of mandate to share related material. Following the publication of the present report, more resources will continue to reach the public domain, including through Climate-ADAPT and the identified national websites.

1. INTRODUCTION

The [EU Strategy on Adaptation to Climate Change](#) of 2013 includes actions to enhance the resilience of infrastructure and mainstream climate adaptation into the European regional and cohesion policy. The [Common Provisions Regulation](#) (CPR) of 2013 states under article 8 that climate change mitigation and adaptation, and risk prevention shall be taken into consideration for investments made with the support of the European Structural and Investment Funds (ESI Funds). The regulation integrates climate change adaptation considerations into the preparation and approval of major projects¹ or other projects funded by the ESI Funds through the requirement to conduct climate change vulnerability and risk assessments. In coordination with the ESI Funds, and complimentary to them, the LIFE fund in addition assists in the realisation of the climate change adaptation objectives. Climate change analyses (such as vulnerability and risk assessments) are also sporadically found to be undertaken for infrastructure projects that are financed outside the framework of EU funds.

This report for Germany focuses on the adaptation to climate change of infrastructure projects supporting the requirement to undertake climate change vulnerability and risk assessments by presenting:

- **Legal, policy and institutional framework:** A schematic outline of national and regional policy and legal framework, and organisational structure to deal with adaptation;
- **Resources:** Offering the most important resources supporting the realisation of climate change vulnerability and risk assessments for infrastructure projects. The available resources for data, methodologies, tools, guidance, design standards, system framework and institutional capacity are contextualised and listed in this section;
- **Sector overview:** Identifying the approach, main strengths and weaknesses for each of these sectors: Transport, Broadband, Urban development, Energy, Water and Waste; and
- **Case studies:** Current practice in adaptation and resilience of infrastructure projects.

Country Overview

The key documents regarding climate change adaptation in Germany are the [German Strategy for Adaptation to Climate Change](#), combined with the [National Action Plan](#) and the [Progress Report on the German Strategy for Adaptation to Climate Change](#). Every four years the Interministerial Working Group on Adaptation Strategy publishes a [Monitoring Report on the Impacts of Climate Change](#) (2015). The German [Federal Environment Agency \(UBA\)](#) and the associated [Competence Center on Climate Impacts and Adaptation \(KomPass\)](#) provide institutional support for climate adaptation. Climate change adaptation is a competence shared between the federal level and the regions. Each Bundesland has developed climate change adaptation strategy for their territory. The National Action Plan lays down a set of criteria for measures to be taken at the level of the regional level.

There is a wealth of resources available in Germany to support climate adaptation available through authorities, several universities and research institutions. The German Federal Environment Agency (UBA) uses data of the [Deutscher Wetterdienst](#) (DWD) to create climate models. Associated to the DWD is the [Deutscher Klimadienst](#) (DKD), which is a

¹ major project: an operation comprising a series of works, activities or services intended in itself to accomplish an indivisible task of a precise economic or technical nature which has clearly identified goals and for which the total eligible cost exceeds EUR 50 000 000 and in the case of operations contributing to the thematic objective under point (7) of the first paragraph of Article 9 of Regulation 1303/2013 where the total eligible cost exceeds EUR 75 000 000

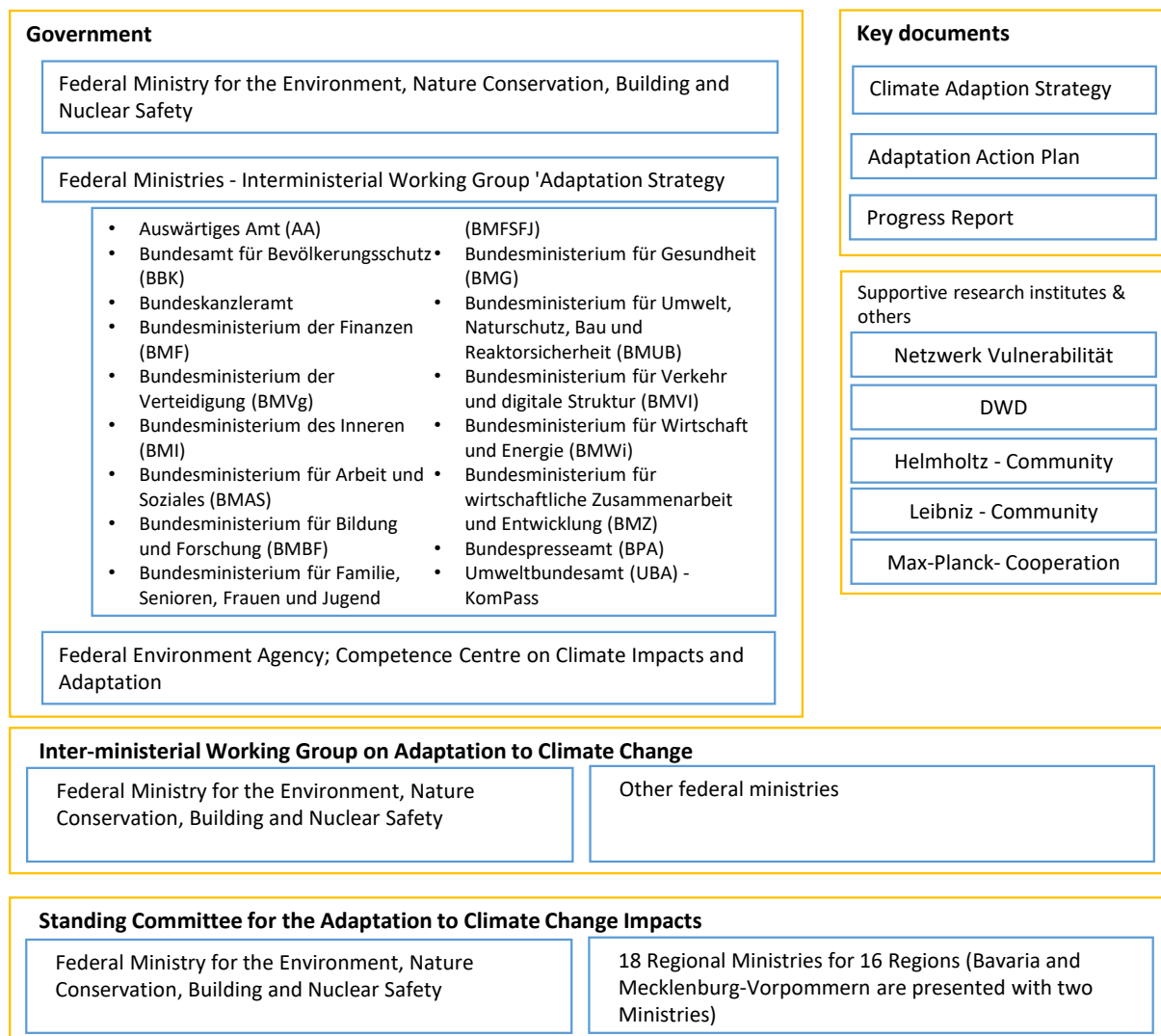
network of authorities and offices that provide operational, reliable and long-term climate information and climate services. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is in the process of creating an online data platform, which will be freely accessible and is expected to be launched in 2018 under the name "Klimavorsorgeportal" (KliVoPort). A number of tools are available from different authorities, ministries and research institutions, such as [Tatenbank](#), [Klimalotse](#), [Stadtklimalotse](#) and [Klimanavigator](#). [Tatenbank](#), for instance, offers more than a hundred examples of measures and projects on climate adaptation in Germany. The main portal "KomPass" offers direction on 'how to start' addressing climate change adaptation for different target groups and which instruments and project examples are available. The [Deutsches Institut für Normung](#) (DIN, the German Institute for Standardisation) has established two working groups dealing with the adaptation of DIN standards due to climate change. Since 2012, the German Institute for Standardisation has set up the [Working Group on Adaptation to Climate Change \(DIN KU-AK 4\)](#) through the coordination centre for environmental protection. The aim is to more effectively take into account the consequences of climate change in standards. The German [Federal Environment Agency \(UBA\)](#) and the associated [Competence Centre on Climate Impacts and Adaptation \(KomPass\)](#) provide institutional support. Both the [Adaptation Strategy](#), 2008 and the [Action Plan](#), 2011 require regular evaluation and updating. This process is supported by the Competence Centre for Climate Impacts and Adaptation at the Umweltbundesamt (KomPass). At the municipality level, several municipalities have put in place so called "[Klimaschutzmanager](#)" – climate protection managers. Currently, approximately 309 municipalities around Germany employ climate protection managers. EU resources are in use, such as the [Guide to Cost-Benefit Analysis of Investment Projects](#), the publication on [Climate Change and Major Projects](#) and the non-paper [Guidelines for Project Managers](#).

