



Climate change adaptation of major infrastructure projects

Country report for the United Kingdom of Great Britain and Northern Ireland

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and Northern Ireland

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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 the United Kingdom (UK) 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 [Climate Change Act](#) (2008) created a framework for building the country's ability to adapt to climate change, and mandates the development of a [National Adaptation Programme](#). It includes a number of duties related to climate change adaptation and a [UK-wide Climate Change Risk Assessment](#) that must take place every five years for all devolved administrations (Scotland, Wales and Northern Ireland). The first [Northern Ireland Climate Change Adaptation Programme](#) (NICCAP) was adopted in 2014. In Scotland, the [Climate Change \(Scotland\) Act](#) of 2009 requires the Scottish Government to develop an Adaptation Programme. An [Adaptation Sub-Committee](#) (ASC) of the independent Committee on Climate Change assesses progress on the government's climate change adaptation programme. A large number of resources are available in the UK to support climate adaptation. The [Meteorological Office](#) holds most of the weather-related parameters some of which are freely available and some which require payment. The [Environment Agency](#) provides useful data for flood-related parameters in their Flood Map web Portal, which is widely used in infrastructure development. The [Scottish Environmental Protection Agency](#) provides a similar flood mapping tool as an equivalent

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

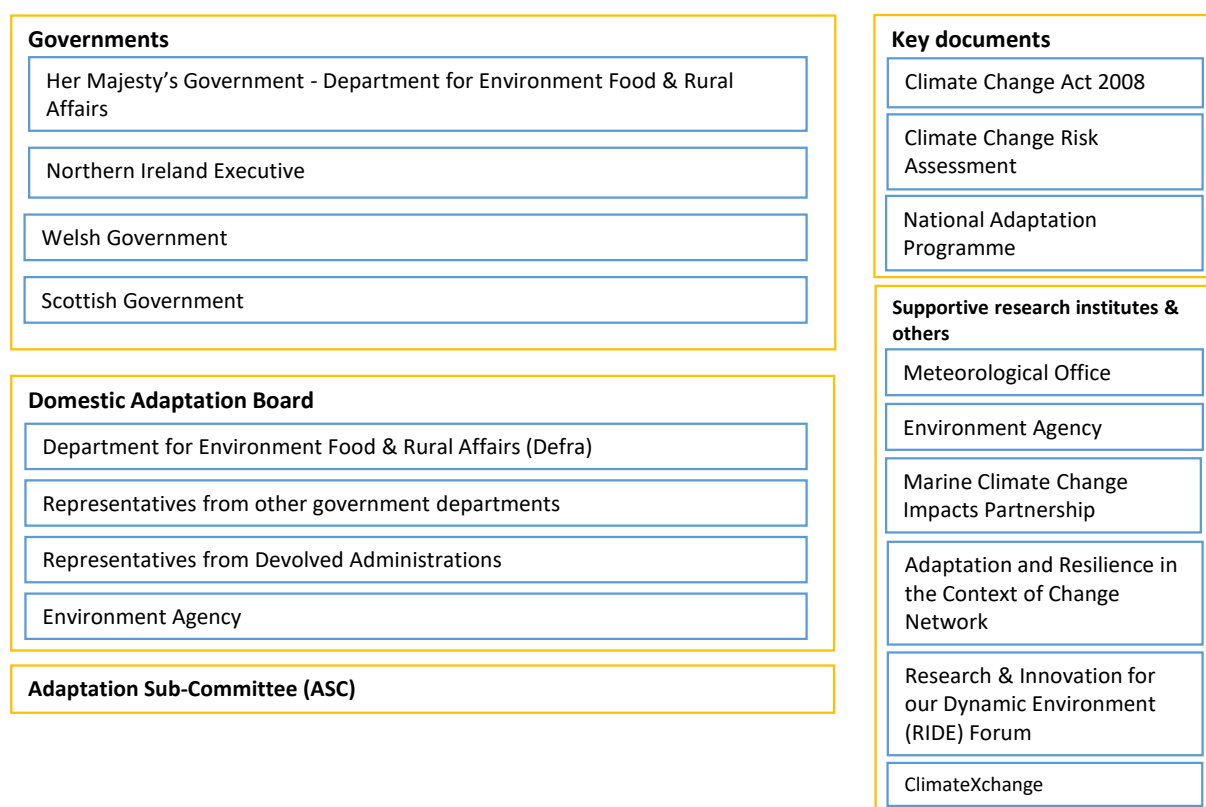
service to assist in planning, specifically in Scotland. The [Highways England Adaptation Framework Model](#) (2009) provides a seven-stage process to identify activities that will be affected by the changing climate. The [Scottish Environmental Protection Agency](#) provides a methodology to assess the relative adverse consequences of flooding across Scotland and which can be used to perform a risk assessment that incorporates vulnerability, exposure and value for non-motorway roads and rail links. Various tools exist in the UK; the [BeST \(Benefits of Sustainable Drainage Systems Tool\)](#) is publicly available and enables the user to assess the benefits of sustainable drainage systems. The Environment Agency provides an [Online Flood Map for Planning](#). This is publicly available and allows the user to learn about flooding probability at location as part of development planning. The [Network Rails CV065 Geotechnical Asset Management web site](#) is an example of an in-house tool tailored to assist specific adaptation needs. The '[Progress in preparing for climate change - Report to Parliament \(2017\)](#)' is a recent evaluation report on the current UK situation provides an objective analysis from a national and global perspective. [Setting price controls for 2015-20 – risk assessment tool supporting documentation](#) (2014) is a national document published by the water regulator Ofwat that addresses the level of risk included in an organisation's business plan and how this risk is allocated between the company and its customers. The [Design Manual for Roads and Bridges](#) (2017) provides for the management of flood risk in the planning process and allows for making predictions for increased precipitation associated with climate change. The [Railway Drainage Systems Manual \(2015\)](#) sets standards that includes allowances for impacts from future climate in the design of railway assets. The [Design Standard for the Construction of New Electricity Substations](#) (2009) provides guidance on how to improve the resilience of electricity substations to flooding in the energy sector. 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](#).

