



## **Chapter 6:** **Business and industry**



## Chapter 6: Business and industry

**Lead contributor:** Swenja Surminski (London School of Economics)

**Contributing authors:** Alastair Baglee (Acclimatise), Catherine Cameron (Agulhas: Applied Knowledge and University of Essex), Richenda Connell (Acclimatise), Kat Deyes (Frontier Economics), Anna Haworth (Acclimatise), Bingunath Ingirige (University of Huddersfield), Robert Muir-Wood (Risk Management Solutions), David Proverbs (Birmingham City University) and Paul Watkiss (Paul Watkiss Associates)

**Additional contributors:** Lyn Sze Goh (Government Economic Service summer intern at the Adaptation Sub-Committee Secretariat)

**ASC contributors:** David Style, Manuela DiMauro and Alex Townsend

**This report should be referenced as:**

Surminski, S., Style, D., Di Mauro, M., Townsend, A., Baglee, A., Cameron, C., Connell, R., Deyes, K., Haworth, A., Ingirige, B., Muir-Wood, R., Proverbs, D., Watkiss, P., and Sze Goh, L. (2016). *UK Climate Change Risk Assessment Evidence Report: Chapter 6, Business and Industry*. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change, London.

### Implications of the vote to leave the European Union

This chapter was written before the results of the EU Referendum were known. Leaving the European Union is unlikely to change the overall scale of current and future risks from climate change, but in some areas it may affect policies and programmes important to address climate-related vulnerabilities.

If such policies and programmes are changed, it will be necessary for UK measures to achieve the same or improved outcomes to avoid an increase in risk. The Adaptation Sub-Committee will consider the impact of the EU Referendum and the Government's response in its next statutory progress report on the UK National Adaptation Programme, to be published in June 2017.

## Contents

Key messages .....	3
6.1 Context .....	8
6.1.1 Scope of the chapter .....	8
6.1.2 Approach to the assessment.....	10
6.1.3 Investigating business adaptation .....	12
6.1.4 Summary of CCRA1 .....	14
6.1.5 The evidence base for CCRA2 .....	15
6.2 Climate risks and opportunities for site locations .....	19
6.2.1 Policy framework .....	19
6.2.2 Current and future flood and coastal erosion risk to site locations .....	21
6.2.3 Adaptation responses and gaps for flood and coastal erosion risk to site locations.....	28
6.2.4 Current and future water availability risks to site locations .....	32
6.2.5 Adaptation responses and gaps for water availability risks to site locations .....	38
6.3 Climate risks and opportunities for access to capital.....	41
6.3.1 Policy framework .....	42
6.3.2 Current and future risks and opportunities for access to capital.....	43
6.3.3 Adaptation responses and gaps for access to capital .....	53
6.4 Climate risks and opportunities for workers and labour productivity .....	56
6.4.1 Policy framework .....	56
6.4.2 Current and future risks from higher temperatures in working environments.....	57
6.4.3 Adaptation responses and gaps from higher temperatures in working environments.....	58
6.4.4 Current and future risks for workers and productivity from extreme weather.....	59
6.4.5 Adaptation responses and gaps for workers and productivity from extreme weather.....	61
6.5 Climate risks and opportunities to supply chains and distribution networks .....	64
6.5.1 Policy framework .....	64
6.5.2 Current and future risks for supply chains and distribution networks .....	65
6.5.3 Adaptation responses and gaps for supply chains and distribution networks .....	71
6.6 Climate risks and opportunities for products and services .....	75
6.6.1 Policy framework .....	75
6.6.2 Current and future risks and opportunities for products and services.....	76
6.6.3 Adaptation responses and gaps for products and services.....	83
6.7 The importance of adaptive capacity .....	84
6.8 Conclusions .....	95
6.8.1 Priorities for government action in the next five years.....	95
6.8.2 Knowledge gaps.....	97
Annex 6.A Policy frameworks.....	99
References .....	104

## Key messages

**Recent empirical evidence highlights the growing impact that climate risks and extreme weather have on business and industry in the UK. Flooding and extreme weather events which damage assets and disrupt business operations pose the greatest risk to English businesses now and in the future. New regulation or other government intervention made necessary by climate change also poses an indirect risk to businesses.**

- Currently, the risk of direct and indirect losses and damages to businesses from flooding is high in many regions in the UK, with local differences in exposure and protection levels, particularly with regards to key infrastructure. It is expected that this risk will continue to rise unless government and businesses increase their efforts in addressing flood risk.
- Businesses located or operating in coastal areas face the additional risk of losing coastal business locations or access to assets and facilities because of coastal erosion or flooding.

**Reduced water availability is a risk projected to increase across the country, with the exception of some catchments in the north of Scotland, and some central and west midlands catchments in England.** This is expected to impact on water-intense industries with implications for other sectors across their supply chains.

**Through their international supply chains, distribution networks and global markets, UK businesses are exposed to extreme weather risks from around the world.** Climate change is expected to increase the risk of weather-related disruptions, particularly for supply chains and distribution networks that involve more vulnerable countries, such as in South and South East Asia, along with sub-Saharan Africa.

**The need to adapt to climate change is expected to increase the demand for some products and services and reduce others.** Risks and opportunities relating to adaptation goods and services have been identified for the following sectors; engineering and consulting, tourism, insurance and other finance products, and agriculture and food.

- Products and services from heavily regulated industries also face indirect risks related to regulatory responses. These risks particularly apply to the finance, food and utilities sectors, and are expected to increase.
- If and how businesses respond to climate risks and opportunities depends on their adaptive capacity. This is currently understood to be low for many small businesses; a key issue requiring urgent attention.

**The interdependency of infrastructure systems, business activities and adaptation actions is essential to account for in planning appropriate adaptation actions.** For example, businesses may rely on a common infrastructure asset such as a transport link or communications network, but have no control over its climate or weather resilience. Also, insurance companies can exit the market or adjust premiums when the level of risk increases, which affects businesses and households that rely on insurance. While this can create incentives for more adaptive behaviour across businesses, it may also raise affordability questions.

**Addressing impacts early and anticipating future changes is likely to open up new opportunities for a range of sectors. In fact, most adaptation action is expected to be delivered by the private sector.** A range of case studies conclude that businesses play an important role, from building adaptive capacity within industries to delivering specified adaptation action at regional and national level.

**Government has a role in enabling, facilitating and supporting private sector adaptation through policies, regulation and other supportive measures such as information sharing and raising awareness.** Resilient infrastructure, in particular ICT, power, fuel supply, transport and water, is crucial in enabling businesses to minimise disruptions to their operations from climate change risks.

Table 6.1 summarises the key risks and opportunities for business and industry from climate change. The assessment of urgency is based on the expert judgement of the ASC, in consultation with the report authors and peer reviewers. Further details on the assessment of urgency for business and industry can be found in the ASC's Urgency Scoring Tables, published as a separate annex to the ASC synthesis report, and below in Section 6.8.1. See Chapter 2 for more details on the method taken to assess urgency.

It is important to note that some aspects relevant for businesses are covered in other chapters of this evidence report (see Section 6.1.1 for details).

**Table 6.1.** Urgency scores for business and industry

Risk/opportunity (relevant section(s) of chapter)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for scoring
<b>Bu1:</b> Risks to business sites from flooding (sections 6.2.2, 6.2.3)	England	Northern Ireland, Scotland, Wales			More effort is needed in England to address flood risks and inform businesses of their current and future exposure and what steps they might take to limit impacts.  More research needed elsewhere in the UK to understand uptake of flood protection measures by businesses and how spending plans on defences and other measures may or may not protect individual businesses.
<b>Bu2:</b> Risks to business from loss of coastal locations and infrastructure (6.2.2, 6.2.3)		UK			More research needed on costs and benefits of adaptation options for different coastal areas.

<p><b>Bu3:</b> Risks to business operations from water scarcity (6.2.4, 6.2.5)</p> <p>NB: Also see related infrastructure risk In9.</p>			UK		Sustain current actions to create more flexible abstraction regimes and promote water efficiency among businesses.
<p><b>Bu4:</b> Risks to business from reduced access to capital (6.3)</p>				UK	Monitor and research action by regulators, banks and insurance firms, and information disclosures by UK companies.
<p><b>Bu5:</b> Risks to business from reduced employee productivity, due to infrastructure disruption and higher temperatures in working environments (6.4.2, 6.4.3, 6.4.4, 6.4.5)</p>		UK			More research needed on disruption to ICT, power and transport infrastructure which prevents workers accessing premises or working remotely, and on impacts of higher temperatures on employee safety and productivity.
<p><b>Bu6:</b> Risks to business from disruption to supply chains and distribution networks (6.5)</p> <p>NB: Also see related international risks It1 and It3.</p>			UK		Sustain and monitor the uptake of existing guidance which helps businesses improve the resilience of supply chains and distribution networks, particularly at the international level.
<p><b>Bu7:</b> Risks and opportunities for business from changes in demand for goods and services (6.6)</p>				UK	Monitor sales of adaptation goods and services within the UK, and by UK companies.



### **Flooding and extreme weather events**

The risk of flooding to business sites and assets is a priority for more action in England and a research priority in Northern Ireland, Scotland and Wales.

Currently, the risk of direct and indirect losses and damages to businesses from flooding is high across many UK regions, with local differences in terms of exposure and existing protection measures. Projections suggest that this risk will rise, unless there is an enhanced response from both government and the private sector, to avoid continuing development on the floodplain (see Chapter 5), adopt sustainable drainage systems, ensure access to resilient infrastructure, and implement other business continuity efforts. A lack of collaboration among businesses may result in failure to recognise interdependencies and incorporate these into flood risk management plans, particularly with regard to business clusters, industry parks and new commercial sites. The development of localised longer-term scenario projections of flood risks along with practical guidance may enable businesses to make better investment decisions and help local planning bodies to account for future risk trends.

Extreme weather events can impact on labour productivity through denying workers access to sites, preventing them from working remotely, or causing them to have to take leave to deal with problems at home. A common response to extreme weather events from businesses is for staff to work remotely, which highlights business' dependency on resilient ICT and electricity infrastructure. Business continuity planning, adoption of management standards such as ISO14001, increasing and ensuring the resilience of ICT and transport networks, and more flexible working patterns can improve and enhance resilience. Most businesses who implement Business Continuity Management (BCM) plans report a wide range of benefits. However, many businesses do not develop these until affected by an extreme weather event. Smaller businesses in particular are less likely to have BCM plans.

Business supply chains and distribution networks are disrupted by adverse weather now and such disruptions may become more frequent due to changes in exposure, through economic growth and migration to more coastal and urban areas, and changes in weather and climate. For the businesses concerned, this is likely to result in unfulfilled orders, breach of delivery contracts, loss of revenue and reputational damage. There may be areas where there are only a few companies providing key services (for example ICT and haulage), the resilience of which many other businesses depend on. Many large companies are considering the risks from climate change to their supply chains and distribution networks and collaborating with their suppliers. This can have positive wider effects and increase the resilience of smaller businesses in their supply chains. Despite the range of surveys and case studies, data are mostly limited to those reported by larger multi-national companies and it is difficult to evaluate the impact and effectiveness of existing adaptation measures, and existing guidance and tools.

### **International risks**

International elements of UK businesses' distribution and supply chains are already impacted, and expected to be more at risk as they may involve countries deemed highly vulnerable to climate change and less able to adapt. The reliance of UK businesses on overseas markets as part of their supply chain or for distribution of goods and services can make companies more resilient to domestic (and international) risks but creates exposure to climate change impacts abroad. The manufacture and supply of food, clothes and electronic equipment are understood to be particularly exposed to international climate change impacts.

### **Coastal locations**

Businesses located or operating in coastal locations face additional risks from sea level rise. Flooding and coastal erosion can lead to loss of coastal business locations, or access to them, and disrupt infrastructure provision. The possible realignment or retreat of coast protection structures due to

increasing erosion and flood risks will have an impact on businesses located in the affected areas. In these cases, public–private partnership could help raise funds to sustain current structures or influence replacement options. More research is required to understand the costs and benefits of different adaptation responses to loss of coastal locations for business.

### **Higher temperatures in working environments**

Workers engaged in particular sectors or occupations, for example heavy outdoor manual labour, are likely to be at the greatest risk of heat stress. The limited evidence available suggests sustained periods of higher temperatures, for example the 2003 heatwave, resulted in large losses for the UK manufacturing sector. Very few studies have considered the impacts of higher temperatures on productivity in the UK and so there is considerable uncertainty about the magnitude of impacts. There is a lack of understanding around the effectiveness or possible unintended consequences of planned or autonomous adaptation to manage the risk of higher temperatures, including the role of workplace temperature guidance.

### **Water availability**

Reduced water availability is a risk that is expected to increase across the country, with the exception of some catchments in northern Scotland, and some central and west midlands catchments in England. This is likely to impact on water-intense industries with implications for other sectors across their supply chains. Sustained effort is needed to ensure that flexible licencing systems are in place and that businesses are able to build on their existing progress in becoming more water efficient.

### **Access to capital**

Access to capital may become material if credit becomes more expensive or limited for companies that are considered to be taking insufficient adaptation action. In this way, the cost of capital could begin to reflect risks from climate change, raising capital costs for vulnerable companies. Similarly availability and affordability of insurance cover can be affected by rising risk levels, which in turn would also have implications for business' access to capital. Such signals from the banking and insurance sectors can prompt risk reduction, including the relocation of business functions where appropriate, however current evidence for this is limited. Evidence on flood insurance indicates that this is currently a significant problem for a small number of small and medium enterprises (SMEs). However, this could grow if left unaddressed. A separate issue can arise if a company cannot secure an affordable loan to finance adaptation measures. There is some evidence of this creating a barrier for adaptation. Therefore it is important to monitor the affordability of insurance, access to adaptation funding, and to investigate potential tipping points in companies' access to capital that might require intervention.

### **Changes in demand for goods and services**

The risks and opportunities in relation to the design and type of new products and services are particularly relevant for adaptation goods and services from the following sectors: engineering and consulting, tourism, insurance and other finance products, and agriculture and food. Identifying market opportunities and managing risks are core business activities. Unless prevented by access to capital or hampered by low adaptive capacity, it is expected that companies will respond to growing risks and opportunities. Companies also operate within a regulatory environment that will constrain some activities and promote (including through price incentives), others. Regulation may or may not be aligned with promoting growth in adaptation related goods and services.