On the sectoral level, there are a number of initiatives. Transport is one of the sectors analysed within the [National Adaptation Strategy](#). Most of it focuses on transport infrastructure issues, but some aspects of transport services. Broadband services in the field of climate change adaptation are used in the [I-Sand project](#) in the city of Dresden. For the urban sector, the Federal Institute for Building, Urban and Regional Research (BBSR) commissioned the Federal Ministry of Education, Building and Urban Affairs (BMBF) to focus on a "[cross-evaluation](#)" of central federal cooperation projects on adaptation to climate change on urban and regional development. Examples of cities that developed climate change adaptation strategies are the city of Nürnberg, Stuttgart, Munich, Cologne and Berlin. In the energy sector examples of climate change adaptation most often refer to the (changing) energy demand of companies, cities or regions in association with extreme weather phenomena due to climate change. The water sector in Germany shows reasonable resources with respect to climate change adaptation. Most cases refer to flood protection measures, adapting to heavy rainfall events in urban areas and adapting the water supply and management system within a city or region. At the national level, adaptation measures aimed at reinforced arrangement of natural flood surfaces and recovery of retention surfaces (e.g. polders formed close to nature) / dyke relocations according to the [National Flood Protection Program](#). The waste sector is not involved in the federal or regional authority climate change adaptation plans or initiatives organised by governmental bodies.

Case studies for climate adaptation identified within the context of the present study comprise of the [Future Cities' Green-Blue corridor](#), which disconnects storm water from the nearby paved areas, and ecologically improves the Kamen stream; a case study for [Sun-Protection for Bus Stops](#) in Nordhessen; and the [KiezKlima](#) project in Berlin.

2. LEGAL, POLICY AND INSTITUTIONAL FRAMEWORK

The [German Strategy for Adaptation to Climate Change](#) (DAS, 2008) was developed by the Interministerial Working Group on Adaptation to Climate Change in which most of the Federal Ministries were represented. The [Competence Centre on Climate Impacts and Adaptation \(KomPass\)](#), which was set up at the end of 2006 at the Federal Environment Agency (UBA), provided support. Federal coordination is ensured vertically by the Permanent Committee on Adaptation to Climate Change Impacts.



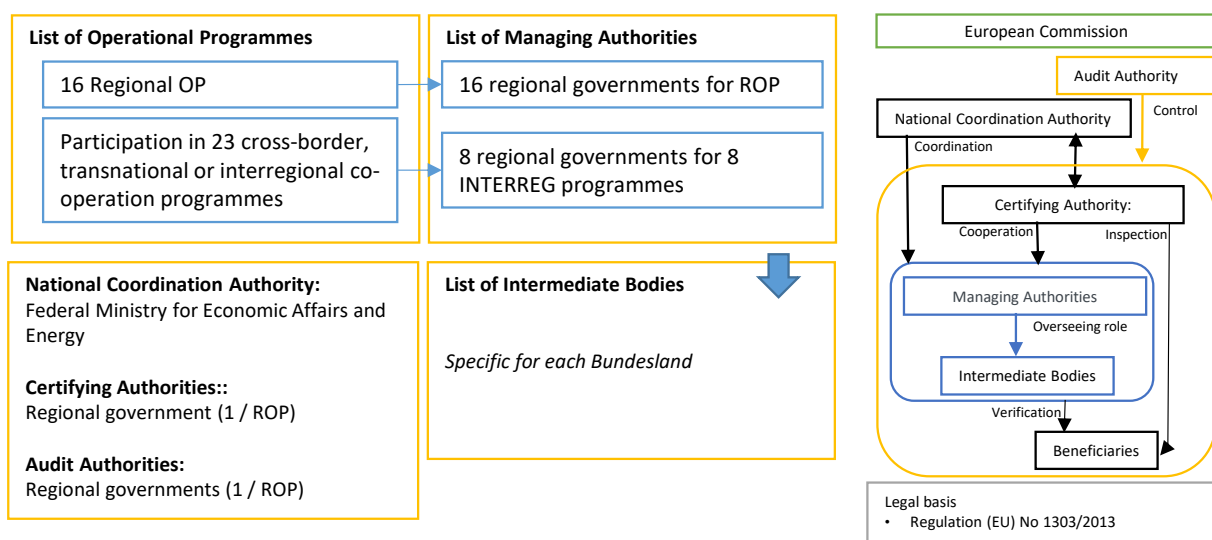
As an essential step in the development of the strategy, a [National Adaptation Action Plan](#) (APA) was developed in 2011, in cooperation with the Bundesländer and other socially relevant actors. This has been supported by a broad communication process and initiatives to improve knowledge base and decision-making. Support was also provided by the Climate Service Centre, which was set up in July 2009. The main objectives of the APA are to implement the DAS and to take steps for the next revision of the national strategy. The APA presents a sectoral approach. The sectors presented are Human health, the Building sector, Water regime, Water management, Coastal and marine protection, Soil, Biological diversity, Agriculture, Forestry and forest management, Fishery, the Energy industry (conversion, transport and supply), the Financial services industry, Transport and transport infrastructure, Trade and industry, Tourism industry; and Cross-sectional topics such as Spatial, regional and physical development planning and civil protection.

The [first Progress Report on the DAS](#) (Fortschrittsbericht DAS, 2015) was submitted to the Federal Cabinet on 16 December 2015. The activities of the APA II are allocated to the clusters "Water", "Infrastructures", "Land", "Health", "Economy" and "Spatial planning and

protection of the population". These six clusters were also used in the Vulnerability Analysis. Activities with an area of interdependence, such as the provision of data and information services or support activities to adapt to climate change, are under an additional cluster "Overreaching".

The '[Netzwerk Vulnerabilität](#)' is a network of federal authorities, which provides the overall picture of how vulnerable Germany is to climate change. The network of federal authorities is thus helping to implement the [DAS](#) and the [APA](#). Experts from all relevant departments and authorities are invited to participate and to contribute with their expertise to the '[Netzwerk Vulnerabilität](#)'. With the support of the network, a consortium was commissioned by BMUB (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)/UBA (Federal Environment Agency)².

In Germany, the EU Structural Funds are coordinated by the Federal Ministry for Economic Affairs and Energy. Implementation and administration is handled by the Bundesländer.



3. RESOURCES

This country report has reviewed the currently available resources in Germany for adapting to the impacts of climate change across six key infrastructure sectors. Adaptation to climate change is integrated in the legal basis³ for ESIF-funded projects, through the processes of vulnerability and risk assessments which are, broadly:

- Vulnerability – evaluating the sensitivity and exposure of infrastructure to climate change
- Risk – estimating the likelihood and impact of relevant climate hazards

² Einführung zum Netzwerk: Organisation und Prozess - Fachkonferenz „Vulnerabilität Deutschlands gegenüber dem Klimawandel“, Berlin, 1. Juni 2015

https://www.ioew.de/fileadmin/user_upload/BILDER_und_Downloaddateien/Veranstaltungen/2015/Netzwerk_Vulnerabilitaet/Praesentationen/2015-06-01_01_Netzwerk_Kahlenborn.pdf

³ Regulation (EU) No 1303/2013, Commission Delegated Regulation (EU) No 480/2014, Commission Implementing Regulation (EU) No 1011/2014, No 215/2014, 2015/207; and the Directives 2001/42/EC, 2011/92/EU and 2014/52/EU

- Adaptation - consideration of adaptation options and integration into the project planning

The legal requirements for major projects also foresee climate change mitigation. This study however is focused on climate change adaptation and does not cover mitigation aspects.