Infrastructure sectors are undertaking studies and actions to improve their resilience. The report [Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change](#) (2010) provides guidance on the key vulnerabilities and impacts associated with climate change. The [Transport Resilience Review](#) published in 2014 by the Department for Transport provides a review of the resilience of the transport network to extreme weather events. With regards to the rail sector, [Tomorrow's Railway and Climate Change Adaptation: Final Report](#) develops recommendations to improve the climate change resilience of the rail network. For broadband sector infrastructure, from the research conducted, limited resources were identified relating to formal authorities and institutions for addressing climate adaptation. In the energy sector, ETR-138 is used as a design standard for the construction of new electricity substations. This standard provides guidance on how to improve the resilience of electricity substations to flooding. The report, '[Planning for Climate Change – Guidance for Local Authorities](#)' provides specific guidance on the local planning approach for adapting to climate change. The [National Planning Policy Framework](#) (2012) states that Local Plans should take account of climate change over the long term. The [Climate Change Allowances for Flood Risk Assessments](#) (2016) provide a clear design standard for the urban development sector. The water sector is adapting to climate change, and Eleven water companies were invited by Defra to produce [progress reports](#) under the climate change adaptation reporting power. Methodologies for a vulnerability assessment and a sensitivity analysis of climate change on options relevant to Water Resource Zones (WRZ) are outlined in the Environment Agency guidance [Climate change approaches in water resources planning – overview of new methods](#). Comprehensive guidance is provided by the regulator Ofwat in the form of the '[Drainage Strategy Framework: Good practice guidance](#)' (2013) and the Environment Agency on climate adaptation in the water sector. One of the key recommendations highlighted in the report [Increasing the climate resilience of waste infrastructure](#) is that in the climate change adaptation reporting power should be applied in the waste sector to increase awareness of adaptation and assist waste infrastructure operators to build adaptation measures into their assets.

Three detailed case studies that demonstrate how climate change adaptation is being incorporated into infrastructure projects have been highlighted: the [High Speed 2](#) railway project, the [Veolia Energy Recovery Facility at Newhaven](#), and the [North West Bicester Eco Development](#).

2. LEGAL, POLICY AND INSTITUTIONAL FRAMEWORK

The [Climate Change Act](#) (2008) created a framework for building the country's ability to adapt to climate change. It includes a number of duties related to climate change adaptation and a UK-wide climate change risk assessment that must take place every five years, this is conducted for all devolved administrations (Scotland, Wales and Northern Ireland). The first UK Climate Change Risk Assessment (CCRA), together with its supporting evidence report, was published in January 2012 and the second in January 2017. A National Adaptation Programme must be put in place and reviewed every five years to address the most pressing climate change risks to England (to be laid before Parliament as soon as reasonably practical after the completion of the Climate Change Risk Assessment). The first [National Adaptation Programme Report](#) (NAP) was published in July 2013. The 2013 NAP is split between 6 thematic chapters on the Built Environment, Infrastructure, Healthy and Resilient Communities, Agriculture and Forestry, the Natural Environment and Business. The second NAP is expected in 2018.



The Climate Change Act (2008) also provides the Secretary of State with the power to require "bodies with functions of a public nature" and "statutory undertakers" to report on how they have assessed the risks of climate change to their functions, and what they are doing to address these risks (the Adaptation Reporting Power).

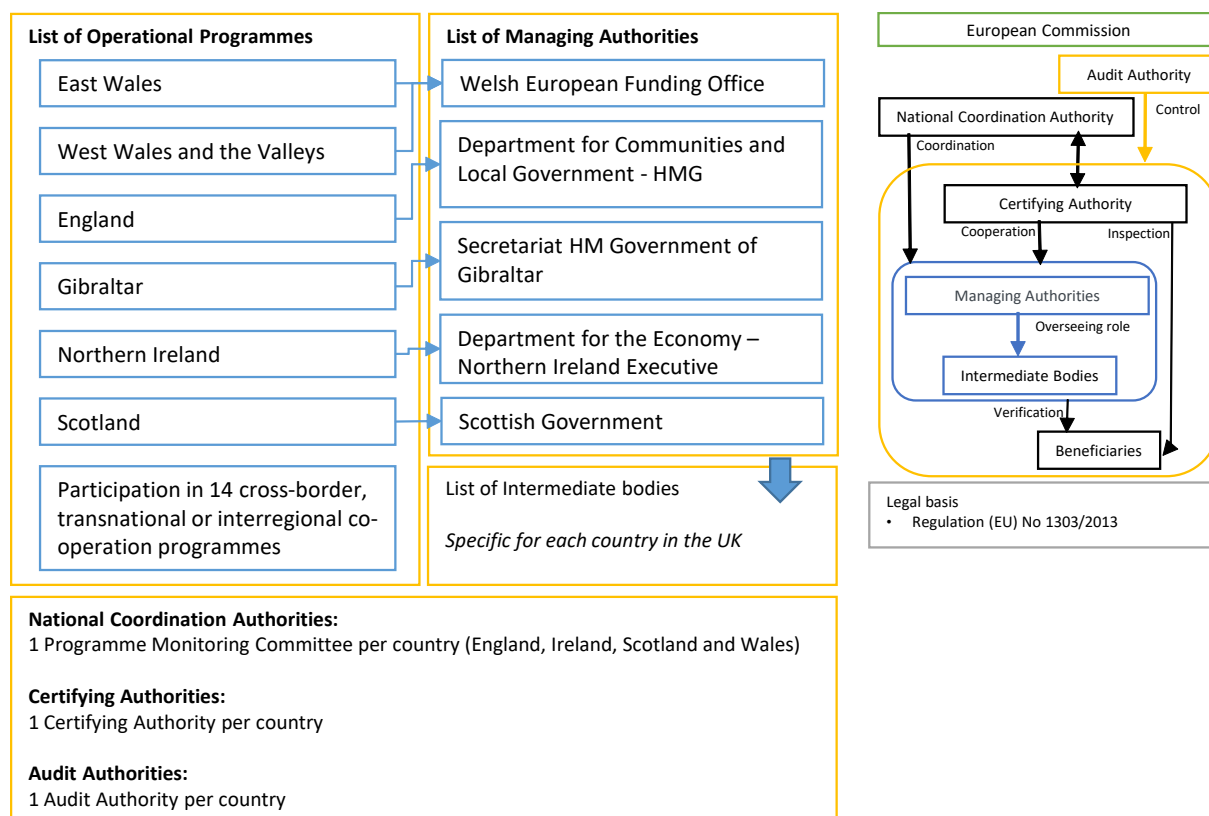
[The Climate Change \(Scotland\) Act](#) (2009) requires the Scottish Government to develop an Adaptation Programme to address the risks identified for Scotland in the CCRA. The Climate Change Act (2008) requires Welsh Ministers to lay from time to time a report before the National Assembly for Wales on the objectives, actions and future priorities of

Welsh. The Climate Change Act (2008) requires Northern Ireland Departments to prepare an adaptation programme to address the climate change risks to Northern Ireland, as soon as reasonably practicable after the laying before Parliament of the CCRA, and to review them every five years.

This second reporting round included organizations from the water, transport and energy sectors. The Adaptation Sub-Committee is jointly sponsored by the Northern Ireland Executive, the Scottish Government and the Welsh Government. The Adaptation Sub-Committee reports to Parliament every two years on the Government's progress in preparing the UK for the impacts of climate change through delivering the National Adaptation Programme.