In addition, two cross-cutting issues are discussed in this chapter:

**Adaptive capacity among businesses:** addressing barriers that are implicitly limiting private sector adaptation is critical for managing risks to business and industry. Managing climate risks and making the most of opportunities is not likely, or even possible, unless businesses have appropriate adaptive capacity. This is currently understood to be low for small businesses; a key issue requiring urgent attention. Studies indicate that SMEs do not necessarily associate weather events with climate change.



To respond to the variability and uncertainty of climate risk an adaptive management approach is advocated. This allows parties to learn over time and for new information to be reflected in decision-making processes. Support may be required to adopt such a flexible management approach. One specific area of attention is the better integration of climate change and non-climate risk information, to ensure that future risks are not disregarded and efforts to build resilience are strategic rather than piecemeal.

- **Indirect risks from regulatory responses to climate change:** national governments may need to intervene further and faster, either to limit greenhouse gas emissions or to promote cost-effective adaptation by businesses and industry. This is particularly relevant for the finance, food and utilities sectors. As well as risks, regulatory action can create new markets, price signals and revenue streams for forward-thinking companies.

### Box 6.1. Comparison with the first UK Climate Change Risk Assessment (CCRA1)

Overall, the risks and opportunities for business and industry identified in this evidence report are broadly in line with those from CCRA1. The assessment in CCRA1 was limited to the following sub-sectors: financial services; tourism; food and beverage manufacturing; oil, gas and mining; and chemical manufacturing. This Evidence Report uses a business function approach to identify and assess risks and opportunities across different business types, different economic sectors and industry sub-sectors as well as across regions. The synthesis of evidence has highlighted that there are particular sectors for which the risks and opportunities from climate change are more relevant (engineering and consulting, tourism, insurance and other finance products, agriculture, food and utilities), the majority of which were part of the CCRA1 assessment. Recent research, particularly on insurance and other finance products, was incorporated in this assessment. This Evidence Report has also considered risks and opportunities from regulation and limited adaptive capacity, in addition to those arising directly from climate hazards such as higher temperatures, flooding and water scarcity. There has been greater engagement with businesses and industry representatives in the production of this chapter than there was for CCRA1.

## 6.1 Context

### 6.1.1 Scope of the chapter

The chapter reviews if and how the current and future climate poses risks and creates opportunities for business activities in the UK. This is in order to explore where government action is needed most urgently between 2018 and 2022 to support private sector adaptation.

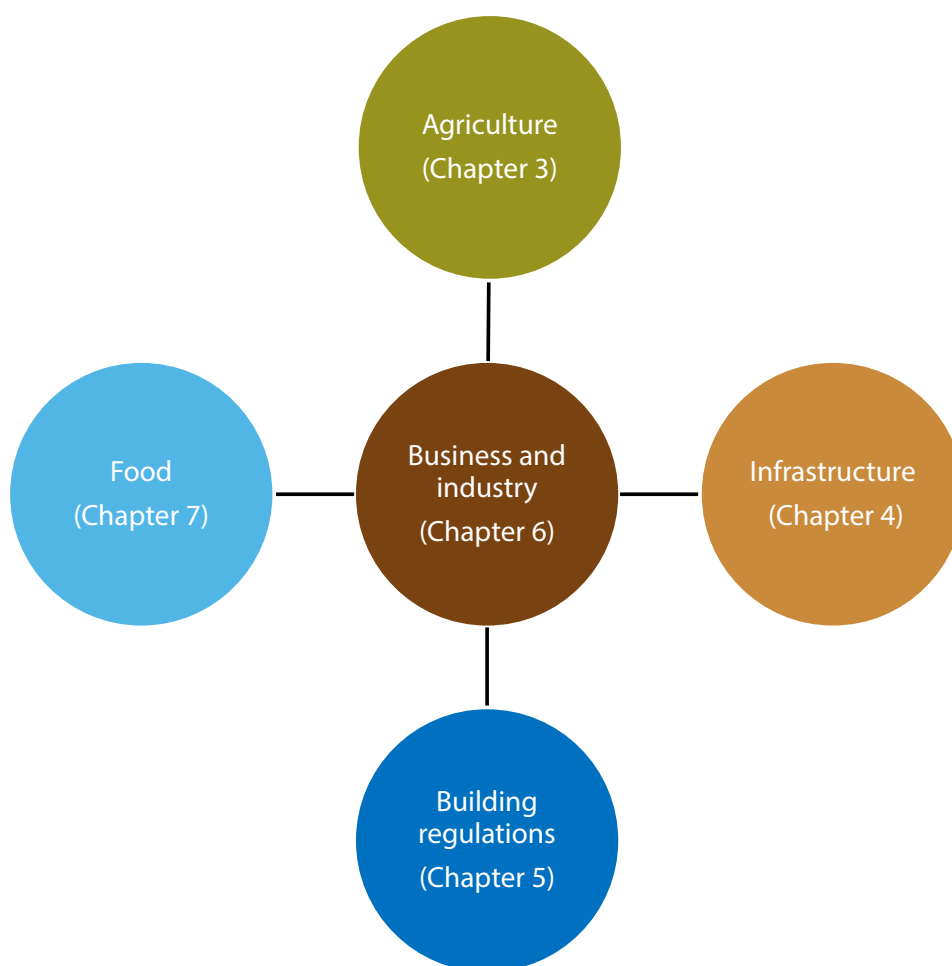
In 2015, the size of the UK economy was £1.8 trillion (Office for National Statistics (ONS), 2016a). Growth and employment in an economy over time depends not only on the total amount of goods and services produced, but also how efficiently they are produced (the amount of value delivered for a given level of inputs such as labour, capital or natural resources). This is influenced by a range of global, national and even local factors that bring both risks and opportunities for businesses. Several recent reports and business surveys indicate that climate risks are becoming increasingly serious for firms, often acting as a 'risk multiplier', aggravating already existing resource constraints or production vulnerabilities (Cambridge Institute for Sustainability Leadership (CISL), 2015).

We investigate this in the context of six main business functions: products and services, employees and labour productivity, site location, distribution (output), supply chain (input), and access to capital. The business function approach provides a framework for identifying and analysing risks and opportunities arising from climate change across different business types, different economic sectors and industry sub-sectors, as well as across regions. Our assessment is based on the current evidence available on this topic, taking into account qualitative, quantitative and where necessary anecdotal evidence.

Our aim is to identify the priority risks for upcoming UK national adaptation programmes – in line with the overall CCRA2 approach. Therefore, the audience for this assessment is the national governments and related adaptation decision makers, rather than individual companies and other stakeholders. However, companies may find the contents of this and other chapters useful for risk management and adaptation planning.

To avoid confusion, it should be noted that several aspects relevant for business and industry are covered in other chapters of the CCRA2 Evidence Report. These are set out in Figure 6.1.

**Figure 6.1.** Aspects relevant for business and industry that are covered in other chapters of CCRA2



**Source:** CCRA2 Evidence Report authors.

### 6.1.2 Approach to the assessment

For this chapter we take a ‘business function’ approach to assessing the risks posed by climate change. We ask ‘what do you need to make a company work’ and consider this through six key business functions, applicable across different types of business. We then investigate each to consider if and how climate change impacts can disrupt current business practices or create new opportunities. This allows for analysis of risks and opportunities from climate impacts across business and industry sub-sectors as well as across regions (UK Climate Impacts Programme (UKCIP), 2014a).

- **Site locations** refers to the way in which buildings and sites are designed, constructed and maintained, how these facilities are managed, and the impacts on business processes when premises are affected. It considers how a business’ choice of location affects climate risks and opportunities.
- **Access to capital** reflects on the implications for access to finance, including loans, investor relations and credit-worthiness.
- **Labour** looks at the implications for the workforce in terms of the working environment and commuting to and from their place of employment. Labour productivity and changing lifestyles and social trends are important aspects alongside climate change.
- **Distribution networks and supply chains** refers to logistics, which includes transport infrastructure. ‘Distribution’ addresses the downstream side of production processes and business interactions, in other words, the ways in which finished products and services are distributed to customers and across markets. ‘Supply Chain’ covers the upstream part of the production process relating to searching for and acquiring or extracting materials and resources.
- **Products and services** refers to markets and the structure of the UK economy. Markets include the changing demand for goods and services as well as changes in consumer behaviour. It also takes into account emerging markets for new products and the early movers’ perspective in developing products and services. In other words, products and services look at economy-wide factors and trends, rather than being firm-specific.

This methodology and understanding of risks, opportunities and adaptation action builds on the work conducted under the ‘Economics of Climate Resilience’ (Frontier Economics et al., 2013) project for Defra. This proposed a framework for assessing current or potential climate threats and opportunities for business divided into ‘operations’, ‘supply chain’ and ‘strategy and markets’. Box 6.2 sets out this framework in more detail.

### Box 6.2. Framework for assessing current or potential climate threats and opportunities for business

The Economics of Climate Resilience report identifies three key business areas relevant to climate change risks and adaptation planning. The report was commissioned by Defra to provide economic evidence to support HM Government's first UK National Adaptation Programme.

#### Operations:

- Flexibility in locations in which the business operates (domestic or overseas).
- Sensitivity of those locations to climate change.
- Scale of capital assets that are owned or operated by the company that could be at risk and assets or infrastructure that are shared with others that could be at risk. The latter point refers to interdependencies across operations.

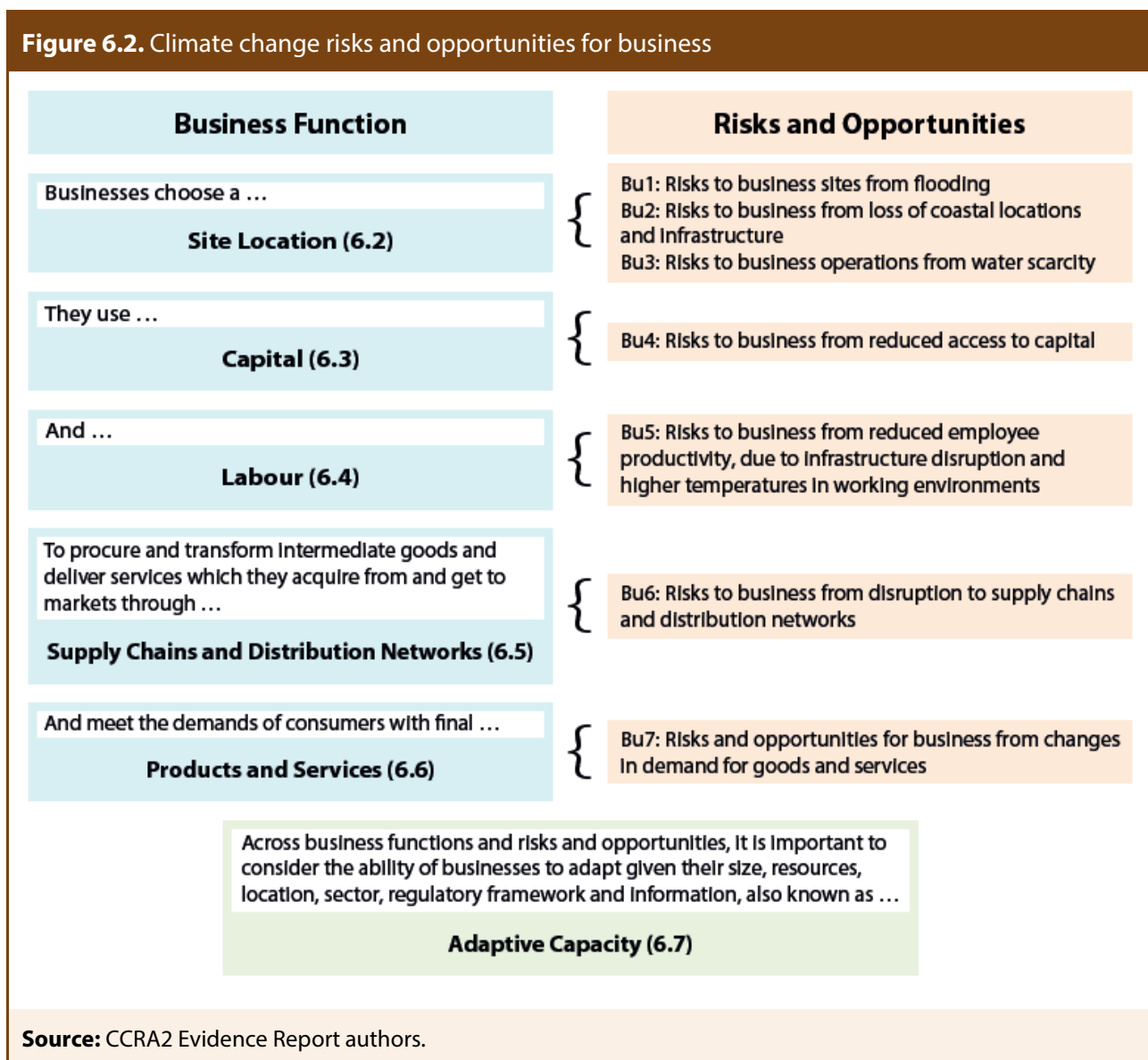
**Supply chains and distribution networks:** this is relevant, both in terms of considering those from whom supplies or inputs are purchased (i.e. 'upstream') and those to whom the business supplies and delivers its products – the consumer markets (i.e. 'downstream' or 'distribution'). Factors include:

- Complexity of the chain (including the extent of operations overseas and the number of companies and their locations).
- Degree of potential substitutability of inputs.
- Flexibility in the supply chain, including levels of inventory (reliance on 'just in time' implies low levels of inventory), or contract variability.

**Strategy and markets:** the scale of markets affected by climate change risks and associated opportunities.

**Source:** Frontier Economics et al. (2013) for Defra.

Figure 6.2 shows how business functions relate to each other and how this chapter is structured in accordance. Businesses have to choose their site location (Section 6.2). They use capital (Section 6.3) and labour (Section 6.4) to deliver services and transform intermediate goods – procured through the supply chain (Section 6.5) into final products (Section 6.6). In addition, they have to choose their way to market using distribution networks (Section 6.5).



For each of these functions we consider current and future risks and opportunities arising from climatic changes. These impacts can be both immediate, for example if flooding causes a business to close temporarily, and over time in a more gradual and sustained way, for example by increasing the costs of operating in an area. Impacts can be both direct, through exposure of core business operations to extreme climatic events such as business interruption and damage to physical assets in case of flooding, and indirect, such as exposure through market changes, infrastructure vulnerability, regulatory responses or increased competition for certain resources (PricewaterhouseCoopers (PwC), 2013; Organisation for Economic Cooperation and Development (OECD), 2015).