Information on the requirements for climate change adaptation is available in the 2016 publication [Climate Change and Major Projects](#), and details on the methodology of climate resilience analysis is provided in the 2017 JASPERS publication [The Basics of Climate Change Adaptation, Vulnerability and Risk Assessment](#). Further resources are being identified in the present publication and its references. Effective vulnerability and risk assessments for the adaptation of major projects to climate change require the resources explained in the following table:

Resources	Explanation
Data Availability	The availability, accessibility and applicability of data on climate projections and impacts, on past and historic events, on geophysical parameters, on long-term scenarios, on economic, environmental and social impacts, etc.
Methodologies	The existence of quantitative or qualitative methodologies (a system of processes, a set of principles and rules) for integrating climate change adaptation in the development of infrastructure projects.
Tools	The availability of tools for planning, evaluation, impact estimation (i.e. software, maps, computer simulations, long term climate forecasts etc.) to assist with the adaptation of infrastructure to climate impacts
Guidance	The provision of guidance on how to use methodologies (i.e. for conducting climate change vulnerability and risk assessments) or develop the required infrastructure project documentation relating to climate adaptation.
Design Standards	The availability of published engineering design standards (i.e. by BSI, DIN, ISO) for infrastructure projects that include sections or appropriate provisions to ensure resilience to climate change impacts
System	The institutional and legal framework that the formal authorities work with to deliver their primary responsibilities for climate adaptation, infrastructure, and management of European Structural and Investment Funds
Institutional Capacity	The human and technical capacity of institutions to carry out their functions. It depends on being adequately resourced, on having the appropriate expertise, and on collaborating effectively and enforcing laws and regulations

3.1. Data Availability

Quantitative data are essential to understand the relevant risks and the requirements for any corresponding climate change adaptation in key sectors. Projections are available on both the Federal and the Länder level.

Meteorological data as well as processed data in e.g. vulnerability studies for Germany is available through authorities, several universities and research institutions; the

used/preferred source always depends on the region and scale. Climate data for Germany on a small scale/regional level are not always available and are often incomplete.

The German Federal Environment Agency (UBA) uses data of the National Meteorological Service [Deutscher Wetterdienst](#) (DWD) to create climate models. The DWD monitors weather and meteorological conditions over Germany and provides weather services for the general public and for nautical, aviation and agricultural purposes. Associated with the DWD is the [Deutscher Klimadienst](#) (DKD), which is a network of authorities and offices that provide operational, reliable and long-term climate information and climate services. UBA has also requested data from [Copernicus](#) as part of the Monitoring Report of the [German Adaptation Strategy, 2008](#). This Monitoring Report is updated every four year ([2015 update](#)) and monitors extreme weather events and the impacts of climate change on the different sectors covered by the DAS.

The [Federal Statistical Office](#) (FSO) is the leading state authority on statistics, maintaining a national database of statistics relating to the economy, society and the environment. The exact content of this database was not examined in the context of the present study.

Climate research is supported via various research institutes within the [Helmholtz Association of German Research Centres](#) (HGF), and via institutions of the [Max Planck Society](#) (MPG), [Fraunhofer-Gesellschaft](#) (FhG) and the [Gottfried Wilhelm Leibniz Science Association](#) (WGL). The [Max Planck Institute for Meteorology](#) (MPI-M) has developed regional climate projections for Germany, Austria and Switzerland in cooperation with the Federal Environmental Agency (UBA) and the Federal Institute for Water Sciences (BFG). Using the [regional climate model REMO](#) of the MPI-M, data in high resolution of 10 km x 10 km lattice was calculated and provided for the investigation of regional climate impacts.

The [Potsdam Institute for climate impact research](#) (PIK) offers current weather data, climate diagrams, weather analysis and climate impact research for different sectors. It also provides methodologies, such as monitoring programmes, systems and scenarios analysis, modelling, computer simulation and data integration.

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is in the process of creating an online data platform, which will be freely accessible and is expected to be launched during the summer of 2018 under the name 'Klimavorsorgeportal' (KliVoPort). Information provided will be continuously processed and the platform will offer wide-ranging data on climate change impacts, risk and vulnerability assessments, actions (implementation & evaluation), methods and tools and best practice examples. The data platform will also provide information for different fields of action (e.g. heavy rainfall) for different audiences (such as citizens, municipalities, Bundesländer and other actors). The platform also aims to refer to different adaptation tools as well as best practice examples.

DWD provides access to a large amount of its data through the [Climate Data Centre](#); a [national Atlas of Observed Climate](#) over the past decades is also available. [Regional atlases](#) are also available for refined data and observations. The Zweckverband Raum Kassel provides [climate data](#) on the Kassel region.

Coastal protection information is made available by the [Norddeutsche Klimabüro](#).

The [Climate Centre Service Germany](#) hosts a number of relevant documents and report providing useful data and information on climate change and adaptation.

The first [vulnerability assessment of climate change impacts for selected fields of actions](#) in Germany was conducted in 2005 and led to the establishment in 2011 of the "Vulnerability Network" with the aim to conduct an up-to-date, standardised cross-sectoral vulnerability assessment, which led to the report "[Germany's vulnerability to climate](#)

change” (2015). [Germany’s Sixth National Communication](#) to the United Nations Framework Convention on Climate Change (UNFCCC) also provides long-term climate change assessments across a range of sectors, with scenarios on risk and vulnerability by sector.

To address the need for scenario data on how infrastructure will look like in the future, the project [KLARIS](#) investigates the weak spots of current infrastructure and develops scenarios for future infrastructures considering climate and extreme weather events, societal and technological change as well as a vision of future climate resilient and sustainable infrastructures.

Updates for a wide range of national adaptation actions, can be found in the [National adaptation actions deliveries database on EIONET](#), and on the [Climate-ADAPT](#) website.

3.2. Methodologies

Methodologies for integrating climate change adaptation into the development of infrastructure projects rely on the basic rules of risk assessment.

The [APA II](#) includes prioritisation of adaptation options, based on the vulnerability assessments, urgency and the time that it takes to implement a measure; however at present, there are no common practice methods with regard to climate change adaptation. The Federal Environment Agency (UBA) refers to several single methods and manuals, such as [Tatenbank](#), [Klimalotse](#), [Stadtklimalotse](#), [Klimanavigator](#) mainly via implemented projects.

[Tatenbank](#), for instance, is a database that offers more than a hundred examples of measures and projects on climate change adaptation. Users have the possibility to share their experiences by uploading current and finalised measures, while at the same time those interested in initiating adaptive measures and looking for new ideas will find several climate change adaptation examples on this website. Innovative ideas for dealing with floods or with heat waves, barriers to the implementation of individual adaptation measures, the impact of the implemented measures and information on funding their respective activities can be found. The main focus is on local and regional case studies. In addition to criteria of good practice, some tried and tested methods are provided, which should also be taken under consideration when adapting to climate change.

The [Klimalotse](#) is an online guide to support municipalities and cities to avoid climate change risks and to follow up on opportunities (e.g. saving costs through adaptation measures and positive climate change impacts). In April 2016, the Klimalotse was extensively revised, so that it has now been designed more flexibly and includes many climate change adaptation aspects in more detail. Through five modules, the tool supports cities and municipalities to achieve different goals, such as developing a simple adaptation strategy, creating an integrated climate protection and adaptation strategy, or planning and implementing individual adaptation measures. It is not necessary to have advanced knowledge in order to use the guide.

On the Klimalotse website, decision-makers can download templates for cities and municipalities such as the documentation of past extreme events or a blueprint for the creation of a climate change adaptation strategy. Klimalotse also provides support through tips from practitioners or in the form of links to other instruments.

Vulnerability assessments are currently not available for all regions and municipalities, though climate data and maps are becoming increasingly popular among the municipalities and are used as a basis for decision making. There is no blue print yet regarding the methodology of vulnerability assessments, but the national vulnerability assessment of

Germany has been strongly connected to the development of new methodologies, still to be finalised.

The project "[Climate-Resilient Regions](#)" had the aim to study the vulnerability of (critical) infrastructure in the context of climate change and develop approaches to design climate-resilient infrastructures, including the considerations as regards social, organizational and institutional consequences that are associated with the adaptation of existing or alternative infrastructures.

3.3. Tools

Tools are highly valuable for facilitating climate adaptation studies and planning for infrastructure. They can be public or private, numerical or descriptive, and be provided in many mediums, such as software, text documents, maps, and so on. Some tools are generic (such as in risk assessments) whilst others are specific to a certain set of circumstances.