Although the governments and assemblies of the devolved administrations are covered by the Climate Change Act, they do have separate climate change policies. This means that the devolved administrations can create climate change policy in their own country as well as support UK wide policy. Support for adaptation measures in Northern Ireland is provided by Climate Northern Ireland, in Scotland the Scottish Climate Change Adaptation Programme is used to address the risks identified in the UK Climate Change Risk Assessment for Scotland. In Wales, the Welsh Government Climate Change Team are responsible for producing Adaptation Delivery Plans as well as climate change strategy.

In the UK, ERDF is through Operational Programme managed at country level (England, Ireland, Scotland and two for Wales), as well one OP for Gibraltar.



3. RESOURCES

This country report has reviewed the currently available resources in the UK for adapting to the impacts of climate change across six key infrastructure sectors. Adaptation to climate change is integrated in the legal basis² for ESIF-funded projects, through the processes of vulnerability and risk assessments which are, broadly:

1. Vulnerability – evaluating the sensitivity and exposure of infrastructure to climate change
2. Risk – estimating the likelihood and impact of relevant climate hazards
3. 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

² 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

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
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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.

The [UK Climate Projections](#) are publically available and provide the most comprehensive source of existing climate projection data (UKCP09), including maps and graphs. This is currently the most comprehensive source of future climate data for the UK. The next set of projections (UKCP18) are due to be released in 2018.

The UK's National [Meteorological Service](#) (the Met Office) holds the nation's weather and climate records. These are summarised in the annual State of the UK Climate report, which provides an accessible, authoritative and up-to-date assessment of UK climate trends, variations and extremes. The [Met Office Hadley Centre](#) (MOHC) Climate Programme provides world-leading climate science and led the production of the current UK Climate Projections ([UKCP09](#)). UKCP09 gives projections of future changes to the climate in the UK to the end of this century.

The Met Office Hadley Centre (MOHC) Climate Programme provides world-leading climate science and led the production of the current UK Climate Projections (UKCP09). UKCP09 gives projections of future changes to the climate in the UK to the end of this century.

The [Environment Agency](#) provides the most useful data for flood-related parameters in their Flood Map web Portal, which is widely used in infrastructure development. The [Scottish Environmental Protection Agency](#) provides a similar flood mapping tool as an equivalent service to assist in planning, specifically in Scotland.

The [Office for National Statistics](#) (ONS) 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.

The UK Government published its second [Climate Change Risk Assessment](#) (CCRA) in 2017. This was informed by an [underpinning evidence report](#) prepared independently by the [Adaptation Sub-Committee](#) and published in July 2016. The evidence report analyses around 60 present-day climate risks and opportunities and current levels of adaptation, and assesses how climate and socio-economic change may alter those risks and opportunities in the 2020s, 2050s and 2080s. The evidence report has taken a policy-focused approach to presenting the results, using the concept of urgency to prioritize the risks and opportunities. It considers where additional action is needed in the next five years, taking into account current and planned policies, and identifies six priority risk areas of flooding, water scarcity, overheating, impacts on natural capital, food security, and pests and diseases.

The '[Progress in preparing for climate change - Report to Parliament \(2017\)](#)' is a recent evaluation report on the current UK situation provides an objective analysis from a national and global perspective. This report provides an objective analysis from a national and global perspective. It updates and extends the Adaptation Subcommittee analysis and advice on the current National Adaptation Plan, and makes further recommendations to the Government as it considers its priorities for the next National Adaptation Plan, expected by summer 2018.

The UK's [Seventh 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.

Research institutes active in the area of climate adaptation include the [Grantham Institute on Climate Change and the Environment](#), the [Tyndall Centre for Climate Change Research](#), and the [Environmental Change Institute](#).

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 available methodologies tend either to be relevant to the transport sector or to sectors that could be affected by flooding.

The [Environmental Agency's Climate Ready Service](#) has developed a [Cost Benefit Analysis methodology](#).

In England, the NAP is supported by the economic annex "[Economics of the NAP](#)", which builds on the CCRA to develop an approach to the roles of society/government in adaptation efforts, the challenges of uncertainty, the costs and benefits of climate change and the impacts of climate change on productivity and growth.

[Scotland Climate Change Adaptation Programme](#) provides an economic assessment of adaptation options to the risks highlighted by the CCRA. The [Scottish Environmental Protection Agency](#) provides a methodology which assesses the relative adverse consequences of flooding across Scotland and can be used to perform a risk assessment that incorporates vulnerability, exposure and value for non-motorway roads and rail links. Again, with some knowledgeable intervention, this model would work for most forms of infrastructure

The [Highways England Adaptation Framework Model](#) (2009) is a transport sector framework that provides a seven-stage process that identifies activities that will be affected by a changing climate, determines associated risks and opportunities, and identifies preferred options to address them. With some knowledgeable intervention, this model would work for most forms of infrastructure.

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.

The [BeST \(Benefits of Sustainable Drainage Systems Tool\)](#) is publicly available and enables the user to assess the benefits of sustainable drainage systems. It provides a structured approach to evaluating a wide range of benefits, often based upon the overall drainage system performance. It follows a simple structure that begins with a screening and qualitative assessment to identify the benefits to evaluate further.

The Environment Agency provides an [Online Flood Map for Planning](#). This is publicly available and allows the user to learn about flooding probability at location as part of development planning.

The [CityCAT \(City Catchment Analysis Tool\)](#) was developed in collaboration between Newcastle University and the Environment Agency and is based on an existing state-of-the-art Noah 2-D hydrodynamic model developed previously at Newcastle University. This is a unique software tool for modelling, analysis and visualisation of urban surface water flooding and experimentation of flood alleviation measures.

The [Targeted Flood Warnings Services](#) allows asset managers to compare their organisational assets (buildings, structures) against current flood warning data to gauge the real-time flood risk and hence take appropriate action regarding existing infrastructure. The application interfaces with data from the Environment Agency as well as Civil Contingency Act.

The [Network Rail CV065 Geotechnical Asset Management web site](#) is an example of an in-house tool tailored to assist specific adaptation needs. It captures data on drainage assets from a number of existing sources employing a range of techniques.

Adaptation Scotland provide the latest information to support adaptation planning and action, including past climate trends and future climate projections, through an accessible and visually engaging climate trends [online tool](#).

The UK Universities of East Anglia and Cambridge have been participating in the project [ToPDAd](#), which developed an [interactive tool](#) aiming to help businesses and regional governments find the best strategies to adapt to climate change. ToPDAd focuses on the energy, transport and tourism sectors in particular.

Other resources related to climate change adaptation included tools to [better understand social vulnerability and climate change](#), [monitor impacts of severe weather](#), assess [climate impacts on businesses](#), [business resilience](#) and [farm business resilience](#), [analyze the costs and benefits of adaptation](#), [project climate change impacts on wetlands](#), assess the [climate resilience of catchment management methods](#), and [develop a practical action plan to increase resilience](#).