### 6.1.3 Investigating business adaptation

As risks to businesses represent risks to the UK economy it is vital to understand the impacts of both extreme weather events and anticipated longer-term climate change, as well as how associated risks and opportunities can be managed. This applies to businesses already operating in the UK, and to those considering locating here. Continuing to attract inward investment from the latter is a valuable source of growth in an increasingly globalised economy. Furthermore,

any action taken by a company has implications far beyond its own premises and operations. For example, investments made without considering climate risks may not necessarily be a problem for the investor, but could create significant costs for others, including governments, homeowners and other business. This underlines the importance of increasing understanding of if and how companies assess and address climate risks. Box 6.3 provides examples of how businesses have an influence on adaptation beyond their own operations.

### Box 6.3. Businesses have an influence on adaptation beyond their own operations

The Concept paper for the fourth session of the Global Platform for Disaster Risk Reduction (DRR) (United Nations Office for Disaster Risk Reduction (UNISDR), 2012) states that around 85% of all investments worldwide stem from the private sector, including companies but also SMEs and individual investors. The private sector therefore has been identified as playing an important role in helping to incorporate DRR into the development (and redevelopment) of communities across the world (Bosher, 2013).

Each sector has a number of interdependencies with other sectors. An interruption in one sector or organisation can affect the extent to which other organisations can manage a particular climate threat. The extent to which a sector is reliant on energy, raw materials and a range of products through supply chains has a strong influence on the specific risks that need to be considered (Frontier Economics et al., 2013).

Businesses have become increasingly aware of the critical role they play in enabling effective, timely and appropriate adaptation. They recognise the risks that climate change poses, not only for their operations, but also to their suppliers, employees, customers and people living in the areas in which they operate. Businesses have also begun to recognise opportunities to expand operations and increase their market share through developing climate-resilient products and services to help people, other businesses and governments adapt (UN Global Compact and UN Environment Programme, 2012).

**Sources:** Bosher (2013). Frontier Economics et al. (2013) for Defra. UN Global Compact and UN Environment Programme (2012).

Responding to climate change requires businesses to adapt to 'complex, non-linear and potentially irreversible environmental changes with uncertain impacts' (Linnenluecke and Griffiths, 2010; Winn et al., 2011; Linnenluecke et al., 2012). Traditional risk management approaches can be applied, but new approaches may be needed to deal with the discontinuous change that climate change represents, particularly with regard to factoring in future uncertainties (Winn et al., 2011; Sur, 2012). If and how a changing climate will impact on a company or a sector depends on a wide range of factors. Recent studies show that size, sectoral focus, location and policy and regulation frameworks all play a role in determining the impact of climate change and extreme weather on businesses, as well as the current and expected future level of adaptation by companies. This poses a few challenges that need to be considered:

- **Terminologies when identifying adaptation action.** Companies use a wide range of terms when describing their responses to climate risks: resilience, business continuity, enterprise risk management, water management, supply chain resource security or flood risk management, to name a few (Agrawala et al., 2011). Many actions undertaken by businesses to improve their resilience or manage environmental or climate risks may be part of their standard risk management processes and may not be explicitly labelled as adaptation



(Averchenkova et al., 2016). Large organisations compile risk registers, including through horizon scanning. Risks are re-prioritised as they are perceived to be imminent or as new information emerges. However, risk registers tend to focus on the short-term (1 – 5 years). Risks are also mitigated through insurance and re-insurance. However, common catastrophe models are calibrated on expert judgement and past events, thus do not necessarily reflect future changes in climate. Surveys of SMEs indicate that terminology and perceptions of current and future risks can play an important part in determining if and how a company increases its resilience (see Section 6.7 on adaptive capacity).

- **Considering indirect and secondary as well as direct impacts.** Adaptation responses taken by one sector may have implications for others. An example would be the impacts of insurance companies withdrawing insurance from certain markets or for certain perils, which would have implications for those who seek insurance cover. There would also be implications (positive and negative) if climate risk related terms and conditions were introduced into infrastructure investments and finance. Timely action on adaptation to maintain robust and resilient infrastructure systems is expected to enhance the attractiveness of the UK to inward investment with climate change. It can also generate skills and experience in the UK, which would help UK businesses capitalise on export opportunities as other countries engage in adaptation. Indirect impacts of extreme weather events may also outweigh the direct impacts. Survey results have found that it was not the direct impact of flooding, but business interruption through indirect factors that were more significant for cost and time of recovery (Bhattacharya-Mis and Lamond, 2014). Uninsured losses from extreme weather events may lead to decreases in collateral values and in turn this could result in bank losses, demonstrating the relevance of interconnectedness for considering indirect and secondary impacts.

### 6.1.4 Summary of CCRA1

The first CCRA in 2012 identified the Business, Industry and Services sector as highly vulnerable to a changing climate, including both extreme (acute) events and incremental (chronic) climate change. It concluded that climate change impacts are likely to be felt across the spectrum of sub-sectors and from SMEs to large multi-national corporations. The report outlined ten key climate risks or opportunities for businesses:

- Reduced returns for UK financial institutions' investments due to the absence of mainstreaming climate risk and adaptation into decision-making processes (BU1).
- An increase in monetary losses as a result of an increasing proportion of UK tourist assets (natural and built) at risk from flooding (BU2).
- A decrease in water (groundwater and surface water) availability for industrial usage (BU3).
- An increase in monetary losses as a result of interruption to business from flooding (BU4).
- A decrease in productivity and revenues due to ICT loss or disruption (BU5) from extreme climate events.
- Increased exposure for mortgage lenders (BU6).
- An increase in insurance industry exposure due to flooding (BU7).
- An expansion of new or existing tourist destinations in the UK (BU8).

- A decrease in output for UK businesses due to an increase in supply chain disruption as a result of extreme events (BU9).
- Loss of staff hours due to high internal building temperatures (BU10).

In terms of major opportunities, CCRA1 noted that warmer temperatures are likely to increase the attractiveness of the UK as a tourism destination in the long term. Opportunities for UK businesses to offer new climate-related products and services were not covered by the report; however, this has recently become a focus of UK and European policy (HM Government, 2013; European Commission, 2015).

There are a number of differences between the approach in CCRA2 and in CCRA1 that affect the assessment of climate change risks to business and industry. More general differences between the two studies are described in Chapter 2.

For CCRA1, international dimensions were covered in a separate Foresight Report (2011). As many UK-based multinational companies import their most challenging climate risks through value chains, this aspect of the methodology resulted in a fragmented and potentially underestimated assessment of the climate risks facing UK businesses. CCRA2 incorporates the international dimensions of climate change more openly; however, there is still potential to focus too heavily on physical climate impacts in the UK.

CCRA2 also attempts to consider how climate change interacts with other socio-economic factors that may affect the level of risks and opportunities for business. This is a considerable challenge that was generally omitted from the CCRA1 methodology. Similarly, the effects of current and planned UK policies and other actions in terms of reducing vulnerabilities to climate change are considered here for the first time. The division of evidence between chapters in CCRA2 is intended to bring together related risks and opportunities, as well as draw out cross-sectoral linkages.

Finally, the other main difference relevant to the business and industry chapter is the use of a different, new approach to identify the key risks relevant to business functions, rather than to specific business sectors.

### 6.1.5 The evidence base for CCRA2

The CCRA2 approach is based on a synthesis of existing evidence, rather than new analysis. This synthesis includes academic peer-reviewed literature and 'grey literature', such as official reports. This broad approach is necessary given the limited peer-reviewed material available on this topic. CCRA1 concluded that the quantitative evidence base in the Business, Industry and Service sector was low: a finding confirmed by more recent reviews including the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC, 2014). Furthermore, relevant information is often not publicly available, as it is owned by companies and considered commercially sensitive. Some statutory (for example, the 2008 Climate Change Act's Adaptation Reporting Power, see Defra, 2015) and voluntary instruments exist, requiring or encouraging businesses to disclose information about the risks they face and the actions they are taking in response. CDP<sup>1</sup> surveys are widely used by government and other stakeholders to assess corporate action in response to climate change. Box 6.4 offers a snapshot of responses from

---

<sup>1</sup> CDP (formerly the Carbon Disclosure Project) is a global not-for-profit organization. They provide a disclosure system where companies and city governments can voluntarily report on actions to address environmental risks. See [www.cdp.net](http://www.cdp.net) for more information.

Financial Times Stock Exchange (FTSE) 100 companies to climate change risk questions from the CDP.

### Box 6.4. CDP insights into climate change adaptation

Defra asked CDP to analyse survey responses from 89 FTSE 100 companies to determine the resilience of UK businesses to climate change and to gather insights into business attitudes and action on adaptation. CDP analysed responses to the Investor CDP 2011 and CDP Water Disclosure 2011 questionnaires. This sample was selected as it represented companies that are potential leaders for private sector adaptation in the UK.

Findings: 80% of responding companies consider climate change a 'considerable risk' to their business. Generally, risks are evenly spread across all risk drivers (for example, changes in mean (average) temperature, sea level rise and uncertainty of physical risks) and direct risks to company operations are more apparent than indirect risks. Of risks reported, 29% are identified as current, 25% with a timeframe of 'greater than 10 years' and 27% with an unknown timeframe. Of the risks identified, over 60% of companies report the greatest impact as increased operational costs, followed by a reduction in or disruption to production capacity (48%), and 21% report financial impacts of climate risks. Further analysis demonstrates that international business operations may result in substantial adaption focused outside the UK; global supply chains can be a vulnerable point at which climate disruption can occur.

However, companies are also able to identify opportunities arising from climate change including efficiency savings and new investment opportunities. Many new business risks can also be seen as opportunities because there is the possibility of gaining competitive advantage. Therefore adapting to the risk is seen to be an important step in this direction, yet only 10% of companies report they have a specific climate change risk management process in place; 88% state 'risk management is integrated into multi-disciplinary companywide risk management processes' and 3% report they have no documented processes for climate risk management or assessment. Only 17% of companies specifically mention an adaptation strategy. However, companies may not use the term 'adaptation' with adaptation strategies not being differentiated from more general risk management strategies. Of companies, 72% identify potential opportunities to instigate change in their businesses. Direct opportunities are more apparent than indirect opportunities, with most opportunities (39%) on a current timescale. Opportunities identified are increased demand for products and services, as well as reduced operational costs. 84 % of companies state that they are engaging with policy-makers on adaptation.

**Source:** CDP (2012) for Defra.

More recently, Acclimatise (2016) for the Environment Agency used CDP data to assess impacts and market opportunities from climate change. Key findings included:

- 86% of companies identified one or more climate-related risks;
- 34% of the climate risks identified are being managed using a low-cost, 'business-as-usual' approach;
- 33% of the opportunities identified are expected to arise within three years;
- approximately one opportunity was identified for every three risks reported; and
- 44% of companies do not know the financial costs of climate impacts.

In the absence of formal reporting requirements, these surveys are valuable sources of data. However, while offering relevant information it is very important to be aware of the limitations of the surveys and business reports that are based on voluntary self-reporting (Averchenkova et al., 2016). A key issue for survey evidence is how representative it is. This can be in terms of geography, sector or business size. For example, the responses of FTSE 100 companies may not be representative of the responses of much smaller firms, who in fact account for the vast majority of private sector enterprises: 96% of private sector enterprises have fewer than 10 employees and account for 33% of employment and 18% of turnover. Businesses with more than 249 employees account for 0.1% of private sector enterprises, 40% of employment and 53% of turnover (BIS, 2015a). It is therefore important to keep in mind the difference in the level of resources that large and small firms have for climate change adaptation, and therefore how representative survey responses or limited data may be. Other business surveys that were considered in this report include those carried out by the Federation of Small Businesses (FSB) and AXA<sup>2</sup>, as well as some regionally focused studies, undertaken by local climate change partnerships.

The lack of quantitative analysis in this field is a further concern. To date there has yet to be a comprehensive and systematic assessment of the climate change risks and opportunities for UK companies. Conducting this for the UK would be a major undertaking, and may not be feasible or cost-effective. Several studies and reports have attempted quantifications for certain sectors, and several others provide elements of quantitative analysis. Table 6.2 sets out some of the different ways in which this has been attempted.

---

<sup>2</sup> The AXA group is a global financial services company. More information is available at: <http://www.axa.co.uk/about/our-company/>

<b>Table 6.2.</b> Attempts to quantify climate change risks and opportunities for business and industry	
<b>Report</b>	<b>Example of quantification</b>
EU Commission (2014). Assessing the Implications of Climate Change Adaptation on Employment in the EU.	Impacts of hot weather on productivity.
Frontier Economics, Irbaris and Ecofys (2013) for Defra. The Economics of Climate Resilience.	Impacts of various 'what if?' illustrative climate change scenarios on business and industry.
K-Matrix (2013) for BIS. Adaptation and resilience to climate change (ARCC): Report for 2011/12.	Value of sales of adaptation goods and services.
Martin et al. (2011). The sensitivity of UK manufacturing firms to extreme weather events.	Regression analysis of the impacts of extreme weather events on manufacturing firms.
PwC (2013). International Threats and Opportunities from Climate Change for the UK.	Threats and opportunities assigned to magnitude categories on a similar basis to the CCRA2.
<b>Note:</b> This is an indicative and not an exhaustive list of studies.	

Recognising the limited amount of peer-reviewed analysis in this area, we also considered opinion pieces and documents compiled by business actors. To complement this we conducted direct engagement exercises with individual companies and business representatives, hosted workshops as well as specific sessions in the devolved administrations. This enhanced our understanding of climate risk management in UK businesses. However, we also recognise the limitations that arise from this in terms of confidence and academic scrutiny.

Lack of evidence should not be seen as an indication of no or low risk. The fact that we do not have sufficient insight into processes and activities could be considered as a key risk itself. Developing a better understanding and informing both government responses and business activities accordingly remains a priority area.

## 6.2 Climate risks and opportunities for site locations

This section explores the climate risks and opportunities posed to businesses as a consequence of their physical and geographical location.

### Key messages

#### **Bu1: Risks to business sites from flooding**

The current level of risk to many business premises and assets from flooding is high in many parts of the UK.

Given current levels of adaptation, this risk is projected to increase in future.

Public–private partnerships can fund flood defences that benefit business and would not otherwise be provided by government.