A number of tools are available from different authorities/ministries as well as research institutions, such as [Tatenbank](#), [Klimalotse](#), [Stadtklimalotse](#) and [Klimanavigator](#). The [Federal Environment Agency](#) lists a number of them.

The Federal Institute for Research on Building, Urban Affairs and Spatial Development within the Federal Office for Building and Regional Planning published a report titled "[Anpassung an den Klimawandel in Stadt und Region, 2016](#)". In this report, 64 tools have been identified, which can be used by regions and municipalities. The tools cover different aspects such as climate impact assessment, good practice, adaptation methods, procedures and instruments or climate change (impacts). The tools can be used in various formats and types (e.g. guide, manual, expertise, case study, checklist, online tool).

Selected tools for incorporating climate change adaptation in urban and regional planning are briefly described below:

- [Stadtklimalotse](#): The Stadtklimalotse supports authorities in urban development with the selection and implementation of climate protection and climate adaption measures;
- In the ClimateExchange research programme, the Stadtklimalotse has been used as a tool to support decision-making for small and medium-sized municipalities - in particular for urban planning. It helps municipalities to assess their own concern in ten areas of action. The core of the tool is a database with approximately 140 customised measures designed to help the user select appropriate context-specific measures;
- [Klima Stadt Raum](#) is a web portal on climate change and spatial planning;
- [Klimanavigator](#): The Klimanavigator is a national internet portal which provides climate information. The aim of the portal is to give an overview about relevant climate research, climate change and climate change initiatives on an easy understandable level;
- [Projektkatalog](#): Projektkatalog records scientific projects from Germany and Central Europe that generate basic knowledge on adaptation to climate change. It informs stakeholders from research and research sponsors by bringing together existing knowledge about climate impacts and adaptation;

- [Adaption Compass](#): Developed within the framework of the European cooperation project "Future Cities", the adaptation tool provides employees in municipal administrations with the help of a workbook as well as numerous linked documents with information on their own concern and the identification of cross-sectoral adaptation measures; and
- [Klimacheck-Tool](#): The Klimacheck-Tool is developed on behalf of the Federal Ministry for Economic Affairs and Energy (BMWi). It supports companies in the identification of climate-related risks and the development of initial approaches to deal with these risks. Klimacheck is explicitly aimed at medium-sized companies in the manufacturing industry, but can also be applied to other business areas, such as logistics. The Klimacheck guideline provides an introduction into climate-related risks for companies in Germany. The Klimacheck Tool is a step-by-step approach to companies dealing with climate change with four successive modules. It is based on MS Excel. The results of the Klimacheck tool can be further processed using standard software or integrated into existing risk management systems.

EIONET provides [Flood Maps](#) which are publically available, mapping areas of potential significant flood risk. EIONET also contains Flood Risk Management Plans.

For a continual update of available tools, the reader is referred to the European Climate Adaptation Platform [Climate-ADAPT](#), which has a dedicated tools section.

3.4. Guidance

Guidance is an essential requirement to ensure consistency in applying methodologies and tools.

The main portal "[KomPass](#)" offers direction on 'how to start' addressing climate change adaptation for different target groups and which instruments and project examples are available. The user can access different kinds of guidance; KomPass brings together current research results and develops target group specific information. Additionally, KomPass promotes the cooperation of the actor network through workshops and conferences on the topic.

The [Klimalotse](#) as offered by UBA in its old version addressed the private sector and municipalities, whereas the new version is rather targeted at municipalities.

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is in the process of creating an online data platform, which will be freely accessible and is expected to be launched in 2018 under the name 'Klimavorsorgeportal' (KliVoPort). Information provided will be continuously processed and the platform is supposed to offer detailed and extensive data on climate change impacts, risk and vulnerability assessments, actions (implementation and evaluation), methods and tools and best practice examples. Next to the different steps within the process of climate change (adaptation), the data platform will also provide information for different fields of action (topics/sectors) to different audiences (such as citizens, municipalities, Bundesländer and other actors). Depending on the field of action, the platform aims to refer to different tools as well as best practice examples. The project started with a survey about what has been already done in the field of climate change adaptation. The survey and questions were addressed to the Bundesländer, municipalities and experts.

Regarding implementation of climate change adaptation measures in municipal planning practice, the UBA provides assistance with the "[Praxishilfe Klimaschutz in der räumlichen Planung, 2012](#)". The document was commissioned in 2009 to address legal uncertainties

in the practical planning process, and provides generalised design and planning recommendations based on the analysis of climate relevant instruments within regional planning and building regulations.

3.5. Design Standards

Design standards are critically important for all infrastructure projects to ensure stability and optimal functioning under the strain of natural phenomena. For civil works (including bridges, buildings, masts and towers for the mobile access networks), EN standards are available to address natural forces such as wind and snowfall, e.g. EN1991-1-4 (Eurocode 1) and EN1993 (Eurocode 3) for structures in steel. However, these standards might be outdated and not account for the impacts of climate change.

The German Institute for Standardization ([DIN](#)) is collaborating with the [European Standardisation Organisations](#) in the context of the EU Regulation No 1025/2012 on European standardisation. The European Committee for Standardisation (CEN) and Electrotechnical Standardisation (CENELEC) established the [Adaptation to Climate Change Coordination Group \(ACC-CG\)](#) to coordinate standardisation work in the field of adaptation to climate change in support of the implementation of the EU Strategy on Adaptation to Climate Change. More information is available in the section on *Available resources at the EU level* in the Final Report of the present study (European Commission, 2018).

There are [technical guidelines](#) for installation safety, which dictate how industrial facilities should be built to endure and withstand floods, storms and other weather events due to climate change. An example for the integration of climate change adaptation measures into regulations is the technical rule for plant safety "[Precautions and measures for the sources of rain and flood](#)" (TRAS 310; 2012) by the Commission of Plant Safety. This regulation specifies the responsibilities of plant operators, with regard to Hazardous Substances (StörfallIV) or the Federal Pollution Control Act (BImSchG). In order to consider possible climatic changes by 2050 when planning protective measures, a climate change factor of 1.2 was estimated for the 2010 target; intensities of high river water, flood events as well as heavy rainfall. Regarding storm flood events, an increase of the setpoint for dykes up to 1m is possible. In addition, the TRAS 310 is updated every five years and provides new insights into the impacts of climate change.

DIN has established two working groups dealing with the adaptation of DIN standards for climate change. Public authorities, environmental associations and research institutions are very strongly represented in both committees. Within the working groups, the private sector/industry is still missing (as it is not yet specific enough for companies to recognize their individual benefit).

The [Working Group on Adaptation to Climate Change \(DIN KU-AK 4\)](#) aims to take into account the consequences of climate change in standards. It acts as a DIN internal advisory body to provide specific help to the standards body in the consideration of climate change, in all relevant standards. A survey in the DIN standards committees tried to create awareness and find out which standardisation items were and will be affected by climate change. There are still difficulties, even in the case of already identified adaptation requirements, to convince standard committees to revise the standards concerned. The KU-AK 4 is constantly working on the sensitisation of the standards. The KU-AK 4 has developed the specification [DIN SPEC 35220 "Adaptation to climate change - dealing with uncertainties in the context of projections"](#), 2015, which is available in German and English. At present, a supplemental sheet to this document is being prepared with a specific example of a vulnerability assessment.

The [Standards Committee NA 172-00-13 AA](#) "Adaptation to the consequences of climate change" in the DIN Standards Committee Principles of Environmental Protection, organises the generic standardisation work in the area of adaptation. The Work Committee was set up in February 2016, when "Adaptation" work was started at ISO level. At ISO level, a series of guidance documents are planned to assist organizations of all types to develop appropriate adaptation measures. So far, two ISO projects regarding this topic have been launched: The [ISO 14090 "Framework for adaptation to climate change"](#) is going to be a standard of the general approach and the various stages in the process of adaptation to climate change. In additional standards, the procedure at the various stages will be shown.

A guide to vulnerability assessments will be given in [ISO 14091 "Climate Change Adaptation - A Guide to Vulnerability Assessment"](#), which is developed under German leadership. ISO 14090 is expected to be published in 2019, ISO 14091 in 2020. Further standards, such as adaptation planning, monitoring and evaluation, are going to follow successively.