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. [Climate change approaches in water resources planning – overview of new methods](#) (2013) was published by the Environment Agency and examines how climate change has been built into Water Resource Management Plans to date, and recommends best practice for the future, with particular reference to the use of probabilistic climate data in UKCP09 (see Data Availability).

The [Progress in Preparing for Climate Change - Report to Parliament](#) (2017) (Chapter 5) provides an objective analysis of the UK infrastructure resilience in both a national and a global perspective. In addition to inland infrastructure resilience this report also identified risks to coastal infrastructure as a result of increased coastal flooding and faster rates of coastal erosion.

[Setting price controls for 2015-20 – risk assessment tool supporting documentation](#) (2014) is a publicly-available national document published by Ofwat that addresses the

level of risk included in an organisation's business plan and how this risk is allocated between the company and its customers. As part of this risk assessment the guidance specifies that both an increase/decrease in volume of rainfall should be assessed by considering different rainfall scenarios.

The [Drainage Strategy Framework: Good Practice Guidance](#) (2013) was commissioned by the [Environment Agency](#) and [Ofwat](#), and provides direction for identifying potential adaptation measures. It also provides guidance on how water companies should develop their Drainage Strategies, so that they follow a risk-based approach in accordance with the [National Flood and Water Management Act 2010](#).

Natural England and the RSPB, in partnership with the CRSS and the Forestry Commission published the '[Climate change adaptation manual: evidence to support nature conservation in a changing climate](#)' to support conservation practitioners in adapting to climate change.

Adaptation Scotland offers Public sector guidance on '[Five steps to managing your climate risks](#)', giving the public sector a standard approach for adaptation planning and reporting.

Other resources related to climate change adaptation included guidance on [resilient local highways](#), [business continuity](#), [a resilient built environment](#), [making the case for adapting the built environment](#), [tackling overheating](#), adaptation for [health and social care](#), [the paper and pulp sector](#), [chemicals businesses](#), and [the food and drink sector](#), [resilient supply chains](#), [farm business resilience](#), [business opportunities](#), and [climate-proofing health and wellbeing strategies](#), [adaptation in the natural environment](#), and a [quick guide for small and medium-sized businesses](#).

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 [British Standards Institution](#) (BSI) is collaborating with the [European Standardization Organizations](#) 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).

The [Design Manual for Roads and Bridges](#) (2017) (Volume 11, Section 3, Part 10, Road Drainage and the Water Environment) provides for the management of flood risk in the planning process and allows for making predictions for increased precipitation associated with climate change. The Design Manual for Roads and Bridges provides mandatory standards, advice notes and other documents that relate to the design, assessment and operation of motorways in the UK.

The [Railway Drainage Systems Manual](#) (2015) sets standards that includes allowances for impacts from future climate in the design of railway assets. For new and remediated railway drainage, a 20% increase in the estimated present-day design flow for design

event return periods is added. These are mandatory standards that require designers incorporate the future climate into new and refurbished assets.

The [Climate Change Allowances for Flood Risk Assessments](#) (2016) provide a clear design standard for the urban development sector. These are provided by the Environment Agency and help developers to make an allowance for climate change in their flood risk assessment, minimising vulnerability and providing resilience to flooding and coastal change in the future.

The [Design Standard for the Construction of New Electricity Substations](#) (2009) (ETR-138) provides guidance on how to improve the resilience of electricity substations to flooding in the energy sector.

The [EN 50600 TR Availability Classes](#) provides a standard for the construction of new data centres though not exclusively for climate change risks.

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

Responsibility for climate change adaptation is split between the four countries of the United Kingdom, with national governments in Northern Ireland, Wales and Scotland responsible for adaptation in all devolved policy areas.

The [Climate Change Act 2008](#) is the basis for the UK's approach to tackling and responding to climate change. It has built a framework for the UK to adapt to climate change, by mandating that a [UK-wide Climate Change Risk Assessment](#) (CCRA) must take place every five years; and that a UK [National Adaptation Programme](#) (NAP) must be put in place to address the most pressing climate change risks and reviewed following each CCRA. It also includes the establishment of the [Adaptation Sub-Committee](#) (ASC) of the independent Committee on Climate Change to assess progress on the government's climate change adaptation programme. Their role includes advising on the CCRA and evaluating the NAP.

Additionally, the [UK Adaptation Reporting Power](#) grants the Secretary of State the power to require public service organisations to produce reports on what they are doing to adapt to climate change. In September 2016 Defra asked the Adaptation Sub-Committee (ASC) to carry out a [second round review of the Adaptation Reporting Power](#).

In response to the CCRA, the Climate Change Act also requires the UK government to produce a [National Adaptation Programme](#) (NAP). The first NAP of 2013 sets out actions that leading businesses, councils and communities, as well as government, are taking to tackle climate threats and take advantage of new opportunities. The second NAP is expected in 2018.

Wales has strengthened the legislative requirements to build resilience in Wales to the impacts of climate change through the Wellbeing of Future Generations (Wales) Act 2015 and Environment (Wales) Act 2016.

Northern Ireland Departments are required under the Climate Act of 2008 to prepare an adaptation programme to address the climate change risks. The first [Northern Ireland Climate Change Adaptation Programme](#) (NICCAP) was laid before the Assembly in

January 2014. It contains the Government's response to the risks and opportunities identified in the CCRA for Northern Ireland published as part of the UK CCRA. It provides strategic objectives, proposals and policies by which each department will meet these objectives, and associated timescales.

In Scotland, the [Climate Change \(Scotland\) Act](#) 2009 requires the Scottish Government to develop an Adaptation Programme to address the risks identified for Scotland in the CCRA. Scotland's first statutory Climate Change Adaptation Programme (SCCAP, May 2014) aims to increase the resilience of Scotland's people, environment and economy to the impacts of climate change.

The National Risk Assessment is undertaken in line with thematic ex-ante conditionality 5.1, according to which, national or regional risk assessments for disaster management need to be taking into account climate change adaptation.

Responsible authorities

The Department for Environment, Food and Rural Affairs (Defra) co-ordinates the UK government's work on adaptation in England, and throughout the UK. The Climate Change Act (2008) provided a strong institutional framework in the UK. The following institutions have various roles and responsibilities with regard to climate change adaptation:

- The [Environment Agency](#) (EA)
- The [Scottish Environmental Protection Agency](#) (SEPA)
- The [Northern Ireland Environment Agency](#) (NIEA)
- The [Department of Food and Agricultural Affairs](#) (Defra)
- The [Infrastructure Operators Adaptation Forum](#) (IOAF)
- The [Committee on Climate Change](#) (CCC)
- The [Adaptation Sub-Committee](#) (ASC)

The Domestic Adaptation Board (DAB), chaired by Defra, is the horizontal coordination body. It oversees cross-Government action and has members from most government departments, the Devolved Administrations and EA. The overarching role of the DAB is to provide strategic, high level input and direction to the statutory programme of work delivering the UK's 5 yearly Climate Change Risk Assessment (CCRA) and National Adaptation Programme (NAP).