The uptake of existing protection measures by business, such as flood warnings, business continuity plans and property-level protection is low.

#### **Bu2: Risks to business from loss of coastal locations and infrastructure**

The loss of coastal business locations is mainly driven by coastal flooding, rather than coastal erosion.

More research is required to understand the costs and benefits of different adaptation responses to loss of coastal locations for business.

#### **Bu3: Risks to business operations from water scarcity**

Water-intense manufacturing sub-sectors such as chemicals and chemical products, basic metals, paper and paper products, beverages and food products are at higher risk of water scarcity.

Projections of future water availability suggest large supply-demand deficits at average low flows in catchments across the UK. In contrast to the present day situation, there could be catchments where there is no water for human use, once environmental flow requirements are adhered to, at average low flow conditions.

Sustained action is required to create more flexible water abstraction systems and promote water efficiency among businesses.

### 6.2.1 Policy framework

Here we set out the policy framework for individual business functions. However, many of the policies, programmes and tools are also aimed at promoting general awareness of climate change risks and opportunities among businesses, and are therefore relevant across business functions. We discuss these below and then make reference to this section in the policy framework sections of subsequent business functions.

#### *UK*

The UK Government stated five objectives in the UK National Adaptation Programme (NAP) (HM Government, 2013), which are relevant to climate risks and opportunities across business functions:



**Objective 23:** To raise awareness and understanding among businesses about climate change risks.

**Objective 24:** To increase the extent to which businesses are actively considering climate change impacts in their risk management and resilience planning and decision-making processes and taking appropriate adaptive action.

**Objective 25:** To raise awareness and understanding among businesses about domestic and international adaptation opportunities.

**Objective 26:** To help businesses better understand and manage climate change risks to their supply chains.

**Objective 27:** To undertake research to increase the understanding of climate change impacts on growth and the economy, working with investors, insurers and other industry partners.

These objectives are supported by tools and guidance for businesses. The Climate Ready Support Service, led by the Environment Agency, has provided advice and support to the public, private and voluntary sectors to enable them to adapt to the changing climate. Climate UK, a not-for-profit community interest company, has supported local organisations in England and Northern Ireland to manage their climate risks and respond to opportunities through their network of partnership organisations. Climate UK also hosts a range of online tools and resources for businesses.

In addition to tools and guidance, the Climate Change Act 2008 gives government the power (referred to as the adaptation reporting power) to monitor adaptation by asking certain organisations to produce reports on the current and future predicted impacts of climate change on their organisation and their proposals for adapting to climate change. This applies to organisations responsible for essential services and infrastructure, such as energy or transport companies.

### *Northern Ireland*

Objective 3 of the first Northern Ireland Climate Change Adaptation Programme (Department of Agriculture, Environment and Rural Affairs (DAERA), 2014) is to 'Raise awareness of the likely effects of climate change and the need for adaptation'. Climate Northern Ireland, set up and funded by DAERA, aims to increase understanding of climate change impacts and promote adaptation action. They have produced a range of online guidance and factsheets for business. One of the aims of the Regional Development Strategy (RDS) is to take action to facilitate adaptation to climate change (Department for Infrastructure (DfI), 2010). The Northern Ireland Executive's Economic Strategy (Northern Ireland Executive, 2012) encourages business growth by exploiting market opportunities in emerging sectors, including the low carbon and green economies in order to meet key global challenges such as climate change. The Investment Strategy for Northern Ireland also identified climate change as part of the 'environment' priority area for investment.

### *Scotland*

Scotland's Climate Change Adaptation Framework was accompanied by a Business and Industry Sector Action Plan (Scottish Government, 2009). Adaptation Scotland, funded by the Scottish Government, provides advice and support to help organisations, businesses and communities in Scotland prepare for, and build resilience to, the impacts of climate change. They intend to work

with various sectors within business and industry to develop sector specific guidance and training modules that help businesses to identify risks and opportunities from climate change and develop adaptation strategies to deal with these. Further online guidance includes a Climate Risk Management Plan for Businesses and a guide for adapting to climate change.

### *Wales*

The Welsh Government has published an adaptation delivery plan (Welsh Government, 2010). Objective 24 of this plan is to provide adaptation advice to businesses, with an expected outcome that businesses will be aware of opportunities and threats brought by climate change and know where to go for further advice. This is supported by the online Climate Change Adaptation Business Tool for businesses in tourism (Welsh Government, 2015a). The Climate Change Commission for Wales held workshops in May 2015 to feed into an Adaptation Plan for the Business and Tourism sector in Wales.

### *Other policies relevant to site locations*

Many relevant UK Government programmes and policies for site locations are described in the policy framework sections of Chapter 4 (Infrastructure) and Chapter 5 (People and the Built Environment) of this Evidence Report.

## **6.2.2 Current and future flood and coastal erosion risk to site locations**

### *Current risks*

Flooding represents the clearest weather-related risk to business operations with climate change (ASC, 2015). It imposes costs to business through damage to assets and disruption to productivity. The magnitude of damage and disruption to businesses from flooding is high today and likely to increase in the future due to increases in exposure and changes in climate.

### *Number of businesses at risk*

Estimates of the number of businesses at risk of flooding vary according to the methodology applied. ASC (2014) found that, after taking into account community level defences, there were 260,000 business units (individual commercial properties) in England susceptible to flooding from rivers or the sea, and 60,000 business units in England susceptible to surface water flooding based on data for 2013. However, these estimates were based only on businesses required to register on the Interdepartmental Business Register, which is voluntary for companies falling below the VAT threshold. 56% of businesses in England fall below the threshold; therefore, there is potential for a significant proportion to have been excluded from this analysis.

Another way of estimating the number of businesses at risk from flooding is to use the number of non-residential properties. While more comprehensive in terms of businesses, this will also include police stations, schools, hospitals and all other building assets defined as 'non-residential' (OECD, 2016). Environment Agency (2014) estimated that there were 594,000 non-residential properties in England at risk of flooding from rivers and the sea and 598,000 non-residential properties in England at risk of flooding from surface water. Sayers et al. (2015) for the ASC found 1.1 million non-residential properties in the UK were at risk from all sources of flooding.

A subset of business units or non-residential properties is at a higher risk of flooding. The analysis by Sayers et al. (2015) for the ASC found that 38% of UK non-residential properties were in areas with a 1-in-75 or greater chance of flood inundation in any given year. Similar analysis found 25 – 41% were in areas with a 1-in-100 chance of flood inundation in any given year, depending on whether business units or non-residential properties were being measured.

Sayers et al. (2015) for the ASC also estimate the current day number of non-residential properties at risk in each of the four UK countries. Their findings in brief were:

- 960,000 non-residential properties in England were at risk of flooding, with 360,000 of these in areas with a 1-in-75 or greater chance of flooding in any given year.
- 15,000 non-residential properties in Northern Ireland were at risk of flooding, with 7,000 of these in areas with a 1-in-75 or greater chance of flooding in any given year.
- 42,000 non-residential properties in Scotland were at risk of flooding, with 25,000 of these in areas with a 1-in-75 or greater chance of flooding in any given year.
- 86,000 non-residential properties in Wales were at risk of flooding, with 34,000 of these in areas with a 1-in-75 or greater chance of flooding in any given year.

The most significant source of flooding today is fluvial (river) flood risk, contributing £560 million (40%) of total UK Expected Annual Damage (EAD) including damage to residential and non-residential properties. Coastal flooding contributes £320 million (24%), surface water £260 million (20%) and groundwater £210 million (16%) (Sayers et al., 2015). SEPA (2016) estimates that for 2016-21, the most significant source of flood damage in Scotland is projected to be river flooding (56%), followed by surface water flooding (23%) and coastal flooding (21%).

### *Impacts of flooding on business*

Business interruption can be highly costly to businesses of all sizes. Monetary losses can include those due to the loss of business or trading activity, damage to the building premises and to stock, finished goods and materials, and increased insurance costs and insurance excesses.

Sayers et al. (2015) for the ASC estimate the present day EAD to non-residential properties. These estimates only include direct damage (indirect would include disruption of economic networks and activity, and related consequences of flooding). They also do not include intangible losses (trauma, ill health and loss of treasured possessions). For the UK as a whole, present day EAD from flooding to non-residential properties is estimated at approximately £800 million. For the four UK countries, EAD for non-residential properties is as follows:

- England: £590 million.
- Northern Ireland: £19 million.
- Scotland: £120 million.
- Wales: £59 million.

Analysis by the Scottish Environment Protection Agency (SEPA, 2016) finds that for the period 2016 to 2021, approximately 29,000 non-residential properties are at risk of flooding. Annual average damages from all sources of flooding (coastal, fluvial and pluvial) for this period are estimated to be £91 million. Damages in this assessment incorporate economic damages to the following receptors: residential properties, non-residential properties, vehicles, emergency services, agriculture and roads.

The current risk to business can also be shown by the assessments of impact conducted after recent flooding events. Estimates are usually based either on survey responses from affected businesses or from insurance claims. Box 6.5 provides examples of recent estimates.

### Box 6.5. Impacts on business from recent flooding events

#### 2013/14 winter flooding in England and Wales

Total damages to businesses were estimated to be between £230 and £310 million, with a best estimate of £270 million, approximately 21% of total damage. Of this, 1% or £3.4 – 4.6 million occurred in Wales.

The total number of businesses affected was estimated to be between 3,189 and 4,897. Damage per business asset was estimated at between £9,200 and £110,000, with a best estimate of £82,000.

63 % of damage to business was from coastal flooding, with the remainder caused by fluvial or groundwater.

Estimates were based on Association of British Insurers (ABI) claims information for business properties affected by flooding during the period from 23 December 2013 to 28 February 2014. These data were adjusted and extrapolated to include the estimated damages caused by coastal flooding (resulting from tidal surges) in early December 2013.

**Source:** Chatterton et al. (2016) for Environment Agency.

There are many other examples which illustrate that the impacts on business sites can be compounded by the impacts on infrastructure that allow access to a site or allow it to operate (Localise West Midlands (2015), Cumbria Intelligence Observatory (2010), Chatterton et al. (2010) for Environment Agency). Damage to infrastructure can affect customers' and stakeholders' ability to access premises, for example preventing people from being able to travel to a particular business site. Where businesses are co-located in clusters and share particular infrastructure assets (such as energy and ICT), the resilience of that shared asset affects all businesses that use it. Relevant information is not likely to be readily accessible by other businesses. Appropriately protecting operational assets, both those directly owned by the business or shared with others, must be considered by businesses in areas at high risk of flooding. The Welsh Government (2015a) reported that the extreme weather events and storms of winter 2013/14 caused considerable disruption for many tourism businesses in Wales through loss of access to premises and infrastructure disruption such as energy and ICT.

#### *Future risks - Flooding*

Projections using both business units and non-residential properties find that there will be significant increases in the number of properties at risks in the 2020s, 2050s and 2080s. It is important to note that these analyses do not project any changes in the number of business units and non-residential properties over time. While this is an important factor, it is not possible to incorporate credible estimates due to numerous uncertainties in the pattern of future economic activity.

EADs from flooding to non-residential properties are also projected to increase significantly over time. Table 6.3 sets out these estimates for the UK as a whole and each of the four UK countries. Depending on the extent of climate change, this figure is projected to increase by 6 – 31% (by

the 2020s), 26 – 69% (by the 2050s) and 48 – 140% (by the 2080s). Regardless of the climate change scenario, EADs are estimated to be over £1 billion by the 2050s, and with more extreme scenarios could be double that by the 2080s.

<b>Table 6.3.</b> Percentage change in expected annual damages to non-residential properties (assuming no population growth)						
<b>Time period</b>	<b>Climate scenario, by the 2080s</b>	<b>UK</b>	<b>England</b>	<b>Northern Ireland</b>	<b>Scotland</b>	<b>Wales</b>
Present day	-	£800m	£590m	£19m	£120m	£59m
2020s	2°C	6%	7%	11%	4%	5%
	4°C	31%	33%	30%	22%	36%
2050s	2°C	26%	26%	36%	19%	29%
	4°C	69%	68%	62%	60%	96%
2080s	2°C	48%	49%	63%	40%	55%
	4°C	140%	130%	140%	120%	200%

**Source:** Sayers et al. (2015) for the ASC.

**Note:** Analysis by SEPA (2016) finds that for the period 2016 to 2021, annual average damages from all sources of flooding (coastal, fluvial and pluvial) are estimated to be £91 million.

In some circumstances, increased flood risk may also lead to permanent loss of business locations. This is particularly important for coastal areas where firms require locations close to the sea. This could be because of transport services, access to cooling water, tourism, or existing business clusters (Baglee et al., 2012). In the future all sources of flood risk, including from coastal flooding, are projected to increase. Under a 4°C emissions scenario, no population growth and continuation of current levels of adaptation, expected annual damages from coastal flooding to residential and non-residential properties are projected to increase by the 2080s by about:

- 175% in England from a baseline of £260 million (30% of total expected annual damages from flooding) at present.
- 60% in Northern Ireland from a baseline of £2 million (8% of total expected annual damages from flooding) at present.
- 450% in Scotland from a baseline of £26 million (16% of total expected annual damages from flooding) at present.
- 300% in Wales from a baseline of £28 million (34% of total expected annual damages from flooding) at present.

### *Future risks – Coastal Erosion*

Many industrial facilities already have active risk management procedures and a level of existing protection, so autonomous adaptation in the future is likely. However, businesses in the tourism sector, particularly smaller ones, may be less aware of the risk and less able to protect themselves and may therefore be more vulnerable (Baglee et al. 2012).

The National Flood and Coastal Erosion Risk Management Strategy (Environment Agency, 2011) reported that, of the 4,500km of coast in England, approximately 1,800km is at risk of coastal erosion (approximately 340km of which is defended). According to the Environment Agency (2014), 700 residential and non-residential properties in England could be lost to coastal erosion over the next 20 years, and about a further 2,000 could be lost in the next 50 years.

Analysis of 2008 property data for England by HR Wallingford et al. (2015) for the ASC suggests that the number of non-residential properties at risk of coastal erosion, even in the long-term constitutes a very small proportion of non-residential properties, less than 0.1%. Based on coast protection under current and future policy, and management strategies such as shoreline management plans, the number of non-residential properties at risk of coastal erosion falls to fewer than 200 across short, medium and long-term planning horizons.