3.6. System

The institutional system for adapting to climate change requires a legal framework (laws and implementing regulations) and strategies and policies (with implementing action plans). The system is usually conflated with disaster management (and its various components, preparedness, reduction etc.) and more generally with resilience.

Institutional and legal framework

The [German Strategy for Adaptation to Climate Change](#) (DAS, 2008) was developed by the Interministerial Working Group on Adaptation to Climate Change in which most of the Federal Ministries were represented. The [Competence Centre on Climate Impacts and Adaptation \(KomPass\)](#), which was set up at the end of 2006 at the Federal Environment Agency (UBA), provided support. The key legislative documents regarding climate change adaptation in Germany are:

- The [German Adaptation Strategy to Climate Change](#) (DAS, 2008) "Deutsche Anpassungsstrategie an den Klimawandel";
- The [Action Plan Climate Adaptation](#) (APA, 2011) "Aktionsplan Anpassung der Deutschen Anpassungsstrategie an den Klimawandel";
- The [Progress Report on the German Adaptation Strategy on Climate Change](#) (2015) "Fortschrittsbericht zur Deutschen Anpassungsstrategie an den Klimawandel".

Every four years the Interministerial Working Group on Adaptation Strategy publishes a [Monitoring Report on the Impacts of Climate Change](#) (2015) in the sector covered by the DAS. These documents are complemented by the climate adaptation [strategies of the 16 Bundesländer](#). The working group is supported by the Standing Committee for the Adaptation to Climate Change Impacts, a coordination body of the 15 regional governments.

Both the [Adaptation Strategy, 2008](#) and the [Action Plan, 2011](#) require regular evaluation and updating. This process is supported by the Competence Centre for Climate Impacts and Adaptation at the Federal Environment Agency (KomPass). In 2015, the [Monitoring Report on the German Adaptation Strategy](#) and the [Progress Report on the German Adaptation Strategy on Climate Change, 2015](#) were published including the Adaptation Action Plan (APA II). The monitoring report should be published regularly every four years, with the next progress report scheduled for 2020.

There is strong consistency between the objectives of the [Climate Adaptation Strategy \(DAS, 2008\)](#) and the [National Critical Infrastructure Strategy \(KRITIS-Strategie\)](#), particularly with regard to the reduction of vulnerability, as well as the maintenance and enhancement of the adaptability of critical infrastructure against extreme weather events.

The [National Sustainability Strategy, 2017](#) provides several links to implement climate change adaptation measures. In addition, the implementation of the DAS as well as the measures to adapt to climate change are guided by the objectives and criteria of sustainable development.

The importance of climate protection and climate change adaptation was increased and stressed by amendments to the [Building Code](#) (§1 Absatz 5 Satz 2 BauGB), while other sector-specific laws have also included climate change adaptation, such as '[Raumplanung](#)'/'[Raumordnungsgesetz](#)' or '[Bauleitplanung](#)'/'[Bundesbaugesetz](#)'.

The revised Environmental Impacts Assessment Directive (EIA) has been recently transposed into national legislation as part of a [wider reform](#) of the country's urban planning legislation in March 2017 and now includes consideration as regards climate change adaptation.

The Federal Environment Agency, the Umweltbundesamt, (UBA) is creating an Adaptation Strategy Evaluation Method. The results will be published in 2019, and it will be applicable from then on.

Responsible authorities

Considering that Environmental policy (including climate change adaptation) is a competence shared between the federal level and the regions, each Bundesland has developed climate change adaptation strategy for their territory. The National Action Plan lays down a set of criteria for measures to be taken at the level of the regional level.

In the majority of adaptation plans of the Bundesländer, the environmental impact assessment is mentioned as an existing tool to deal with effects of climate change in local spatial planning. The Regional planning policy (Raumordnungsgesetz) promotes environmental protection and adaptation to climate change impacts.

The Interior Ministry (Innenministerium) and the Federal Office for Civil Protection and Disaster Assistance (BKK), are responsible for disaster risk management and prevention.

Management of the ESI Funds

Germany has 16 Regional operational programmes, whose Managing Authorities are the 16 Regional Governments. The country is also participating in 23 cross-border, transnational or interregional co-operation programmes, which are managed by eight regional governments for eight INTERREG programmes. The intermediary bodies are numerous and specific for each Bundesland. The National Coordination Authority for the ESI Funds is the Federal Ministry for Economic Affairs and Energy, while the regional Governments are both the Certifying and the Audit Authorities.

3.7. Institutional Capacity

The institutional challenge for climate change adaptation is that climate policy is a cross-cutting issue, and requires co-operation across a large number of institutions. To be effective in delivering climate change adaptation a minimum level of capacity is needed on leadership, technical and human resources, analytical capabilities, and financial support.

Technical and human resources

A particular strength seems to be the close cooperation of research institutions and universities on the one hand and local communities and private sector on the other hand. The presence of the existing political mandate for climate change adaptation contributes to the development of preparedness. However, there seems to be a gap between the acknowledged impacts of climate change and the proposed measures or approaches for systemic adaptation to those impacts.

At the municipality level, several municipalities have put in place so called [‘Klimaschutzmanager’](#) – climate protection managers. Currently, approximately 309 municipalities around Germany employ climate protection managers. These climate protection managers have a central and strategic role in the implementation of municipal climate protection concepts, these mainly include mitigation measures.

In addition to UBA and KomPass, the [‘Netzwerk Vulnerabilität’](#) provides institutional support. The ‘Netzwerk Vulnerabilität’ is a network of federal authorities, which has established itself with the goal of creating an overall picture that shows how vulnerable Germany is to climate change. The network of federal authorities is thus helping to implement the "German Climate Adaptation Strategy" (DAS) and the "Adaptation Action Plan" (APA). Experts from all relevant departments and authorities are therefore invited to participate and to contribute with their expertise to the ‘Netzwerk Vulnerabilität’.

Effective collaboration

Federal coordination is ensured vertically by the Permanent Committee on Adaptation to Climate Change Impacts.

The German [Federal Environment Agency \(UBA\)](#) and the associated [Competence Centre on Climate Impacts and Adaptation \(KomPass\)](#) provide institutional support.

Financial resources

The [ESI Funds are enabling the development of major projects](#) in the 2014 – 2020 programming period. Concerning major projects, by early 2018, there have been no funds allocated for major projects in Germany for the 2014 - 2020 programming period according to the datasets of the European Commission. However, the [dataset will be updated regularly](#) to reflect changes in the programme lists and major project notifications.

According to the [ESIF-viewer](#), Germany is planning investments of 19.5 Billion EUR. Projects under the Thematic Objective 5 on promoting climate change adaptation, risk prevention and management will be receiving 372 Million EUR, with an additional 76 Million EUR approved for Network Infrastructures in Transport and Energy (Thematic Objective 7); and 556 Million EUR in Environment Protection & Resource Efficiency (Thematic Objective 6). The shares within these Thematic Objectives that may relate to climate adaptation are unknown.

The Federal Ministry for the Environment (BMUB) funds climate adaption projects with 4 Million EUR per year.

4. SECTOR OVERVIEW

4.1. Introduction

Since 2014, the requirements for major projects to obtain ESIF funding⁴ demand that project applications integrate climate change considerations⁵, such as a vulnerability and risk analysis and adaptation option appraisal. At EU-level, material is available to assist in fulfilling these requirements. Key websites and documents are:

- The [Climate-ADAPT](#) website containing many links to data and a [map viewer](#)
- EUROPEAN COMMISSION Directorate-General for Regional and Urban policy: The [Guide to Cost-benefit analysis of Investment projects](#) (also referred to as the 'CBA guide')
- EUROPEAN COMMISSION DIRECTORATE-GENERAL CLIMATE ACTION: [Non-paper of Guidelines for Project Managers: Making vulnerable investments climate resilient](#)
- JASPERS Guidance note: [The Basics of Climate Change Adaptation, Vulnerability and Risk Assessment](#)
- JASPERS Guidance note: [An overview of the most important sources for integrating climate change in \(major\) projects](#)

Additional relevant material can be found in the Final Report of the present study (European Commission, 2018) in the section *Available resources at the EU level* and in *Annex I*.⁶

4.2. Transport

Investments in the transport sector are very diverse, covering roads (including bridges and tunnels), inland waterways, rail, ports / airports, and public transport infrastructure. Any disruption caused in this sector can affect many other sectors (economic and societal) directly. Potential threats are sea-level rise and extreme weather events, such as extended heatwaves, flooding, heavy rainfall or storm, and landslides amongst others. Extreme weather events are a potential threat to both infrastructure and operation of the transport system.