Management of the ESI Funds

The UK has six national programmes financed by the ERDF, and the corresponding Managing Authorities: the East Wales OP, and the West Wales and The Valleys OP managed by the Welsh European Funding Office; the England OP managed by the Department for Communities and Local Government - HMG; the Gibraltar OP managed by the Secretariat HM Government of Gibraltar; the Northern Ireland OP managed by the Department for the Economy – Northern Ireland Executive; the Scotland OP managed by the Scottish Government. The UK is participating in 14 Cross-border, transnational and interregional co-operation programmes. For the quality control system there are separate Audit and Certifying Authorities per country, and one Programme Monitoring Committee per country (England, Ireland, Scotland and Wales).

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

The Environment Agency, the Scottish Environmental Protection Agency and the Northern Ireland Environment Agency all provide institutional support within each of their individual administrations. Until recently the [Environmental Agency's Climate Ready Service](#) provided strong support for the Local Government Association's Climate programme. This programme in turn supported and encouraged local authorities to formally commit to take action on climate change and to report on their progress. However, this was closed after four years of service in 2016.

In addition to providing support the Environment Agency also provide comprehensive guidance to developers in the form of the [flood risk assessments climate change allowances](#). The Environment Agency will want to see that developers have considered high allowances in their flood risk assessment or strategic flood risk assessments. The high allowances apply in assessments for developments that are very sensitive to flood risk and with lifetimes beyond the end of the century, for example infrastructure projects.

With regards to institutions providing tools that enable successful adaptation planning, the UK Meteorological Office has worked closely with the UK Climate Impacts Programme to deliver the [UKCP09 Climate Projections web portal](#). This web portal features some of the most robust climate projections ever produced and this is set to further improve with the development of UKCP18, which is set to deliver major upgrades.

At the government level, the Adaptation Subcommittee recently published the '[Progress in preparing for climate change 2017 Report to Parliament](#)'. Chapter 5 addresses infrastructure, in this the Adaptation Subcommittee explores current infrastructure vulnerabilities and makes series of comprehensive recommendations on how to adapt these to a changing climate. This document is just one example of the comprehensive research that is currently being carried out by the UK's Governmental institutions.

[Adaptation Scotland](#) offers training resources for Strategic Development Planning Authorities to identify opportunities to include adaptation within strategic development plans.

The [Welsh Government's Knowledge Transfer Programme](#) is an exchange process between the Welsh Government and its key stakeholders in Wales. It aims to build resilience against the impacts of climate change through the exchange of knowledge, skills and resources; and is focused on how to embed adaptation within organisations and developing tools and resources to help sectors and organisations adapt to the impacts of climate change.

Effective collaboration

The Domestic Adaptation Board, chaired by Defra, oversees cross-Government action and has members from most government departments, the Devolved Administrations and the Environment Agency (EA). In Scotland, a Cabinet sub-committee on climate change ensures that delivery is coordinated across portfolios and that climate change considerations are reflected at the very highest level of the Scottish Government. In Wales, the Commissioner and her office will play a central role in developing and enabling actions in the Public Sector. In Northern Ireland, the Climate Change Unit in the Department of Environment is responsible for the co-ordination of the cross Departmental work on adaptation. It leads on development, implementation and

monitoring of the NI Climate Change Adaptation Programme, though responsibility is shared with all government departments.

The following initiatives showcase the level of collaboration within the UK:

- Climate UK is a sub-national network of climate change partnerships covering the UK. It aims to share knowledge and learn about tackling the consequences of climate change in the UK.
- The Local Adaptation Advisory Panel for England provides a forum to champion adaptation activity across local government, identifying best practice for adaptation at the local level.
- Climate NI is a partnership of external stakeholders from a range of key sectors who provide advice and support to Government with the aim of increasing the understanding of the impacts of climate change, sharing best practice and promoting action to address the impacts of climate change.
- Available support for local councils through the [Climate Local initiative](#), with associated [resources](#) and [publications](#).
- The Infrastructure Operators Adaptation Forum is considered an important institution for identifying interdependencies across sectors and facilitating cross sector collaboration between organizations.

The number of adaptation specialists currently working in UK government institutions are about 14. Specifically, the Department of Food and Agricultural Affairs (DEFRA) have approximately six specialists working in their adaptation team as well as one adaptation specialist working in their flooding team; the Department for Transport (DfT) has approximately two adaptation specialists working in their department; and the Adaptation Subcommittee (ASC) currently has six members with expertise climate change adaptation.

The [UK Climate Change Risk Assessment 2017 Evidence Report](#) states that a number of institutional barriers persist within the current institutional frameworks for adaptation in the UK. Obstacles include unclear or unmeasurable adaptation policy goals across correlated risks; a large number of partners involved in delivering adaptation activity; the limited alignment between related policy goals (e.g. flood risk management with housing and planning policies); and capacity gaps, including as a result of funding and resource constraints, particularly at the local level. A number of knowledge, information and data gaps to assess and manage cross-cutting risks have also been identified

Financial resources

The UK is [allocated 5.86 Billion EUR under the ERDF](#) for the between 2014 and 2020. Concerning major projects, by early 2018, there have been no funds allocated for major projects in the UK for the 2016 -2020 programming period according to the [datasets](#) of the European Commission.

According to the [ESIF-viewer](#), projects under the Thematic Objective 5 on promoting climate change adaptation, risk prevention and management will be receiving 106 Million EUR, with an additional 104 Million EUR approved for Network Infrastructures in Transport and Energy (Thematic Objective 7); 370 Million EUR in Environment Protection & Resource Efficiency (thematic Objective 6); and 163 Million EUR for Information and Communication Technologies (Thematic Objective 2). The shares within these Thematic Objectives that may relate to climate adaptation are unknown.

On the national level, Research projects are funded by the Natural Environment Research Council with contributions from Defra, the devolved administrations, and the Environment Agency.

4. SECTOR OVERVIEW

4.1. Introduction

Since 2014, the requirements for major projects to obtain ESIF funding³ demand that project applications integrate climate change considerations⁴, 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*.⁵

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.

Since devolution in Scotland, Wales and Northern Ireland many of the transport powers have been devolved from the UK government. This means that in each individual administration there are different transport operators present.

With regards to the UK transport sector easily accessible and comprehensive climate projection data, including maps and graphs, is available from the [UK Climate Projections 2009](#) website. This is however not specific to the context of the transport sector. The [Climate Adaptation Report](#) (2015) sets out an overview of the current and future predicted effects of climate change on the sector. The [Transport Resilience Review](#)

³ http://ec.europa.eu/regional_policy/archive/projects/major_projects/index_en.cfm

⁴ 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>

⁵ 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.

published in 2014 by the Department for Transport provides a review of the resilience of the transport network to extreme weather events.