Since the publication of the National Coastal Erosion Risk Map, the Welsh Government has collaborated with Natural Resources Wales to analyse erosion data to ascertain the risk to homes, businesses and infrastructure over the three Shoreline Management Plan (SMP) epochs: 0-20 years, 20-50 years and 50-100 years. Estimates suggest that, in the short-term (0 to 20yrs), no non-residential properties in Wales are at risk of loss to coastal erosion. This is estimated to increase to 52 in the medium-term (20 to 50 years ahead) and 182 in the long-term (50 to 100 years ahead). This represents less than 0.1% of all non-residential properties in Wales.

We were unable to find equivalent analysis for Northern Ireland and Scotland. The University of Glasgow is carrying out a national coastal change assessment (CCA) on behalf of Scottish Government.<sup>3</sup> The CCA aims to establish historic coastal change and then consider future coastal change through a coastal erosion susceptibility model. The CCA aims to inform strategic planning and identify areas and assets which will be susceptible in the future, and is expected to be completed by August 2016.

### *The marine economy*

The marine economy is diverse and may be affected by climate change in a variety of different ways. Table 6.4 provides an indication of the range of activities included in the marine economy together with estimates of their Gross Value Added. Sea-level rise, temperature rise or potential increased storminess could impact these diverse activities in a number of ways. For example, sea-level rise may increase the need for coastal defences, while increases in the frequency of storms and severe rainfall events could discourage tourists from visiting the coast, disrupt travel, utilities and/or marine leisure service provision, as well as preventing access to offshore infrastructure (UKMMAS, 2010).

In an assessment of the impacts of climate change on offshore site locations, Side et al. (2013) state that it is possible that the coming decades may see increasing trends in mean and extreme values for wave height and storminess. However, there is uncertainty in future predictions and

---

<sup>3</sup> See [http://www.dynamiccoast.com/about\\_project.html](http://www.dynamiccoast.com/about_project.html) and <http://www.crew.ac.uk/projects/national-coastal-change-assessment> for more information



variation in historic data. Many aspects of offshore operations are weather-constrained and therefore subject to 'weather-windows' during which such operations can safely take place. Reduction in the length of weather-windows, or increases in unpredictability, could have significant implications for maintenance activities, crew transfer or access, for example with regard to offshore oil and gas rigs, wind turbines, fish farms and sand and gravel extraction sites (for more on risks to offshore infrastructure, see Chapter 4).

UK ports may be impacted by storm surges, sea-level rise, temperature change, precipitation and high winds (Wright, 2013). Key areas that could be impacted by climate change include the maintenance of harbour facilities, the resilience of navigational safety functions, the increased need to maintain channels due to changes in sedimentation and tidal patterns, the movement of ships under challenging weather constraints, and port operations including cargo handling activities. Storminess can affect ship's routing, delays on passage and the need for smaller ships to seek shelter (for more on risks to ports and shipping, see Chapter 4).

Climate change risks and opportunities concerning fisheries and aquaculture are discussed in Chapter 3 on the natural environment.

**Table 6.4.** Economic value for the principal activities of the marine economy

Marine activity	Year	Gross Value Added from marine activity (£ millions)
Oil and Gas	2008	37,000
Maritime transport	2007	4,700
Telecommunications	2005	2,700
Leisure and recreation	2003-08	1,289
Defence – Military	2007/08	468
Fisheries	2007	204
Aquaculture	2007	193
Water abstraction	2008	150
Mineral abstraction	2008	54
Renewable energy	2008	50
		<b>Investment value of marine activity (£ millions)</b>
Coastal defence	2007/08	358
Waste disposal	2007/08	9
Education	N/A	N/A
R&D; general management	N/A	N/A
Power transmission	N/A	N/A
Gas storage and pipelines	N/A	N/A

**Source:** UKMMAS (2010).

**Notes:** GVA does not include ancillary and secondary market values. Oil and Gas excludes values from pipelines and hydrocarbon storage as these could not be established. Note that due to the different economic values used it is inappropriate to provide an overall total.

VisitEngland (2015) estimated that in 2014, there were 18 million trips to the seaside on domestic overnight trips in England, 19% of all domestic overnight trips, with spend at £3.9 billion (21% of all spending on domestic overnight trips). There were also 144 million tourism day trips involving a trip to the seaside – or 11% of all day trips – with associated spending of £5.3 billion (12% of all spending on day visits).

### 6.2.3 Adaptation responses and gaps for flood and coastal erosion risk to site locations

Projections of the future risk to business sites from flooding, assuming current levels of adaptation continue, indicate that risks will increase without further action (Sayers et al., 2015), significantly so in some scenarios.

#### *Adaptation activity driven by governments*

##### *England*

The level of flood protection that national governments will be able to justify to the taxpayer may fall short of business needs in some areas. The incentive for governments to prevent flood damage to individual businesses is also limited, as economic activity tends to be displaced or postponed during a flood rather than lost altogether (ASC, 2015). Business benefits are taken into account in the allocation of national funding to flooding and coastal erosion projects. Where national funding is insufficient to meet the full costs of a scheme, businesses can contribute towards the shortfall as part of the Flood and Coastal Resilience Partnership Funding policy (Defra, 2011a). In the three years following the introduction of the policy in May 2011, Defra-funded projects provided an improved standard of flood protection to more than 16,000 commercial properties. Local Enterprise Partnerships can leverage additional funding to support flood risk management measures in their area. This includes funding from sources such as the Local Growth Fund and European Structural Investment Funds (ESIF). In total around £140 million from the ESIF and Local Growth Fund has been allocated to climate change adaptation, primarily to address flood risk.

Tools, guidance and training courses have been provided to date by the Environment Agency through the Climate Ready programme, Climate UK, the Cabinet Office, and the Institute of Environmental Management and Assessment (IEMA). Updates on actions listed in the UK NAP (HM Government, 2013) provided by these organisations suggest the tools and guidance have been used by a number of businesses. For example, the Business Resilience Health Check tool, which helps businesses identify if they are at risk and what they can do to prepare for flooding, has been accessed by 2,000 organisations to date.

Flood warnings provide information to businesses ahead of a potential flood event. These allow decisions to be taken on moving stock, employees and other assets to reduce damages and disruption. The number of businesses actively registered for the Environment Agency's free Flood Warnings Direct (FWD) scheme has increased from about 25,000 in 2007 to 51,000 in 2015. However, analysis by the ASC in 2014 suggested less than one-fifth of businesses in areas at high risk of flooding had actively opted-in to receive the full FWD service (ASC, 2014). Given that the FSB (2015) finds that 78% of small businesses in flood risk areas are aware of the Flood Warnings Service offered by the Environment Agency or the devolved agencies of Scotland, Wales and Northern Ireland, it suggests that awareness of the service is not the issue but perhaps awareness of the relative risk. In response to the Pitt Review, the Environment Agency launched the Extended Direct Warnings (EDW) service, which automatically registers all fixed-line telephone numbers identified as within flood risk areas. The service provided through the EDW is less comprehensive than the FWD, but should ensure most businesses receive at least a basic warning ahead of potential flood events.

Shoreline Management Plans are in place to provide an assessment of the risks associated with coastal processes and present a long-term policy framework to reduce these risks. There is a lack

of information regarding the costs and benefits of different long-term policy options identified with the SMPs, such as increasing levels of protection in some locations, and managed realignment and no active intervention in others. It is therefore difficult to determine whether the policy aspirations identified within SMPs will be achievable and affordable in practice and what this implies in terms of risks to individual business locations.

### *Northern Ireland*

Sustainable Water - A Long-Term Water Strategy for Northern Ireland (2015-2040), published in March 2016, contains a long-term vision to manage flood risk and drainage in a sustainable manner, which will help to address the future risks from climate change (DfI, 2016). The Strategy also includes the following aims relevant to the vulnerability of business site locations:

- Ensure a sustainable water sector to support the Regional Development Strategy 2035.
- Sustainable Drainage Systems (SuDS) are the preferred option for managing surface water in new developments.
- Sustainable Catchment Management.
- A holistic integrated approach to rural and urban drainage provision.
- Improve Flood Resistance and Resilience in High Flood Risk Areas including extending the Homeowner Flood Protection Scheme to non-domestic properties.
- Provide effective, efficient flood emergency information and communication systems.
- Provide information and warnings regarding extreme weather events.

The Water and Sewerage Services Act (Northern Ireland) 2016 introduces new restrictions to the right to connect surface water drains to the public sewer network. The 2016 Act sets out further grounds for refusal of a connection on the basis that there is suitable alternative means of dealing with the surface water or that such means could reasonably be provided. It makes clear that suitable alternatives include sustainable drainage systems.

Shoreline management plans or other policies that assess and plan for changes to coastal locations have not been developed for Northern Ireland.

### *Scotland*

SEPA has produced Flood Risk Management Strategies for 14 Local Planning Districts (LPDs) which aim to help individuals, local communities and businesses to understand their local flood risk and its management. Businesses in Scotland can sign up to Floodline to receive Flood Alerts and Warnings. Over 1,900 businesses have registered. This may be an underestimate since business owners or managers may have signed up to the service as individuals but receive flood warnings specifically for their business premises rather than their own personal properties. SEPA has also developed guidance for businesses on creating flood plans and advice on flood insurance.

Under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 it is a general requirement for new developments with surface water drainage systems discharging to the water environment to have sustainable urban drainage systems in place. Scottish Planning Policy aims to avoid increased surface water flooding through requirements for SuDS and minimising the area of impermeable surface (Scottish Government, 2016). It also states that proposed arrangements for SuDS should be adequate for the development and appropriate

long-term maintenance arrangements should be put in place. There is limited evidence to suggest whether the proportion of commercial sector projects which have made use of permeable paving, or other surface water flood mitigation measures, is increasing. The Scottish Government commissioned JBA Consulting (2014) to assess the flood risk benefits of property level protection. JBA Consulting concluded that *"PLP can be an effective approach to managing flood risk in Scotland"* but that *"take up has been limited"*.

There are non-statutory Shoreline Management Plans in place for some locations in Scotland. In some cases management plans have been agreed with local councils to protect places of importance to the tourism industry from flooding and coastal erosion, for example West Sands, St. Andrews (West Sands Partnership, 2012).

### *Wales*

In Wales between 2011 and 2016 around £285 million was invested in flood and coastal erosion risk management. It is not known what effect this investment has had on the number of non-residential properties in areas at high risk of flooding across Wales. However, there is evidence of investment in improved flood defences which protect local businesses on a case-by-case basis. One example is the £6.7 million Lower Swansea Vale project which provides protection to 284 businesses and industrial premises employing more than 10,000 people. The project has also implemented other measures such as flood warning, awareness raising and emergency planning within the area.

By law, Natural Resources Wales must produce Flood Risk Management Plans, at the River Basin District scale, for the whole of Wales every six years starting from 2015. They also provide a business flood plan template, and report that more than 1,000 communities and individual businesses in Wales now have their own pre-prepared flood plans.

- The Welsh Government published interim SuDS standards in 2015; which also include standards for biodiversity and amenity. The Welsh Government is still considering how to progress Schedule 3 of the Flood and Water Management Act 2010, which relates to standards for the design, implementation and maintenance of SuDS.
- Natural Resource Wales carried out a review of the December 2013 and early January 2014 coastal storms, which concluded that more needed to be done to ensure coastal communities are resilient to future flooding. Natural Resource Wales launched a delivery plan at the beginning of 2015 setting out how recommendations from the review of 2013/14 coastal floods would be taken forward.

Shoreline Management Plans are in place for the full length of the Welsh coastline. SMPs set out coastline management policies (hold the line, no active intervention etc.) to the 2100s and are developed by Coastal Protection Authorities. At the beginning of 2015, Natural Resource Wales announced a delivery plan to make Wales more resilient to coastal flooding.

The SMPs set out the risks to coastal areas from erosion and sea-level rise and indicate how local authorities and other bodies can plan and implement coastal management policies. It is not known how much progress has been made with implementing options, and how this has altered levels of risk. These plans do not consider the impacts of loss of coastal communities and businesses, and what measures should be taken to support communities through such changes (for more on this see Chapter 5).

### *Other adaptation activity by businesses*

Businesses can adapt in various ways, including site-protection measures, business continuity planning and by relocating to properties away from known hazards. Spatial planning policies can prevent new business premises being located in areas at risk of flooding and coastal erosion (HM Government 2012; HM Government 2009). There are few examples of companies relocating facilities in anticipation of extreme weather events, especially after major capital investments have been made. However, SMEs are generally more mobile. For example, in a report on impacts of flooding in Cumbria, 52% of companies which had relocated due to their premises being flooded had not returned after six months (BMG Research, 2011), despite still being in business.

For businesses, there is also the option of supporting local flood defence and risk management schemes - for example through public-private partnerships such as the Humber Estuary Local Enterprise Partnership (2014). Between April 2011 and March 2015, £134m of partnership funding contributions were provided towards new flood and coastal erosion management schemes, compared with £13m in the previous four years. Defra expect that the 6-year investment programme could attract over £600m of contributions in total, of which £270m has already been secured, and potential funding contributions to cover the remaining £330m have been identified. Of the £270m secured contributions £61m is from private sources (including private businesses and companies); £89m is from Local Enterprise Partnerships and other public bodies, for example local councils, highway authorities (over and above the Local levy); and £120m is from the local levy.

Business continuity plans support businesses to prepare, respond and recover from a flood event. The proportion of private sector organisations reporting that they have a business continuity plan in place rose from 42% in 2008 to 58% in 2013 (ASC, 2014). Extreme weather events such as flooding are consistently the main reason for businesses activating these plans. Around four-fifths of businesses with continuity plans in place report that the benefits of having a plan exceed the costs of producing one. This suggests business continuity plans are a cost-effective adaptation measure. Despite the benefits identified, the uptake of business continuity plans remains relatively low, particularly among micro businesses and businesses in the construction sector. Only 25% of businesses with fewer than 10 employees have a resilience plan in place that specifically includes severe weather (FSB, 2015).

Greater information sharing among co-located businesses, regarding shared assets, could lead to joint risk management plans that can be monitored, reviewed and updated at regular (for example 3 – 5 year) intervals. A lack of collaboration among businesses may result in failure to recognise interdependencies and incorporate these into flood risk management plans, particularly with regards to business clusters, industry parks and new commercial sites. Actions to protect key infrastructure (for example, ICT, power supplies and effluent treatment plants in the chemicals sector – see Chapter 4) would have co-benefits in addressing risks to business site locations (Frontier Economics, 2014, for Defra and the Environment Agency).