Road infrastructure

Transport is one of the sectors analysed within the German [Adaptation Strategy](#) (DAS, 2008). The Strategy mainly focuses on transport infrastructure, but transport services are also covered: e.g. development of alternative routes and means of transport, traffic management or review of technical conditions for vehicles. The Ministry of Transport is developing specific actions, as required by the national adaptation plan, which includes specific mandates for the transport sector. The Competence Centre on Climate Impacts and Adaptation published a [thematic report for transport](#) in 2011.

⁴ http://ec.europa.eu/regional_policy/archive/projects/major_projects/index_en.cfm

⁵ For a compilation of the climate change requirements for major projects in 2014-2020, see: <http://www.jaspersnetwork.org/plugins/servlet/documentRepository/displayDocumentDetails?documentId=401>

⁶ European Commission (2018) Climate change adaptation of major infrastructure projects. A stock-taking of available resources to assist the development of climate resilient infrastructure. Final report.

To tackle the challenge of adaptation in the transport sector, the BMVI Network of Experts was set up in 2016 to foster cooperation between research institutes and executive agencies of the Federal Ministry of Transport and Digital Infrastructure.

In the field of road transport infrastructure, the program ["Adaptation of the Road Transport Infrastructure for Climate Change "\(AdSVIS\)](#) analyses climate change impacts on road transport infrastructure. Vulnerability assessments are conducted for individual elements of road transport infrastructure, including customization options and technologies. AdSVIS identifies risks related to climate change that may occur during planning, construction or during operation and maintenance. It is therefore indicative of how much the durability can be shortened by the effects of climate change and how a sufficient durability can be achieved through adaptation measures.

For road and rail infrastructure, flooding and sub-irrigation are primarily a problem which is potentially increasing with climate change. In addition to specific measures in the transport sector, activities in the area of floodwater protection are relevant (see sector water).

See section 4.1 for more information on other documents that can help in taking climate considerations into account.

Railway infrastructure

Deutsche Bahn, the main German railway company, focuses its adaptation efforts in different areas. To adapt rail infrastructure, a vulnerability assessment was performed and the Technical Regulations for Deutsche Bahn AG Infrastructure are evaluated to assess whether they should be updated. Deutsche Bahn is participating in a working group for the revision of standards with the German Standardisation Institute (DIN).

With particular attention for flood and extreme weather events, protocols and operational plans are revised, including the regulation for alternative railway routes. Deutsche Bahn is also working –together with the German Federal Railway Authority – on initiating research projects on climate change and adaptation strategies⁷.

See also section above on Road infrastructure for relevant documents and programs.

Airport infrastructure

The [German Strategy for Adaptation to Climate Change](#) expects that air traffic will be only marginally affected by possible climate changes. But all larger airports in Germany respond to potential effects with a complex system of winter maintenance procedures.

See section 4.1 for information on more general documents that can help in taking climate considerations into account.

4.3. Broadband

The International Telecommunication Union has issued the recommendation L.1502 ["Adapting information and communication technology infrastructure to the effects of climate change"](#) for the purpose of identifying climate threats and their impact. L.1502 supports resilience by design in identified risky areas, and proposes changes to equipment

⁷ [Fortschrittsbericht zur Deutschen Anpassungsstrategie an den Klimawandel \(2015\)](#)

installation standards to ensure protection from more frequent extreme weather phenomena and their impacts. The European broadband sector standardisation bodies have not prepared vulnerability assessment and risk management framework for dealing with climate change in broadband projects.

Specific information with regard to broadband and climate change adaptation is not easily accessible. This does not necessarily indicate that there are no measures and projects implemented. Deutsche Telekom for instance has its own internal guidelines with regard to climate change adaptation/extreme weather events. In addition, for civil works (e.g. masts and towers for the mobile access networks), EN standards are available to address wind and snowfall, e.g. EN1991-1-4 (Eurocode 1) and EN1993 (Eurocode 3) for structures in steel. But these standards don't take climate change into account. CEN-CENELEC is currently working on adapting a number of EN standards to climate change. See Final Report of the present study (European Commission, 2018) for more information in the section on *Available resources at the EU level*.⁸

It is also a general best practice for operators to use flood mapping information from environmental agencies to safeguard new planned data centres from flooding.

The [I-Sand project](#), in the city of Dresden, makes use of broadband services in the field of climate change adaptation. The aim of the project is to increase the adaptability of the city of Dresden with a prototypical monitoring system to be able to better implement the analysis and coordination of supporting measures.

With regard to the funding of Germany broadband infrastructure, there is comprehensive guidance provided in '[European Funding for Broadband 2014 – 2020](#)'. This report states that European Structural and Investment Funds are the largest public funding source that support broadband investments. The report also states that the 2014 - 2020 total budget for broadband deployment in Germany is approximately €372 Million.

See section 4.1 for more information on other documents that can help in taking climate considerations into account.

4.4. Urban Development

Investments in the urban development sector include site developments (industrial and other), urban planning, local infrastructure, building projects (such as hospitals, schools), and much more diverse projects. Cities have a unique position to analyse and respond to local impacts and vulnerabilities, such as heat island effects, which depend on the specific layout of a city, its green spaces, and numerous other factors. Cities can actively support the uptake of climate change adaptation in infrastructure projects through, for instance pilot projects, and can initiate dedicated infrastructure projects to improve their resilience to climate change.

Since 2008, numerous federal government research projects and projects have been initiated and implemented by various ministries to adapt to climate change. Climate adaptation is above all a task for municipalities and regions.

In order to tap this generated knowledge in its interaction, the Federal Institute for Building, Urban and Regional Research (BBSR) commissioned the Federal Ministry of Education, Building and Urban Affairs (BMBF) to focus on a "[cross-evaluation of central federal cooperation projects](#)" on adaptation to climate change on urban and regional development. Between 2014 and 2015, twelve research and promotion programs with 55

⁸ European Commission (2018) Climate change adaptation of major infrastructure projects. A stock-taking of available resources to assist the development of climate resilient infrastructure. Final report.

individual projects from five departments were analysed and evaluated with regard to the interdisciplinary and specific knowledge and tools. The preliminary conclusion of the cross-sectional evaluation of federal research projects is that the establishment of the basis for action to adapt to the consequences of climate change since the [APA I](#) could be clearly advanced and the knowledge about climate change is also more robust. This applies in particular to regions and municipalities involved, as case studies in the federal research projects now have better information based on climate impacts, the assessment of vulnerability, the processes of climate adaptation, formal and informal instruments and good practice. Successful approaches to action can now be transferred to other cities and regions from the experiences and identified success factors and obstacles.

The importance of climate protection and climate change adaptation was increased and stressed by amendments to the [Building Code](#) (§1 Absatz 5 Satz 2 BauGB). Climate protection and adaptation are required to be included in urban planning of municipalities to ensure sustainable urban development. Adaptation to climate change was made explicit in the Building Code for the first time. Through changes in the specific urban planning legislation, climate change adaptation is also incorporated into the legal framework of the urban area (§171a BauGB) and urban redevelopment (§136 BauGB). The Ministerial Conference of the Bundesländer has adopted appropriate model launches for the respective building code amendments in 2011 and 2013. Cities and municipalities are now challenged to implement the recently adopted urban planning regulations for climate protection and adaptation to climate change within the framework of municipal land use planning.

To promote flood and heat prevention through urban development, the Federal Institute for Research on Building, Urban Affairs and Spatial Development published a report outlining [Strategies and measures for rainwater management against urban floods and overheated cities](#) (2015).

With regard to the BMUB, the priority area "Urban strategies for climate change" in the promotion program "[Experimental Housing and Urban Development](#)" (ExWoSt) has to be emphasized in this context. With this research program, the federal government promotes research, studies, initiatives and case studies on innovative planning and measures on important urban development and housing policy topics. Based on this experience, information on the further development of urban development and housing policy should be derived and the transfer of knowledge supported.