Road infrastructure

In relation to available methodologies, the [Highways England Adaptation Framework Model](#) has been designed specifically to meet the needs of Highways England and to address the key aims of the adaptation provisions of the Climate Change Bill.

The [Highways England Design Manual for Roads and Bridges](#) considers climate change adaptation by providing design standards for the management of flood risk in the planning process. An example of this can be found in Volume 11: Section 3 of this design manual, 'road drainage and the water environment' which includes a description of what climate change allowances should be incorporated into road design.

On a government level, the [National Adaptation Programme](#) (2016) sets actions for the next five years for both the Department for Transport (DfT) and the transport sector. Comprehensive guidance is provided separately for the road and rail sectors.

Furthermore, the reports [Adapting to climate change: helping key sectors to adapt to climate change](#), [Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change](#) (2010), [Climate resilient infrastructure: preparing for a changing climate](#) (2011) and [Infrastructure, engineering and climate change adaptation: ensuring services in an uncertain future](#) (2011) provide specific guidance relevant to roads, rail, ports and airports with regards to potential trigger points that infrastructure might have to the effects of climate change.

Progress reports under the climate change adaptation reporting power (Climate Change Act 2008) are available for a wide range of transport operators. Each of these individual reports sets out each operator's progress with regards to climate change adaptation. The following organizations have produced progress reports:

- [Highways England](#)
- [Transport for London](#)

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

Rail infrastructure

With regards to the rail sector, [Tomorrow's Railway and Climate Change Adaptation: Final Report](#) (2016) develops recommendations to improve the climate change resilience of the GB rail network. [Network Rail's Railway Drainage Systems Manual](#) provides design standards that include allowances for impacts from future climate in the design of railway assets. For new and remediated railway drainage, a 20% increase in the estimated present-day design flow for design event return periods is added.

In relation to tools, Network Rail's Asset Management Strategy explicitly includes weather and climate change, and the benchmarking tool, Asset Management Excellence Model (AMEM) which is used to monitor progress as part of 'Risk and Review'.

On a government level, the [National Adaptation Programme](#) (2016) sets actions for the next five years for both the Department for Transport (DfT) and the transport sector. Comprehensive guidance is provided separately for the road and rail sectors.

Furthermore, the reports [Adapting to climate change: helping key sectors to adapt to climate change](#), [Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change](#) (2010), [Climate resilient infrastructure: preparing for a changing climate](#) (2011) and [Infrastructure, engineering and climate change adaptation: ensuring services in an uncertain future](#) (2011) provide specific guidance relevant to roads, rail, ports and airports with regards to potential trigger points that infrastructure might have to the effects of climate change.

Progress reports under the climate change adaptation reporting power (Climate Change Act 2008) are available for a wide range of transport operators, including [Transport for London](#).

The UK government is currently planning a new high-speed rail network that will run from London to Birmingham and to Manchester and Leeds, this is known as [HS2](#), which assessed the risks posed by the climate change and developed relevant adaption measures (See Section 5. Case studies).

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

Airport infrastructure

The reports [Adapting to climate change: helping key sectors to adapt to climate change](#), [Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change](#) (2010), [Climate resilient infrastructure: preparing for a changing climate](#) (2011) and [Infrastructure, engineering and climate change adaptation: ensuring services in an uncertain future](#) (2011) provide specific guidance relevant to roads, rail, ports and airports with regards to potential trigger points that infrastructure might have to the effects of climate change.

Progress reports under the climate change adaptation reporting power (Climate Change Act 2008) are available for a wide range of transport operators, including:

- [The Civil Aviation Authority](#)
- Six strategic airport operators ([Birmingham Airport](#), [Gatwick Airport](#), [Glasgow Airport](#), [Heathrow Airport](#), [East Midlands and Manchester Airports](#) and [Stansted Airport](#))

See section 4.1 for more information on other 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](#)" (2016) 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 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.

From the research conducted, limited resources were identified relating to formal authorities and institutions for broadband in the UK. A voluntary [submission](#) was provided to Defra by TechUK on behalf of the ICT sector under the adaptation reporting

power, this is mostly focused on data centers but also includes informal observations on fixed line communications (broadband).

With regard to the UK broadband sector easily accessible and comprehensive climate projection data, including maps and graphs, is available from the [UK Climate Projections 2009](#) website. This however is not specific to the context of the broadband sector.

A guidance for the ICT sector is outlined in '[Adapting the ICT Sector to the Impacts of Climate Change](#)' (2010). In addition to this a high-level guidance is outlined in '[Infrastructure, engineering and climate change adaptation: ensuring services in an uncertain future](#)' (2011). The [Climate resilient infrastructure: preparing for a changing climate](#) (2011) provides general guidance relevant to infrastructure projects with regards to potential trigger points that infrastructure might have to the effects of climate change.

In 2011 the UK's communications regulator Ofcom provided the Secretary of State with a [report on climate change adaptation in the ICT sector](#) (2010). This report provides a high-level assessment of the potential impacts of climate change in relation to operators in their sector.

The [design standard EN 50600 TR Availability Classes](#) is available to inform operators on the construction of new data centers. While not focused exclusively on climate change risks, the resilience of a data center facility is assessed against four classes of availability which does incorporate risk of flooding. 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*.⁶

With regard to the funding of UK broadband infrastructure there is comprehensive guidance provided in '[European Funding for Broadband 2014 – 2020](#)' (2017). This report states that European Structural and Investment Funds are the largest public funding source that supports broadband investment. The report also states that the 2014 - 2020 total budget for broadband deployment in the UK is approximately €213 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.

With regard to the UK urban development sector easily accessible and comprehensive climate projection data, including maps and graphs, is available from the [UK Climate Projections 2009](#) website. This however is not specific to the context of the urban development sector.

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.

Flood risk assessments for new development proposals provide a methodology for incorporating [climate change allowances](#). These allowances are specific to each region of the UK and take into account total potential change anticipated until 2100.

These climate change allowances are then reflected in surface water drainage strategies and other adaptive measures for new urban development schemes.

The report '[Adapting to climate change: a checklist for development](#)' (2005) provides the user with a list of the key issues that should be considered when climate proofing a new development against the effects of climate change (Location, site layout, building structure, ventilation and cooling, drainage and water).

The report, '[Planning for Climate Change – Guidance for Local Authorities](#)' provides specific guidance on the local planning approach for adapting to climate change. Sections 3 and 4 of this report offer a range of principles and good practice guidance which local planning authorities and communities can use in the preparation and implementation of development plans. One of many examples of good practice is the advice that local authorities should determine planning applications based on a defined criterion e.g. *the new development should be designed to avoid adding to the vulnerability of existing or other proposed developments*.