Property-level resilience measures, such as flood gates and air brick covers, can prevent flood water entering buildings. Following the floods in the winter of 2013/14, the Government introduced a 'Repair and Renew' grant, providing financial support of up to £5,000 for affected businesses and households. At the same time, the Government announced it would provide business rate relief for up to three months for businesses that were flooded. Feedback from flood protection manufacturers suggests overall uptake of property-level resilience measures by businesses is relatively low (ASC, 2015). Among SMEs, companies that have experienced



flooding are more likely to implement property level resilience measures (Wedawatta and Ingirige, 2012).

Permeable paving used in hard surfacing around business premises can improve drainage and reduce the risk of surface water flooding. While the use of permeable paving within the commercial sector has increased in recent years, it remains a relatively small part of total paving activity in England. Impermeable paving remains the dominant paving type in commercial projects, with 86% of block paving supplied for commercial sector projects in 2013 in England being impermeable (Jenco Consultancy Ltd and Climate Resilience Ltd, 2014). Other sustainable drainage solutions such as retrofitting green roofs can absorb rainwater and attenuate peak flows (Lamond et al. (2014) for the Royal Institution of Chartered Surveyors), decreasing the impacts of flash flooding in city centres. Flood risk reduction or improved storm-water management in comparison to traditional paving or roofing can mean the benefits of green roofs and permeable paving outweigh the costs in some cases. However, the requirement for SuDS in new development in England has been significantly weakened, with key findings of the Pitt Review ignored (ASC, 2015). Ongoing and unpublished analysis by the Blue-Green Cities research project<sup>4</sup> is assessing the benefits of blue and green infrastructure in alleviating direct and indirect damages from flooding to industry and infrastructure, using the city of Newcastle as a first case study.

## **6.2.4 Current and future water availability risks to site locations**

### *Current risks*

Water is used by industry for cooling and heating, washing products, dissolving chemicals, suppressing dust and also as a direct input to products. Without sufficient water, production in many businesses would have to be reduced or stopped (ASC, 2015). Typically, household consumption dominates the demand for water. However, some areas may have very high non-household demand reflecting the nature and intensity of local industry and businesses.

Figure 6.3 sets out analysis by HR Wallingford et al. (2015) for the ASC, which assesses present-day abstraction demand from all sectors<sup>5</sup> as a percentage of the available resource at the average of Q95 and Q70 low flow conditions.<sup>6</sup> There are some catchments where abstraction demand is already in excess of the available resource in average low flow conditions. These catchments are mostly located in the east and south of the UK, although there is a small number in Scotland and the north-west of England. 'Negative available resource'<sup>7</sup>, where there is no water resource available for human uses if the environmental flow requirement is adhered to, is not currently indicated as an issue for any catchment in the UK. For each UK nation:

---

<sup>4</sup> More information is available at: <http://www.bluegreencities.ac.uk/bluegreencities/index.aspx>.

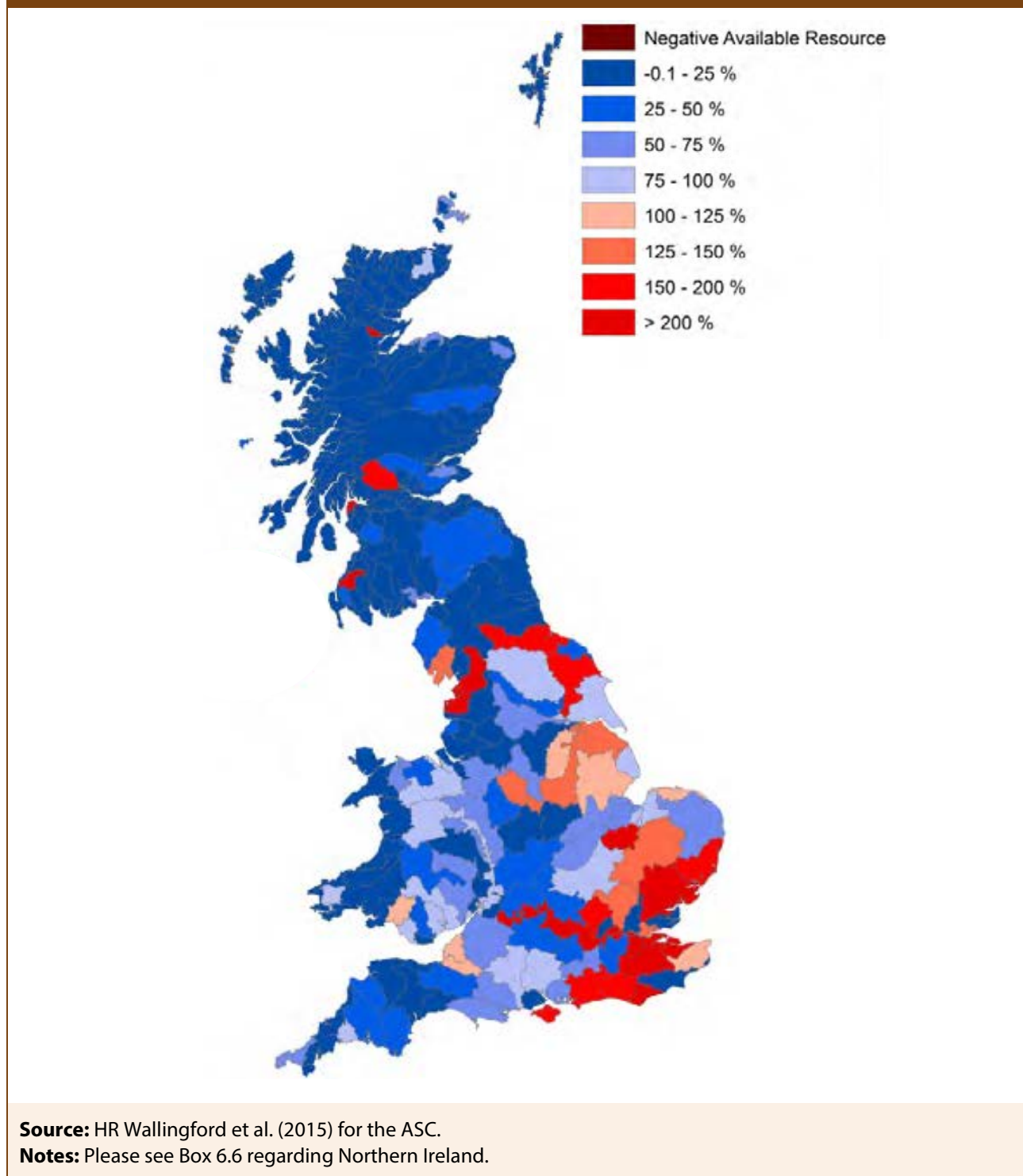
<sup>5</sup> HR Wallingford et al. (2015) defines all sectors as including public water supplies plus agriculture, energy generation, industry and commerce and the natural environment.

<sup>6</sup> Q95 is the river flow that is equalled or exceeded for 95% of the time. Q95 is a common low flow reference (and conversely, Q10 is a high flow reference). In HR Wallingford et al. (2015), Q95 refers to the 30-year annual average Q95 unless specified otherwise. The average of Q95 and Q70 is referred to as 'average low flows' in HR Wallingford et al. (2015).

<sup>7</sup> Natural flows minus Environmental Flow Indicator requirements, plus discharges, equating to a negative number.

- In England, abstraction demand is higher at times of low flows than the available resource once environmental flow requirements are taken into account in catchments in the east and south, and a small number in the north-west.
- Northern Ireland – please see below and Box 6.6.
- In Scotland, the catchments with the largest absolute natural available resource during times of low flows are the Rivers Tay and Spey. The catchments in Scotland with the least absolute natural available resource during times of low flows tend to be small, coastal catchments, although there are a few which are larger and more central.
- In Wales, the available resource even at times of low flows is sufficient in all but once catchment to meet demand and minimum environmental flow requirements. The exception is in a catchment in southern Wales, where demand is slightly higher than the available resource.

**Figure 6.3.** Present-day abstraction demand as a percentage of the available resource at the average of Q95 and Q70 low flow conditions, 2015



It should be noted that the demand-side data for Northern Ireland available to HR Wallingford et al. (2015) for the ASC has since been superseded and has changed significantly. Therefore the projections of water availability for Northern Ireland in HR Wallingford et al. (2015) for the ASC are no longer current and should not be used. Box 6.6 sets out further details.

**Box 6.6.** Analysis of water availability in Northern Ireland

HR Wallingford et al. for the ASC (2015) carried out analysis of water availability in Northern Ireland using the best available data at the time, the planning tables from the 2009 Water Resource Management Plan (WRMP). Since 2009, Northern Ireland Water has undertaken a significant amount of work to reduce by 15% the demand on its system, primarily through leakage control. NIW has produced new data that reflects this work for their next WRMP.

HR Wallingford has reanalysed the public water supply projections for Northern Ireland to evaluate what these changes in demand might mean for projected water availability. In the original analysis, four out of the seven Water Resource Zones (WRZs) in Northern Ireland were projected to be in deficit by the 2030s and all WRZs in deficit by the 2080s under the most severe scenario tested. When the new demand data are used in the projections, no WRZs are in deficit in the 2030s, nor in the same scenario in the 2080s, even without any additional adaptation actions being carried out beyond those in the current WRMP.

The re-analysis shows the influence that assumptions on future demand-side measures can have on the supply-demand balance within a WRZ. Whilst the primary reason for Northern Ireland Water's actions was not for long-term climate change resilience, the effect of their work to control leakage has likely had a significant benefit in this regard. The overall message provided by the re-analysis is that there is a projected surplus, in all future scenarios evaluated, in Northern Ireland.

However, caution should be exercised when interpreting these results as new supply-side data were not available for the new analysis. Therefore, any changes in water supplies since 2009 have not been taken in to account in the new supply-demand balance. However, given the relatively low projected influence of climate change on Deployable Output across Northern Ireland and population growth rate, it is unlikely that the supply-side values would change enough to significantly alter this overall position.

**Source:** HR Wallingford re-analysis based on updated (2016) demand-side data for Northern Ireland.

## England and Wales

Abstraction by industry in 2014, excluding agriculture and energy, was 848 billion litres of water in England and 111 billion litres in Wales (Environment Agency, 2016). This represents approximately 9% and 3% of total abstractions from all sources (except tidal) in England and Wales respectively. There are relatively few examples of business having to stop abstraction at present. However, this may be because most abstraction licences do not currently include the ability to impose restrictions on abstraction when water is scarce. For these abstractors, the only limiting factor will be whether water is physically available (ASC, 2014).

In 2012, 1,014 billion litres were consumed by non-residential customers from the public water supply in England, equivalent to around one-quarter of the total public water supply (ASC, 2015). The use of public water supplies is spread more widely amongst a larger range of sectors, including wholesale and retail, and leisure industries.

Some industrial sectors are more water-intensive than others. WRAP<sup>8</sup> (2011) published analysis of freshwater availability and use in England and Wales, which suggested that, using the Standard Industrial Classification (SIC) 2007, the manufacturing sector was the biggest abstractor in 2006, being responsible for between approximately 45% and 55% of direct

<sup>8</sup> The Waste and Resources Action Programme (which operates as WRAP) is a registered UK Charity. WRAP works with governments, businesses and communities to improve resource efficiency.

abstractions. At a regional level, over 65% of these abstractions were in the north-west of England or in Wales. Other relatively large abstractors included mining and quarrying, and also arts, entertainment and recreation, and other goods and services. Particular manufacturing sub-sectors accounted for more abstractions than others. These included the manufacture of chemicals and chemical products, basic metals, paper and paper products, beverages, food products and coke and refined petroleum products.

WRC<sup>9</sup> (2014) analysed abstractions by the chemical manufacturing, paper manufacturing, and mining and quarrying sectors, as three of the largest abstractors. This analysis highlighted current risks due to site location, as a large proportion of the paper manufacturing industry is located in south-east England where there are already pressures on water resources.

### *Scotland*

Non-domestic consumption of public water supplies was 410 million litres per day in 2014-2015. SEPA analysis (2005) identified the chemicals and food and drink manufacturing sectors as the largest industrial users of water in Scotland. Earlier analysis by CJC Consulting (2002) suggested that the major water using sectors in Scotland (comprising abstracted water and mains supply) were fish farming, malt whisky distilling and paper manufacturing. Long-term water scarcity lasting more than a few months, such as that experienced in parts of Tayside during 2003-2004 is extremely rare in Scotland. Typically, water scarcity is a short-term issue occurring mostly in summer (SEPA, 2015). In terms of summer rainfall, while there is some evidence of a decrease in parts of the north of Scotland by as much as 20%, SEPA conclude that any changes in summer rainfall have so far not resulted in measurable trends in summer water scarcity.

The Scotch Whisky Association commissioned the Scotch Whisky Research Institute to assess climate change risks. Their research noted that low flows in rivers affected a number of sites in recent years and that raised summer temperatures elevated water temperatures making the spirit production less efficient (Scotch Whisky Research Institute (2011) for the Scotch Whisky Association).

### *Northern Ireland*

Data provided by the Northern Ireland Environment Agency suggest that abstractions for general industrial purposes in Northern Ireland account for approximately 6 million m<sup>3</sup> per day. Based on these data, food and drink and mining and quarrying are relatively large abstractors of water within Northern Ireland.

### *Future risks*

Research by HR Wallingford et al. (2015) for the ASC finds that water scarcity may increase considerably in future depending on the level of climate change and population growth. Figure 6.4 sets out abstraction demand in the 2050s and 2080s as a percentage of the available resource at the average of Q95 and Q70 low flows and fixed Environmental Flow Indicators. This estimate is based on high population and high climate change scenarios, and assumes all current behaviours of individuals, groups, companies and government remain the same as they are today, even when existing objectives are not currently being met. Assumed actions include adaptation measures set out in Water Resource Management Plans to the 2030s. Demand of

---

<sup>9</sup> WRC plc is an Independent Centre of Excellence for Innovation and Growth. It operates across different sectors including water, environment, gas and resource management.

more than 150% of the available resource is projected to be present in catchments across Great Britain (approximately 20% of the total number of catchments), primarily in England but also a few catchments in Scotland and Wales. In contrast to the present day situation, there are projections of negative available resource in catchments across the west of Scotland, England and Wales. For each UK country:

- In England, demand of more than 150% of the available resource is projected to be present in catchments in the east and south. In several catchments in the west of England it is projected that at times of low flows, there would be no water available for human use assuming that ecological flow requirements as currently set out would be met.
- Northern Ireland – please see Box 6.6.
- In Scotland, there is a general pattern of a lack of available resource across central Scotland. Only the northern most catchments of Scotland are projected to maintain a high level of water available under all future scenarios.
- In Wales, it is projected that for large parts of the country, there would be no water available for human use for between 5 and 25% of the time<sup>10</sup> assuming that ecological flow requirements as currently set out would be met. At lower climate and population scenarios, there would be sufficient water for human use in all catchments, with generally more water available for use in western Wales compared to eastern Wales.