Examples of cities with climate change adaptation strategies are the city of Nürnberg, Stuttgart, Munich, Cologne and Berlin. While large cities are able to carry out time-consuming and costly climate and vulnerability analyses, small municipalities often lack the financial and human resources to initiate an adjustment process. In addition, in most regions of Germany there is (still) no strong pressure to act. This lack of awareness of the problem leads to low adaptation of existing strategies, norms, beliefs and behaviors⁷.

A large number of tools, guides and method manuals have been developed for the various phases of the adaptation process. This allows the regions and municipalities to be supported in the identification of climate change and climate impacts, adaptation possibilities and implementation (strategies) (for example [Tatenbank](#), [Klimalotse](#), [Stadtklimalotse](#), [Klimanavigator](#), [Klima Stadt Raum](#), etc.)

The aim is to bundle the results of the many federal research projects via central platforms, to provide them and to initiate initiatives for a transfer of knowledge. The tools can support, but not replace, matching planning and decision-making processes.

See section 4.1 for more information on other documents that can help in taking climate considerations into account.

4.5. Energy

Project investments in the energy sector are related to power generation infrastructure, energy distribution networks and energy storage (e.g. through hydropower). With regards to energy consumption, while not part of the 'energy infrastructure projects' as such, there is a link to changes in energy efficiency regulations in buildings and, for instance, building requirements regarding cooling/ shading, etc. Increasingly, peak energy and the relation between the energy transition and climate change adaptation are relevant to provide a secure energy system. Potential impacts of climate change on energy infrastructure may include increased damage to power generation plants or problems with energy provision, leading to black-outs or other disruptions. Disruptions in the energy sector can have large impacts on different sectors due to the increasing dependency on (electric) power provision for all kind of operational systems such as water supply (pumping installations, ...), the food system (transport, cooling, ...), transport (electrified vehicles, dynamic traffic information, ...), etc.

Limited data and information is available in the energy sector in relation to climate change adaptation in Germany. Most of the action in the energy sector is taking place in the field of climate change mitigation and not adaptation.

Examples of climate change adaptation in the energy sector most often refer to the (changing) energy demand of companies, cities or regions in association with extreme weather phenomena due to climate change.

According to [APA II](#), in the energy sector, medium-sized requirements are being indicated for power plants (with regard to the scarcity of cooling water for thermal power plants, damage to generating plants). The examination of hot melt plans under changing hydrological and temperature conditions will provide important impulses for necessary adjustments.

The federal waterway Danube generates sufficient hydropower energy through the many power-stations located alongside the river, which is why it is of relevance for the energy supply from hydropower. The "climate proofing" project aiming to secure climate-resistant transport infrastructure, simulates the impact of climate change on the river's flow and low-water discharge rates⁷.

Power generation and energy supply companies, plant operators, network operators and their associations form the most important non-state actors group in the area of energy. At local level, climate protection concepts and activities are also relevant in the energy sector, which are promoted by the [National Climate Protection Initiative](#) ('Nationale Klimaschutzinitiative') of the BMUB. These structures of climate protection management can also be used for potential municipal adaptation measures. In so-called Energy Advisory Councils, representatives of expert institutions, citizens' initiatives, associations, trade unions and municipal policy are also consulted on the development and implementation of municipal climate protection projects. These councils also include science (universities) and business (IHK, energy industry, regional association, crafts). They potentially play a role in adapting to climate change in the energy sector⁷.

See section 4.1 for more information on other documents that can help in taking climate considerations into account.

4.6. Water

Investments in the water sector are linked to efficient water supply (including reduction of leakage), wastewater treatment and water reuse as well as the implementation of [River Basin Management Plans \(RBMP\)](#) to ensure integrated water management at the river basin scale. Important threats are linked to water quantity (droughts and floods) as well as

quality (water pollution). Climate change can have an impact on both water quantity and quality. Following the EU Floods Directive 2007/60/EC, Member States are obligated to perform flood risk assessment and to elaborate [flood hazard and risk maps](#) and [flood risk management plans](#). Flood risk maps include the history of floods and climate scenarios. Member States also need to take climate change into consideration when developing RBMP. A [Guidance document on adaptation to climate change in water management](#) is available to ensure that the RBMP are climate-proofed. [Evaluations of the RBMP and FRMP](#) are also available on the EC website.

The water sector in Germany shows reasonable resources with respect to climate change adaptation. Most cases refer to flood protection measures, adapting to heavy rainfall events in urban areas and adapting the water supply and management system within a city or region. The water sector is therefore also closely interlinked with urban development, as several of the identified cases are located within cities or communities.

Next to the German coastline, catchment areas of rivers such as the [Este](#) or in the [Emscher-Lippe-Region](#) have come forward with climate change adaptation measures.

The Bundesländer Bayern, Baden-Württemberg and Rheinland-Pfalz together with the DWD, created the project „[Klimaveränderung und Konsequenzen für die Wasserwirtschaft](#)“ ([KLIWA](#), Climate change and consequences for water management). The aim of the project is to work on the effects of climate change with regard to water balance and the ecology of the river basins in the south of Germany, to present consequences and to develop recommendations for action. The results are published on the website.

At national level, adaptation measures aimed at reinforced arrangement of natural flood surfaces and recovery of retention surfaces (e.g. polders formed close to nature)/ dyke relocations according to the [National Flood Protection Program](#) (Nationale Hochwasserschutzprogramm NHWSP) are pursued. The environmental minister's conference from 2.09.2013 has seen the need to categorize flood control as a priority for land use. This way, an effective high-water precaution, which also adapts to climate change, is reached.

In 1956, the [LAWA](#), a German Working Group of the Bundesländer and the Federal Government represented by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety was founded dealing with different subjects of water issues. In 2010, a strategy document was published "[Auswirkungen des Klimawandels auf die Wasserwirtschaft, 2010](#)" (*English: effects of climate change on water management*) resulting in recommendations for action.

Regarding funding, there is the [National Flood Protection Program](#) (NHWSP) and special outline plan for preventive flood protection; a special outline plan for "preventive flood protection" as well as "improvement of the agricultural structure and the seaside defence", this was submitted for the execution of certain priority and land-covering effective measures from the NHWSP.

The [German Association for Gas and Water \(DVGW\)](#), as well as the [German Association for Water, Wastewater and Waste \(DWA\)](#), refer to the adaptation to climate change in their respective activities. The DWA has published several guides related to heavy rain, such as thematic volume "[Risk management in municipal flood control for drainage systems in heavy rain](#)". The DVGW and its association body "DVGW energie | water practice" drafted various practice-oriented professional guides on adaptation to climate change. DVGW and DWA also provide water-related aspects on the topic in forums and seminars for their target groups. Also, the [German Chambers of Industry and Commerce \(DIHK\)](#) addresses, for example with its guideline "[flood protection in the company - recognizing risks - acting correctly](#)" (2014), the individual precaution in companies.

Within the research program [KLIWAS](#) (Impacts of climate change on waterways and shipping), which was launched by the Ministry of Transport in 2009, new methods and tools have been developed regarding the impact of climate change on waterways and shipping with a holistic approach. This already allows some sectors and regions to better define adaptation measures. KLIWAS, with a budget of 18.3 million euros, was developed between 2009 and 2013 and became an important stepping stone within the German national adaptation strategy.

See section 4.1 for more information on other documents that can help in taking climate considerations into account.

4.6 Waste

Project investments in the waste sector are related to separate collection infrastructure, re-use and recycling infrastructure, energy recovery facilities and closure of landfills. Potential impacts of climate change on waste infrastructure may include increased rates of waste decomposition, odour and dust due to increased temperatures, flooding of landfills and waste treatment facilities, and reduced water availability for wet processes in waste treatment facilities. Also the impact on transport infrastructure should be considered, as transport is a critical component of waste management (collection, transport to and from waste treatment facilities). The impact on transportation is discussed in the section on transport above.

In Germany, no specific examples, guides, tools or other instruments have been identified for the waste sector that could assist in addressing climate adaptation. In general, more information is available on climate change mitigation, e.g. recycling, the energetic use of residual waste, and capturing and utilizing landfill gas contributing to the reduction of greenhouse gas emissions.