The [National Planning Policy Framework](#) (2012) states that Local Plans should take account of climate change over the long term. An example of this is the [City of London – Local Plan](#) (2015) which contains extensive coverage of climate change risks to London as well as both adaptation measures. This document contains many measures which are currently being implemented across London one of these is the Thames Estuary 2100 project which aims to ensure that flood defences are raised by up to 0.5 metre by 2065 and 1 metre by the year 2100.

With regard to tools that are used for urban development the Construction Industry Research and Information Association (CIRIA) have developed [BeST](#) (Benefits of SuDS Tool) this tool allows planners to more easily assess the benefits of Sustainable Drainage Systems (SuDS), based on the [Non-statutory technical standards for sustainable drainage systems](#), without the need for full scale economic inputs.

Other available tools include:

- [Climate Just Map](#) is an interactive map shows the geography of vulnerability to climate change at a neighbourhood scale (limited to England)
- For projects in coastal areas, the [Regional Coastal Monitoring Programmes](#) offers a map viewer and access to a data catalogue.
- To assess flood risk, [Flood Maps](#) have been developed by the Environment Agency. The [CityCAT \(City Catchment Analysis Tool\)](#) is a useful software tool for modelling, analysis and visualisation of urban surface water flooding and experimentation of flood alleviation measures.
- The [BeST \(Benefits of Sustainable Drainage Systems Tool\)](#) enables the user to assess the benefits of sustainable drainage systems.

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). 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.

With regards to the UK energy sector, climate projection data (including maps and graphs) is easily accessible from the [UK Climate Projections 2009](#) website, but is not specific to the context of the energy sector.

The report [Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change](#) (2010) provides guidance on the key vulnerabilities and impacts associated with climate change. This has been summarized for different infrastructure elements in the form of an Energy Vulnerability Matrix.

This matrix assesses different elements such as fuel processing facilities and the energy distribution system and displays vulnerability in relation to projected changes in both precipitation and temperature for the 2030s, 2050s and 2080s.

Furthermore, the report [Infrastructure, engineering and climate change adaptation: ensuring services in an uncertain future](#) (2011) provides general guidance relevant with regards to potential trigger points that infrastructure might have to the effects of climate change.

Under the climate change adaptation reporting power (Climate Change Act 2008) the following energy sector regulators and operators have produced their own individual progress reports:

- Regulator: [Ofgem](#)
- Generators: [Energy UK](#) and [Scottish and Southern Energy Power Distribution](#)
- Electricity transmitter: [National Grid](#)
- Electricity distributors: [Electricity North West](#), [Northern Powergrid](#), [SP Energy Networks](#), [UK Power Networks](#) and [Wester Power Distribution](#)

The [Engineering Technical Report ETR-138](#) (2009) specifies design standards for primary electricity substations. This standard is used across the energy sector to ensure that climate change resilience is built into new infrastructure by using a risk based methodology to mitigate the risk of flooding. This includes the requirement that new substations should incorporate a 20% allowance on predicted flood depth to incorporate the impacts of climate change.

Several research projects aims to increase the resilience of the energy sector in the UK:

- [ARIES](#) aims to develop a comprehensive risk framework to assess UK energy system resilience to climate change.
- RESNET aims to develop systems-level approach to analyzing the resilience of the existing and proposed electricity networks

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.

With regard to the UK water sector easily accessible and comprehensive climate projection data, including maps and graphs, is available from the [UK Climate Projections 2009](#) website. This however is not specific to the context of the water sector.

Few methodologies were identified, however methodologies for a vulnerability assessment and a sensitivity analysis of climate change on options relevant to Water Resource Zones (WRZ) are outlined in the Environment Agency guidance, '[Climate change approaches in water resources planning – overview of new methods](#)' (2013).

Comprehensive guidance is provided by the regulator Ofwat in the form of the '[Drainage Strategy Framework: Good practice guidance](#)' (2013) and the Environment Agency on climate adaptation in the water sector. This guidance states that operators should plan to incorporate climate change adaptation into new infrastructure, an example of good practice is given with regard to a risk assessment carried out by United Utilities which used 2010, 2020 and 2036 models. In this example 2D models were used to assess future sewer flooding, taking into account the projected effects of climate change.

Furthermore, the reports [Adapting to climate change: helping key sectors to adapt to climate change](#), [Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change](#) (2010), [Climate resilient infrastructure: preparing for a changing climate](#) (2011) and [Infrastructure, engineering and climate change adaptation: ensuring services in an uncertain future](#) (2011) provide guidance relevant to the sector with regards to potential trigger points that infrastructure might have to the effects of climate change.

Eleven water companies were invited by Defra to produce [progress reports](#) under the climate change adaptation reporting power (Climate Change Act 2008). This addresses the current and future predicted effects of climate change on each organization their proposals for adapting to climate change. All of these reports cover interdependencies between other sectors, failures in the energy and transport sectors in particular have the potential to cause a cascade of failures. One example of good practice is Thames Water who have aimed to reduce their dependence on the electricity grid by increasing renewable energy production through technology such as the Thermal Hydrolytic Process.

An example of this process in action can be seen with the Beckton & Crossness Thermal Hydrolysis Plants which became operational in 2014 these are the sixth largest thermal hydrolysis plants in the world and are helping Thames water to reduce their dependence on the energy sector.

With regard to strategy, water organizations are required to consider climate change adaptation within their price setting and investment strategies. In relation to this Ofwat has produced the report '[Setting price controls for 2015-20 – risk assessment tool supporting documentation](#)'. This risk assessment tool considers both an increase/decrease in the volume of rainfall by assessing different rainfall scenarios.

Water supply asset managers make use of the [Targeted Flood Warnings Services](#) to assess flood risk and develop appropriate actions.

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

4.7. 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.

With regards to the UK waste sector easily accessible and comprehensive climate projection data, including maps and graphs, is available from the [UK Climate Projections 2009](#) website. This however is not specific to the context of the waste sector.

Fewer guidance resources were identified than for the water, energy and transport sectors, however the report, '[Increasing the climate resilience of waste infrastructure](#)' (2012) is comprehensive and accessible. This report provides information on potential climate change effects that could impact the waste sector and recommendations are given in how the waste sector could incorporate climate change adaptation into new infrastructure development.

Unlike the water, energy and transport sectors, the waste sector was not invited by Defra to produce progress reports (second round reports) under the climate change adaptation reporting power (Climate Change Act 2008). Therefore, the waste sector does not have the same level of reporting available on the current and future predicted effects of climate change and proposals for adapting to climate change as these sectors.


One of the key recommendations highlighted in the report '[Increasing the climate resilience of waste infrastructure](#)' (2012) is that in the climate change adaptation reporting power should be applied in the waste sector to increase awareness of adaptation and assist waste infrastructure operators to build adaptation measures into their assets.