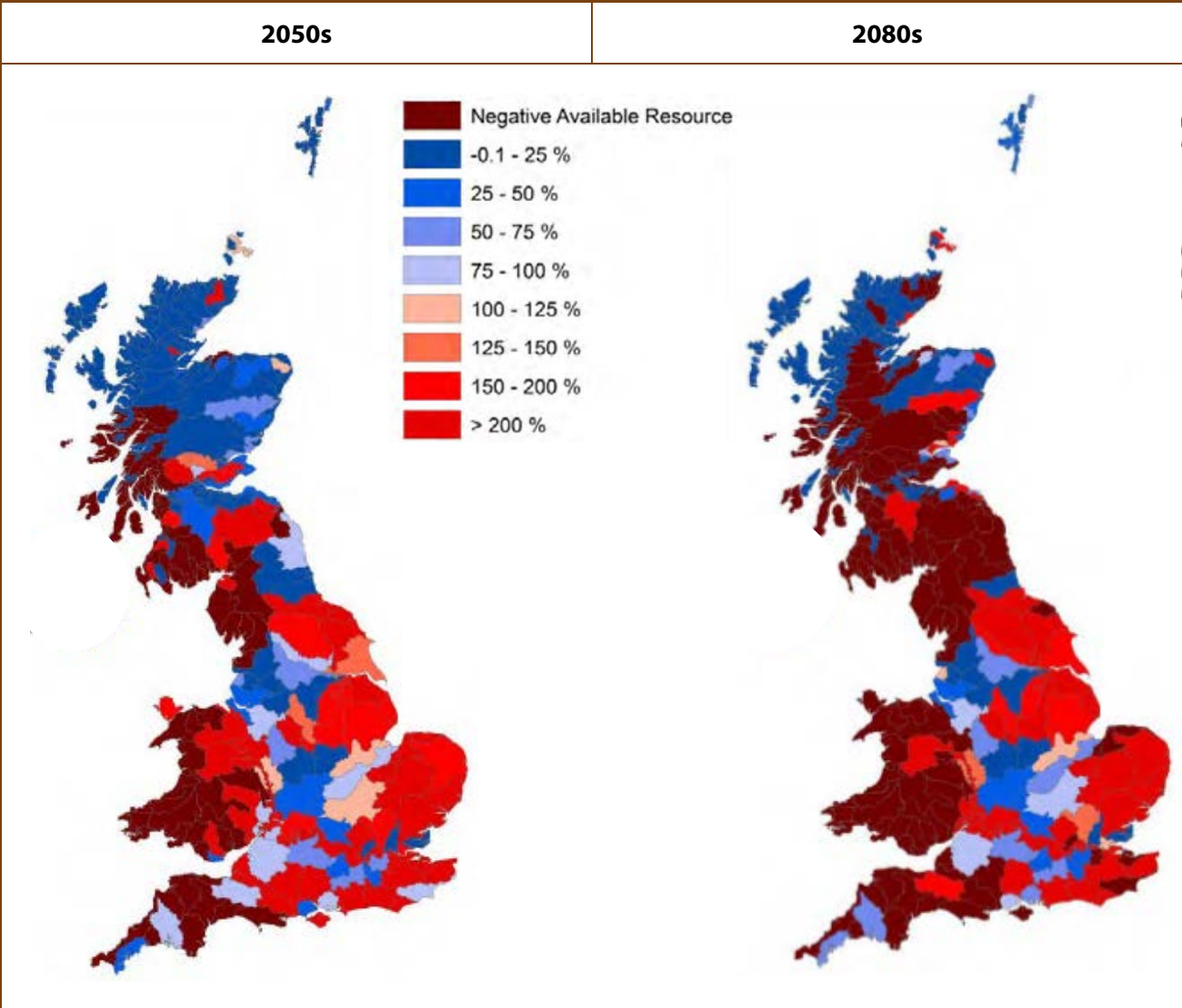
Decreases in future water availability were also found by the Environment Agency (2013) and SEPA (2015). The findings of the latter suggested by 2050 that the reduction from Q95 flows in some rivers in Scotland would be more than 25% and reduced rainfall and higher temperatures may lead to more than a doubling in the frequency of extreme low flow events from once every 40 years to once every 20 years. Less flow means less dilution of the pollutants that make their way into rivers and, combined with the higher temperature, could likely result in a reduction of water quality. This may mean more intensive treatment may be required for raw water used by businesses. Low flows may also affect where business sites are able to discharge water and may require new approaches and costs, for example use of tankers.

---

<sup>10</sup> I.e. based on the average of Q95 and Q75 flows.



**Figure 6.4.** Abstraction demand as a percentage of the available resource at the average of Q95 and Q70 low flow conditions, assuming a high population growth scenario, 2050s and 2080s



**Source:** HR Wallingford et al. (2015) for the ASC.  
**Notes:** Please see Box 6.6 in relation to Northern Ireland.

### 6.2.5 Adaptation responses and gaps for water availability risks to site locations

#### *England and Wales*

One way of adapting to water scarcity is through reform of the water abstraction licencing regime. The English and Welsh Governments have set out proposals for abstraction reform which will be implemented in the early 2020s (Defra, 2016). If reforms are successful, measures such as allowing businesses to take water at high flows may mean pressures are less than they otherwise would be. The Environment Agency and Natural Resource Wales will also be able to instigate risk-based reviews to consider changes to abstraction limits. In certain catchments, businesses that use less water may have a competitive advantage and realise benefits through

water trading, thereby creating incentives for businesses to invest in becoming more water-efficient.

Following the 2014 Water Act, businesses in England will be able to choose their supplier of water and wastewater services from April 2017. Effective competition between suppliers may lead to increases in innovation and incentives for companies to offer water efficiency advice (Defra, 2011b).

There is evidence that sectors and businesses are taking steps to become more water efficient.

In England, estimated abstractions by industry from all sources except tidal waters decreased from 1,360 billion litres in 2000 to 850 billion litres in 2014. Over the same time period, estimated abstractions by industry in Wales from all sources except tidal waters decreased from 270 billion litres in 2000 to 110 billion litres in 2014. For England, ASC (2015) found that “Both direct abstraction from freshwater sources, and consumption of public water supplies by industry, have fallen by around one-quarter since 2000. This has been driven by a fall in production and improvements in water efficiency.”

The Enhanced Capital Allowance Scheme for Water provides tax relief for businesses who purchase equipment and machinery that meets published water saving criteria. Practical support for water efficiency is available from water companies and other sources through water audits, tool kits and on line resources. In addition, the UK Water Partnership aims to foster cross-sector collaboration to address key challenges facing the water sector.

Around 90% of non-residential customers in England are metered (ASC, 2015).

### *Northern Ireland*

The Northern Ireland Environment Agency (NIEA) Abstraction and Impoundment Licensing (AIL) team monitor and control water bodies in Northern Ireland. Industries that abstract over 10 cubic metres per day of surface, coastal or groundwater will be required to notify the NIEA, while Abstractions of over 20 cubic metres per day require a licence. The NIEA and AIL undertake periodic reviews of licences and can review licences at any time and can make modifications.

Sustainable Water - A Long-Term Water Strategy for Northern Ireland (2015-2040), published in March 2016, includes an action to “manage and review abstraction licences to ensure sustainable water resources are available to meet society’s needs without compromising the environment. This will factor in the cost of future abstraction reductions (e.g. new treatment works or trunk main)” (DfI, 2016).

Northern Ireland Water provides advice to businesses on how they can reduce how much water they use.

### *Scotland*

All abstractors have a duty under Regulation 5 of the Controlled Activities Regulations (CARs) to use water efficiently. The CARs were amended in 2011 to include emergency provisions to allow SEPA, in certain circumstances, to amend existing authorisations or issue new authorisations to cope with prolonged periods of dry weather. SEPA identify catchments under pressure from abstraction in River Basin Management Plans and work with appropriate stakeholders to develop site and sector specific solutions. SEPA is also consulting on a national water scarcity plan.

All non-domestic customers in Scotland are metered unless it is not practicable to do so. In 2014/15 about 80% of Scottish Water connected non-household properties were metered (Scottish Water, 2015a).

There are signs that water is being better managed by some businesses. Non-domestic water consumption in Scotland has fallen from 530 million litres per day in 2002/03 to 410 million litres per day in 2014/15 (Scottish Water, 2015b). Resource Efficient Scotland, a free advice and support programme established by Scottish Government, published a guide to improving water efficiency and promote case studies of good practice. The Scotch Whisky industry reported in 2015 that net water use was down 14% from 2008 levels (Scotch Whisky Association, 2015).

### UK

Projections of future water availability have also shown that adaptation responses by industry can significantly affect future water availability. Environment Agency (2013) considered a range of potential future scenarios based on different attitudes to water use (conservationist through to consumerist) and governance (growth-focused through to sustainability focused). Demand from 'industry and commerce' varied by 2,000 Ml/d between 'uncontrolled demand' and 'innovation' or 'sustainable behaviour' scenarios. HR Wallingford for the ASC (2015) applied the behaviours by business suggested in the 'sustainable behaviour' scenario<sup>11</sup> in Environment Agency (2013), in addition to other changes by water companies, agriculture and energy generation to future projections of water availability. This analysis showed that relative to the baseline scenario, these increased levels of adaptation are projected to alleviate future pressures on water availability to some extent.

Evidence from the Federation House Commitment (FHC) shows a decrease in water intensity in the food and drink manufacturing sector. The FHC is a voluntary scheme developed to help food and drink manufacturers reduce water use at their sites to help achieve a water reduction target of 20% by 2020 against a 2007 baseline, part of the Food and Drink Federation's (2015) Five-fold Environmental Ambition. This target was recommended by the Food Industry Sustainability Strategy. Water use excluding that used in product at FHC sites fell by 16% between 2007 and 2013; and water intensity, measured in m<sup>3</sup> per tonne of product, fell by 22% over the same period (WRAP, 2014). 84% of FHC signatories' sites were in England, 2% in Northern Ireland, 10% in Scotland and 4% in Wales. The 'Courtauld 2025' voluntary agreement aims to cut the resource needed to provide food and drink by one-fifth from 2015 to 2025, and will include a specific target for reducing the impact associated with water use in the supply chain (WRAP, 2016).

Businesses are taking action to address water scarcity both domestically and in their operations overseas (J Sainsbury plc, 2016; SABMiller plc submission to CDP, 2014; and Marks and Spencer and WWF, 2014). Some other sectors also monitor their water use. Using self-reported data, the UK industry report for the construction sector shows that mains water use has decreased from 7.7m<sup>3</sup> per £100,000 project value in 2004 to 4.4 m<sup>3</sup> per £100,000 project value in 2015 (Glenigan and CITB, 2015, for BIS). However, other sectors have not established targets and do not monitor progress. Therefore there may be scope for further improvements in water efficiency in these sectors.

---

<sup>11</sup> Reduction in demand primarily due to attitude to efficiency. R&D centrally funded to drive low cost technology. Resulting in industry and commerce demand of 6,250 Ml/d.

## 6.3 Climate risks and opportunities for access to capital

This section investigates if there is evidence that climate change will influence the ability of businesses in the UK to have access to capital.

### Key messages

#### **Bu4: Risks to business from reduced access to capital**

- Access to capital – through debt or equity financing – is a key factor for most private sector organisations from early start-up loans to public listings.
- Access to capital may become material if credit becomes more expensive or limited for companies that are considered to be taking insufficient adaptation action. This would mean that the cost of capital starts to reflect the risks from climate change, raising capital costs for vulnerable companies.
- The costs of insurance are likely to rise due to increases in exposure and changes in climate. Insured flood losses under a 4°C temperature rise in the UK could lead to insurance rate increases of 21%, and £1.9 billion could be added to the £5.9 billion capital requirement. The risk for most businesses of not being able to insure against climate risks is currently low but can increase in the future. This would have implications for their creditworthiness.
- Lack of affordable access to insurance could have implications for cost of capital and credit ratings. Those SMEs that have been flooded can experience difficulties when trying to access insurance or loans. Currently this appears to be a relatively localised and contained issue, but could become more widespread if more businesses become uninsurable or premiums unaffordable.

In the UK, debt finance is the main source of capital in the private sector and particularly relevant for SMEs (BIS, 2012). The two most common forms of debt finance used by all sizes of businesses are overdraft facilities and term loans (ICAEW, 2010). Since the financial crisis ‘the overall level of bank lending to SMEs in the UK has declined by about a quarter’ (Large and Oliver Wyman, 2013).

Whilst on the increase, only a small fraction of British companies issue equity as a source of finance. Yet, those that do are firms that have a relatively large share of economic activity (Pattani et al., 2011). In 2013, the private equity owned sector amounted to around 5 – 8% of the corporate sector (Gregory, 2013). Venture capital firms or business angels may invest in firms at an early stage. Box 6.7 sets out key factors influencing debt and equity.

### Box 6.7. Key factors influencing debt and equity

Debt: capital markets or bank loans, government grants, project based lending.

Relevant factors: size of business, revenue streams, maturity, existing capital structure, rating including financial ratios, technical considerations (how much debt, how long, for what needed), security provided – assets (buildings, cash-flows), financial guarantees, regulation and tax regime (currency controls), market conditions (interest rates, costs of capital).

Equity: public listing, venture capital, business angels, crowd funding.

Relevant factors: oriented on upside or gain, determined by cost of debt financing, access to debt or ability to raise debt, stage of business (start-up cannot get debt), investor appetite, approval from existing shareholders (diluting), value of company.

**Source:** CCRA2 Evidence Report authors.

Climate change could have an impact on access to capital through primary channels (exposure of assets to climate hazards and increasing exposure of the insurance industry) or through secondary channels (regulatory change in response to future climate, development of new tools to manage risks, changes in credit ratings and changes in market expectations and investor behaviour). Risks and opportunities for businesses' access to capital can be understood as the 'flip side' of the risk and opportunities faced by the financial institutions, which provide much of the lending and investments, and their response to changing risks. Insurance can play an important role in the process of borrowing or accessing other funding streams, as it is a factor that influences credit-worthiness. We therefore include this in our investigation. A further aspect considered is the ease with which a company can secure funding to make it more resilient or to invest in new products and services in response to climate change.