For landfills, [Directive 1999/31/EC on the landfill of waste](#) requires that landfills are situated and designed in such a way that pollution of the soil, groundwater or surface water is prevented. This requirement is translated into [national design standards](#) for the construction of landfills that include the consideration of temperature, precipitation extremes and flooding where relevant.

Large waste treatment plant are subject to [Directive 2010/75/EU on industrial emissions](#) (IED), which requires as a general principle that necessary measures should be taken to prevent accidents which may have environmental consequences, and to limit those consequences. This requires that a structured management plan should be available that includes and mitigates hazards such as extreme weather conditions (e.g. flooding, very high winds). In the [BAT reference document \(BREF\) on Waste Treatments Industries](#), some information is provided on the impact of certain climatic conditions (e.g. the impact of higher temperature on biofilter performance, aerobic decomposition, etc.). Although climate change is not specifically addressed.

See section 4.1 for more information on other documents that can help in taking climate considerations into account.

5. CASE STUDIES


5.1. Case studies of climate adaptation projects

Future Cities' Green-Blue corridor, Kamen	
Project description	The Future Cities project aimed to disconnect storm water from the nearby paved areas, as well as to ecologically improve the stream "Heerener Mühlbach" in Kamen, Germany. By combining the effects of green structures with the water system, the potential impacts of climate change would be weakened, and the implemented measures would unfold their potential in every climate change scenario.
Photograph	 <p>Source: https://www.umweltbundesamt.de/en/themen/klima-energie/klimafolgen-anpassung/werkzeuge-der-anpassung/tatenbank/gruen-blauer-klimakorridor-in-kamen</p> <p>Before (2007) and after (2012) transformation</p>
Budget	Based on the results of the feasibility, the costs depended highly on the local situation; the property owners willing to disconnect received from 9 €/m ² to 30 €/m ² (average range: 16-21 €/m ²).
Climate Change Vulnerability and Risks	<p>The 50-150 m wide stream "Heerener Mühlbach" was used as an open wastewater system over a straight concrete bed, where waste and storm water got mixed, affecting the ecosystem and biodiversity enormously. Also, the frequently occurring floods led to damages to private as well as industrial buildings located near the canal, which passes over a length of 2 km through a densely built area in Kamen.</p> <p>Extremely heavy rainfall enhances and aggravates the aforementioned risks. The intensity and the frequency of extreme weather events are most probably to increase in the future. Because of the uncertainties that come along with climate change, decentralized measures are to be applied, rather than technical solutions (for example, higher dikes or wider sewer, which often lack cost-effectiveness and the acceptance of the public) in order to unfold their potential in every climate change scenario.</p> <p>The green-blue corridor at the "Heerener Mühlbach" was realized within a time frame of about twelve months in 2011/2012. Before the beginning of the project, a sewer pipe was placed underground along the river. Afterwards, the concrete bed was removed (except under the bridges), allowing the river to flow on a new, higher and wider sole than before and in a more natural way. The hard edges of the stream were transformed into nature-like edges, where green plants now have the chance to grow along the blue water body.</p> <p>In total, 72 properties of paved areas nearby, which used to feed the combined sewer system, were disconnected.</p>

Climate change adaptation measures	<p>The long-term planning of this water infrastructure needed to be built on a climate change adaptation approach instead of mitigation.</p> <p>By removing the concrete waterbed, the flood risk in the case of more intense and frequent heavy rainfall was significantly reduced, since the water run-off is now slowed down by natural means (for example the meandering and infiltration of the water through the natural bed and banks of the canal). Whereas the separation of the storm water from nearby paved areas also reduces the risk of floods (because the sewer system must no longer cope with that extra amount of water), the use of the now separated storm water also improved sustainably and ecologically.</p> <p>Due to the use of rain water for the open water body, the water cycle remains intact even in dry periods like summer, and evaporation creates a better microclimate. This means that, while combining water management measures with green corridors in the cities, the ecological functions of the water system are strengthened and the climate in the urban surroundings is improved.</p>
Good practice	<p>This was one of the four case studies to be recognized as an "Adaptation Pioneer" by the Federal Environment Agency (UBA) in the first Blue Compass competition in 2016.</p> <p>As a result of this project, a river has been renatured (enabling biodiversity and providing recreational space for the local inhabitants), and the residents of the surrounding area have been successfully made aware of the water cycle and their own responsibility for sustainable development, also improving their housing environment.</p>
Further information	Federal Environment Agency (UBA) official webpage

5.2. Case studies of infrastructure projects which have addressed climate change adaptation

Sun-Protection for Bus Stops, Nordhessen	
Project description	<p>The main goal of this project is the adjustment of public transportation means under extreme weather conditions, which are influenced by climate change. For this, two bus-stop shelters/stations ("<i>Klinikum Werra-Meißner</i>" in <i>Eschwege</i> and "<i>Bahnhof</i>" in <i>Niederrhone</i>) made completely out of glass were adapted with sun protection films in the overhead glazing.</p> <p>The project was executed in cooperation with the University of Kassel.</p>

Photograph	 <p>Source: https://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/werkzeuge-der-anpassung/tatenbank/beschichtung-von-bushaltestellendaechern</p>
Budget	N/A
Climate Change Vulnerability and Risks	Climate change will affect passenger traffic. Even today, traffic is weather-dependent and in unfavourable weather conditions there are relevant impairments (e.g. in the event of a storm, heavy rain or heat). The increase of such events is still unresolved, regarding both the possible changes in behaviour as well as the necessary adaptation of the entire transport system. In the context of a survey in the region of Nordhessen, the project has been able to gain insights into the impact of extreme weather conditions on traffic, the choice of means of transport and the need for improvement and measures that are necessary. In addition, an infrastructure analysis was carried out.
Climate change adaptation measures	There are thousands of stations which had only been designed to offer protection against rain and wind, but were missing sun-protection (especially in the warmer seasons). A good protection system against the sun makes the waiting time at the bus stations easier and better.
Good practice	The case study is an example of an effective adaptation measure that is easy to implement. The adjustment of the bus stops has taken place in a very limited time but also with little (financial) resources.
Further information	Sonnenschutzfolie - Spiegelfolie – Fensterfolie webpage

KiezKlima, Berlin

Project description	The project aimed to inspire the inhabitants of the Berlin "Brunnenviertel" to get socially involved in matters of development and implementation of climate adaptation measures in their place of residence.
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Photograph



Source: L.I.S.T. GmbH

Budget

300.000 euro

Climate Change Vulnerability and Risks

"Heat Stress"

Extreme heat conditions have a negative influence on the metabolism of human, animal and herbal organisms, particularly affecting their hydrologic balance (danger of dehydration). The so called "heat stress" represents, mostly for older people and children, a serious health danger (risk for the heart-circulatory system). In the agriculture sector, heat stress could result in profit losses.

Climate change adaptation measures

Around 120 ideas for adaptation measures were presented. The proposals included were not only ideas for structural design but also for new networks and sponsorships.

Through workshops, the people of the neighbourhood have come up with many ideas for actions and contests for the greening of the neighbourhood. The results have provided the basis for the further planning of the adaptation measures with the residential construction company "degewo" and the district council.

Good practice

On the basis of an all-encompassing/unrestricted evaluation of the project process and results, transferable recommendations for other city districts in Germany are prepared. Questions such as the approach and participation of the population are at the forefront.

This was one of the four case studies to be recognized as an "Adaptation Pioneer" by the Federal Environment Agency (UBA) in the first Blue Compass competition in 2016.

This is what the jury says: The KiezKlima project is something innovative. This is how city planning works, because it is not just about adapting to climate change. Rather, the topic is used to shape neighbourhood management. The participatory approach, in which different forms of citizens' participation are used creatively, should be highlighted. The social component goes far beyond the aspect of adaptation and thus exposes socio-ecological and demographic challenges of urban development.

Further information	<p>Federal Environment Agency (UBA) official webpage:</p> <p>http://www.kiezklima.de/</p> <p>https://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/werkzeuge-der-anpassung/tatenbank/wettbewerb-tatenbank-blauer-kompass#textpart-1</p> <p>http://www.e-p-c.de/kiezklima/2015/</p> <p>https://www.klima.tu-berlin.de/index.php?show=forschung_dch_kiezklima&lan=de</p>
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