Waste management infrastructure needs to comply with environmental legislation, such as the Landfill Directive and the Industrial Emissions Directive. [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

HIGH SPEED 2 (HS2)	
PROJECT DESCRIPTION	The UK government is currently planning a new high-speed rail network that will run from London to Birmingham and to Manchester and Leeds, this is known as HS2. The proposed network will be built to accommodate trains up to a speed of 250 miles per hour which will make it the fastest operating rail network in Europe.
PHOTO	 <p>http://www.regionalbahn.hu/2014/01/nagysebessegu-vonal-vasut-hazajaban-mit.html</p>
BUDGET	£56 billion
CLIMATE CHANGE VULNERABILITY AND RISKS	<p>The Environmental Statement for HS2 Phase 1 assessed the risks faced from climate change impacts on interdependencies, such as the rail network, electricity supply, and ICT. In addition to these other risks identified were potential flooding of tracks and tunnels, as well as the overheating of tunnels.</p> <p>With regard to methods the Environmental Statement uses a high-level climate change risk assessment to assess vulnerabilities and in terms of tools/data availability the assessment makes use of the UKCP09 projections web portal to assess the potential future climate.</p> <p>With regards to scenarios the assessment considers a construction and operation phases of the period 2017-2099. This assessment was conducted in 2013 and further Phases will be assessed in the near future.</p>
CLIMATE CHANGE ADAPTATION MEASURES	Engagement with infrastructure operators helped to identify key interdependencies. Recommendations for the design of HS2 include considering: increased redundancy within the system; collaborative working arrangements with local infrastructure operators; the use of 'what if' scenarios; and the use of common

	<p>standards across sectors/operators where possible.</p> <p>A 'green infrastructure' approach will be used in development. This approach will result in a landscape that is designed to incorporate flood defense measures which will in turn contribute to decreased vulnerability and increased resilience. Furthermore 'stepping stones' will be incorporated into designs (land areas that connect habitats closely together allowing the movement of fauna), this will provide local fauna the ability to achieve autonomous adaptation e.g. this would allow better species distribution as temperatures increase.</p> <p>Efforts will also be made to incorporate appropriate landforms and gradients to minimize flood risk. In addition to this drainage will be designed to accommodate for the 1/ 100 year annual rainfall event, which will incorporate a climate change allowance.</p>
GOOD PRACTICE	<p>It is the one of the largest infrastructure projects in Europe and from the sources provided it is clear that adaptation measures are being considered in the planning stage. A good practice is the use of green infrastructure, which will have sustainability benefits for landscape, ecology and people. With regard to adaptation, green infrastructure will result in a landscape that is designed to incorporate flood defense measures and support autonomous adaptation of local fauna to temperature increase.</p>
REFERENCES	<p>Environmental Statement Volume 5. Technical Appendices: Resilience to impacts from climatic conditions</p> <p>High Speed 2 Information Paper: Adaptation and Resilience 2013</p>

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

VEOLIA ENERGY RECOVERY FACILITY AT NEWHAVEN

PROJECT DESCRIPTION	<p>The energy recovery facility (ERF) was built in 2011 at north quay, newhaven. The plant currently processes around 210,000 tonnes of municipal waste each year that cannot otherwise be reused or recycled. It is situated on the banks of the river ouse which is on the south coast of england and was therefore built in an area which is vulnerable to flooding. The project involved constructing flood protection around the perimeter of the site, in combination with other measures to reduce the rate of flood water flow across of north quay area.</p>
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PHOTO

<https://www.gov.uk/government/publications/increasing-the-climate-resilience-of-waste-infrastructure>

BUDGET	£160 million
CLIMATE CHANGE VULNERABILITY AND RISKS	The main vulnerability and risks were associated with building a large plant in an area that is prone to flooding. Also, it was considered that future flood risk from climate change would increase risk/vulnerability of the development. In this case developers used Environment Agency guidance for carrying out their flood risk assessment, this incorporated the requirement to withstand a 1/200 year flood, a 20% climate change factor and a sea level rise scenario (as specified by the Environment Agency). This plant has been operational since 2011 and so is in the post completion stage.
CLIMATE CHANGE ADAPTATION MEASURES	Innovative two-phase construction technique used where the plant was assembled behind a sealed membrane in a location away from river. This was then floated into position and lowered into its foundations. With regards to the design phase, levees were used for flood protection and Sustainable Drainage Systems were utilized to reduce run-off.
GOOD PRACTICE	The development Is a significant project that proves that if successful adaptation is incorporated into the design phase of a project then developers do not have to be restricted by geographical vulnerabilities.
REFERENCES	Summary of Proposals and results of studies: North Quay Energy Recovery Facility [online] https://www.veolia.co.uk/southdowns/sites/ Increasing the climate resilience of waste infrastructure 2012 [online] https://www.gov.uk/government/publications/increasing-the-climate-resilience-of-waste-infrastructure

NORTH WEST BICESTER ECO DEVELOPMENT

PROJECT DESCRIPTION	The project is an eco-development (housing) that is situated on the north-west of Bicester in Oxfordshire. It is the UK'S very first eco-town and its long-term vision is to provide 6,000 new sustainable
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	homes for the local area over the next 25-year period.
PHOTO	 <p>http://nwbicester.co.uk/about-nw-bicester/</p>
BUDGET	£20 million (for the initial stages)
CLIMATE CHANGE VULNERABILITY AND RISKS	<p>A methodology was developed in order to undertake a climate change risk analysis based on the UKCP09 Weather Generator tool. This involved the use of UKCP09 projections to model for both medium and high emissions for the 2030s, 2050s and 2080s. This was then combined with a vulnerability assessment of future occupants. The risks identified included the following categories: excessive heat, excessive rainfall, flooding, storms, drought and Ice / snow. The findings of this process were then used to inform an options appraisal of suitable adaptation measures. The assessment of climate change risk and adaptation measures began in the planning phase of the development.</p>
CLIMATE CHANGE ADAPTATION MEASURES	<p>The Design for Future Climate report (see reference box below) contains an extensive list of potential adaptation measures, these include but are not limited to the following:</p> <ul style="list-style-type: none"> • Design that incorporates the replacement of pavements and roads with porous, 'cool' materials • Plans for the planting of heat, drought and pollution tolerant plants (Xeriscaping) • The incorporation of Sustainable drainage systems (SuDS) comprising soakaways, swales and ponds • All buildings have been designed outside 1/1000 year flood zones <p>All housing units final floor levels have been designed to be slightly elevated from existing ground level to adapt to potential ground water level changes</p>
GOOD PRACTICE	<p>It is the first Eco-town in the UK and it sets a strong example for other housing developments by incorporating extensive use of UKCP09 projections as well as proposed adaptation measures.</p>
REFERENCES	<p>Design for Future Climate - Adapting Buildings. NW Bicester Eco Development Programme [online] http://www.arcc-network.org.uk/wp-content/D4FC/D4FC24-Bicester-new-town-full-report.pdf</p>

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