### 6.3.1 Policy framework

General policies and programmes related to promoting awareness of climate change risks and opportunities, including in the context of access to capital, are discussed under Section 6.2.1.

Government-backed support for businesses varies according to location, size and activity (HM Government, 2016). Support includes:

- grants
- finance and loans;
- business support (for example mentoring and consulting); and
- funding for small and medium-sized businesses and start-ups.

For example, government-backed support may be available to fund training, research and development or activity within certain sectors.

The primary purpose of international rules regarding information disclosure, risk management and solvency is not climate change, but these rules have implications for adaptation. Such rules include the Solvency II Directive (2009), its statutory receipt (2016) and the Basel III (BCBS, 2011) stability ratio. These directives aim to ensure the financial soundness of finance and insurance undertakings, and particularly to ensure that bankers and insurers can survive difficult periods. This is to protect policyholders (including businesses) and the stability of the financial system as a whole.

Basel III requires regulators to challenge banks more in the construction of their models and broadens regulatory authority under Pillar 2 to require banks to undergo more frequent and demanding stress tests. The Pillar 2 review also consists of a supervisory review enhancement process (SREP) that includes separate assessments of bank capital and governance. The SREP can be utilised to forecast the bank's exposure to systemic risks and related macro-prudential risks (CISL and United Nations Environment Programme Finance Initiative (UNEP FI), 2014).

Solvency rules stipulate the minimum amounts of financial resources that insurers and reinsurers must have in order to cover the risks to which they are exposed. The rules also lay down the principles that should guide insurers' overall risk management so that they can better anticipate any adverse events and better handle such situations. For example, all (re)insurance undertakings must have a regular practice of assessing their overall solvency needs with a view to their specific risk profile, known as 'Own Risk and Solvency Assessment' (ORSA) (European Commission, 2007).

### **6.3.2 Current and future risks and opportunities for access to capital**

#### *Current*

There is very little evidence that climate change is already impacting access to capital, however there are some signs that current climate risks are beginning to be considered by those providing capital or related services, such as insurance.

#### *Banking and investment*

The UK Government's Foresight Project report on the impact of climate change overseas on the UK financial services sector (Silver et al., 2010) concluded that the supply of capital by UK banks is vulnerable to climate change because of three main factors:

- Banks are exposed to vulnerable areas, for example through business with emerging markets, where along with other developing countries, climate change impacts are expected to be greatest in the first part of the century.
- Risks can be locked in for long periods, for example through longer-term loans.
- Many banks have little risk management expertise on the topic of climate change, for example when compared to the insurance sector.

The exposure also depends on the type of investment product, as well as the sector and region. Table 6.5 (Mercer, 2015) provides a brief summary of climate change impacts on the components of investment and lending portfolios.



**Table 6.5.** Climate change impacts on the components of investment and lending portfolios

Components	Impact
Asset class	<ul style="list-style-type: none"> <li>The risk of the returns to investment in various asset classes arises from the climate impacts on prices and the financial performance of companies. These factors determine the rate of return, but the effect varies due to the nature of different asset classes.</li> <li>Investments in growth assets (equity and commodity) are more vulnerable to market fluctuations and business performance compared to investments in defensive assets (bond). Thus, they are also more exposed to climate impacts.</li> </ul>
Industry sector	<ul style="list-style-type: none"> <li>The risk arises from climate impacts on the performance of industry sectors, which may affect the financial capacity of businesses to repay their loans or pay out dividends.</li> <li>Climate-sensitive industry sectors such as consumer staples may be more negatively affected by the direct impacts of climate change (drought, flood and storms).</li> <li>Climate-related policies, the political agenda and changes in consumer behaviour as a result of climate change awareness can lead to growth in some industry sectors and a decline in others.</li> </ul>
Country	<ul style="list-style-type: none"> <li>The risk arises from the ability of a country to manage climate change impacts. This results from the interaction of a range of factors: geographical location, wealth, governance, state of infrastructure and ecosystem resilience.</li> <li>Businesses located in more vulnerable countries (countries in Africa, South Asia and South America) are more likely to be affected by climate change impacts compared to those located in less vulnerable countries (countries in Europe and North America). These countries also tend to be middle- and low-income countries.</li> </ul>

**Source:** Mercer (2015).

**Notes:** Asset classes are groups of investments that have similar financial characteristics, similar reactions to market conditions, and are subjected to the same laws and regulations. The three main asset classes are equities (stock), bonds (fixed-income) and cash equivalents (money market instruments). Real estate, commodities and derivatives are also considered asset classes. Growth assets such as equity and real estate tend to have higher levels of risk and higher returns over long investment time frames. Defensive assets such as bonds and cash tend to have lower risk and lower returns over long-term investment time frames.

Flood risk is also a consideration for commercial property investment, particularly by institutional funds. Property represents about 4% of investments managed in the UK, equivalent to £157 billion. Although flood risk assessments are undertaken when first investing, an ongoing assessment of the properties' continuing risk is not conducted. Ongoing risks due to climate change, the impact of other developments, and catchment flood risks, are not considered and this could impact the attractiveness of properties to investors over time. The impact of the 2007 floods and a lack of evidence of flood risk assessment by commercial property investors raises the issue of due diligence when investing in property. However, there is no clear picture of where and how much investment could be at risk of flooding. There is a common false

assumption among investors that risk levels are unlikely to change and a reluctance to expose an otherwise hidden problem (Pottinger and Tanton, 2014).

Evidence from abroad suggests that access to capital can be particularly problematic in the aftermath of a disaster, if a bank has been directly impacted by the event or is revising its strategy. There is no evidence of this being an issue in the UK but it does apply to markets where UK companies operate. In a study conducted after Japan's 1995 and 2011 earthquakes, natural disasters were found to have negatively affected Japanese firms' access to capital (Hosono and Miykawa, 2014). Moreover, Collier (2014) provides information on lender behaviour under risk of natural disasters in Peru. The study found that damage from flooding led lenders to reduce their credit supply both when anticipating flood risks and following the flood damage.

### *Mortgage provision*

Mortgage lenders have a very long time horizon in terms of their exposure to any changes impacting their assets. There is anecdotal evidence that mortgage lenders have started to use insurance industry data and techniques to stress test their portfolios for exposure to extreme weather events (ClimateWise, 2015b), but this appears more of an exception than a rule, suggesting that the level of vulnerability in this sector is uncertain. The availability of insurance is an important aspect for lenders. Without insurance, property owners must assume financial risks, mortgages are difficult to obtain and properties are almost unsellable. Mortgage lenders require security (the borrower's home) that is likely to maintain or increase its value over a 60-year period (Council of Mortgage Lenders (CML), 2006). Any changes in the provision of insurance, induced by rising risk levels, create a risk to mortgage providers.

### *Insurance*

The insurance industry plays an important role in the UK economy. Services and products of UK insurers are directly and indirectly exposed to climatic risks both in the UK as well as abroad. This applies to those insurance arrangements that provide compensation for climate-related losses, such as flood insurance, business continuity or liability insurance, but it could also have broader implications for other lines of business (Prudential Regulation Authority (PRA), 2015). With London being one of the world's most important insurance markets, many global risk transfer products are underwritten by companies operating in the UK. The impact of climate change on insurers' risk profile, for both assets and liabilities, remains uncertain and hard to quantify (Ranger and Surminski, 2013).

The PRA published 'The impact of climate change on the UK insurance sector' report in response to a request from Defra to complete a Climate Change Adaptation Report, focused on insurance. Their report takes the form of an initial risk assessment and provides a framework for considering the risk and opportunities arising from climate change through the lens of the PRA's statutory objectives in relation to insurers - the safety and soundness of firms and appropriate protection of policyholders. Box 6.8 sets out key points from the PRA's 2015 adaptation report on the insurance sector.

**Box 6.8.** Key points from the 'The impact of climate change on the UK insurance sector' report, compiled by the Prudential Regulation Authority/Bank of England, 2015

- Physical risks of climate change may disrupt current insurance arrangements and create issues for public policy, for example planning and development.
- The three primary climate impact risks to the insurance sector are:
  - Physical risks, which have real-economy effects and material impact on global stock of manageable assets.
  - Transition risks (risks arising from a transition to a lower carbon economy), which may impact those insurers who invest in carbon intensive assets.
  - Liability risks (parties who have suffered loss and damage from climate change), which can be more disruptive than individual extreme weather events.

There is potential for climate change to present a substantial challenge to the business model of insurers through an increasing correlation between weather-related events, as well as increasing correlation between different categories of risk, that could be affecting both the liability and asset sides of the balance sheet, as well as wider market-related impacts relevant to a broader set of investors.

The impact of physical risks arising from climate change on investment portfolios and policyholders is likely to be of particular relevance to life insurance firms. This is both through life insurers' assets, such as investments in real estate, and threats to liabilities through increased morbidity and mortality from severe heat waves, and other indirect impacts of rising temperatures such as an increase in vector-borne diseases.

Discussions identified a potential timing mismatch between one-year insurance contracts and long-term real estate investment, which could become increasingly exposed as insurers re-price on an annual basis, or possibly withdraw coverage.

There is clearly a conflict of views within firms. On the one hand, insurance underwriters correctly view the one-year nature of contracts, and the ability to re-price or withdraw, as an important factor in mitigating the longer-term impacts of climate change. On the other hand, real estate investment teams within insurance firms view access to affordable insurance as an important protection against deteriorating weather-related losses.

The PRA's general view is that firms are reasonably well-equipped to manage the current level of physical risks from climate change; action by insurers that may reduce the risks to the industry include:

- (i) Considering multiple perspectives on risk, including the use of stress and scenario testing.
- (ii) Building close links within the academic community, incorporating the latest scientific evidence into their assessment of risk, including the possibility of more sudden and severe changes in climate.
- (iii) Considering appropriate governance of climate change risks, including discussion at emerging risk committees, assigning senior management oversight and the merits of in-house environment committees.

**Source:** PRA (2015).

Flood insurance is one area where the challenges of adjusting products and services to new risk trends are most visible for the UK. Flood insurance is often regarded as a technically challenging type of insurance due to a lack of accurate assessment of exposure, difficulty in estimating the probability of occurrence of an event and potential losses faced (Botzen et al., 2009; Swiss Re,

2012). Rising losses and increased volatility can affect the fine balance between affordability and profitability, as already seen in many established markets, where existing flood insurance schemes are being reformed to better cope with growing losses. In extreme cases, this could lead to insurers withdrawing from certain markets and regions. Flood insurance may be used to reduce direct risk; by advancing the understanding of cost and benefits of adaptation measures, enhancing further risk knowledge exchange by closer collaboration between industry and government, as well as a clear emphasis on avoiding moral hazard through insurance (Surminski et al., 2016; Surminski, 2014).

A key risk for insurers arises from the inability to anticipate the scale of climate change through existing risk assessment models and techniques. Current probabilistic catastrophe models use modelled data built on observed trends to forecast risk exposure. Climate change trends may be implicitly built into catastrophe models, given the heavy use of historical data in constructing them. However these trends are not necessarily explicitly incorporated into the modelling output (Lloyds, 2014). Uncertainties associated with the estimation of the extent and frequency of the most extreme events means that the climate change impact can be difficult to account for in risk models. Box 6.9 explains how climate change means that past losses are likely no longer a reliable way of estimating future losses.

### Box 6.9. Flood risk modelling for insurance

Given that the record of loss experience is insufficient to understand the full distribution and scope of potential catastrophe losses, the insurance industry relies on models that contain a virtual catalogue (such as 10,000 or 100,000 years) of potential catastrophes. The models are intended to answer key questions of relevance to insurance around risk pricing, strategies for risk diversification and capital requirements. Most such models used by insurers and reinsurers are developed by private catastrophe modelling companies that employ large teams of scientists, mathematicians and engineers and then license the risk modelling software. Each extreme event is simulated across its hazard footprint (which for flood might be the water depth at each location). Based on the insured assets (such as buildings or business activity) in the path of the hazard, and the assessed vulnerability of those assets to the peril, the model outputs the losses and the loss exceedance probability statistics. Some of the principal outputs of these models are:

- For each location and building type at that location, what is the technical premium of flood insurance? This is the sum of the annualised cost of each potential future flood (e.g. each loss multiplied by its respective probability).
- Insurance depends on the potential to diversify portfolios of risk. The role of the model is to provide an environment in which to identify these opportunities for diversification. For example, storm surge flooding may have limited correlation with inland flooding, while inland flooding on a major river artery (that responds to a week or more of elevated precipitation) may not correlate with flash 'off-floodplain' flooding that is the result of an intense rainfall event that only lasts hours. To make it possible to explore risk diversification, the full footprint of each simulated flood 'event' is stored in the model, so that it becomes possible to explore the degree to which losses at multiple locations are correlated across all the events in the model. What constitutes a flood 'event' will also need to include the temporal definition of the loss, which may be based on an 'hours clause' definition provided by a reinsurer, such as the maximum loss over a 168 hour or 504 hour period.
- How much capital does the insurer need to hold to withstand an extreme loss at some regulatory probability, such as a 1-in-200 year loss scenario? This extreme loss will typically be the aggregate loss to the whole portfolio, involving multiple perils as well as multiple event losses of the same peril, such as several flood events across a season. As the very large majority of contracts written by the insurance industry only last for a single year, the focus of these catastrophe models concerns the question of the current level of hazard and risk. Supplied with the appropriate information on how the activity and severity of the hazard, or the underlying exposure and vulnerability is expected to change, it becomes possible to simulate the losses to be expected at some time in the future (along with the inevitable uncertainty in this projection). For example the hurricane and storm surge models developed by the risk modelling company 'Risk Management Solutions' were used to explore the future costs of US hurricane wind and storm surge losses to 2100 (Risky Business, <http://riskybusiness.org/>).

**Source:** CCRA2 Evidence Report authors.

Ipsos Mori (2015) for Defra found that uptake of commercial flood insurance is extremely high. The vast majority (95%) of small businesses arrange commercial insurance cover for their premises, and almost all of these (97%) did not experience difficulty in securing this insurance. Some businesses need to take out insurance as it is a legal requirement; however, there are few businesses for which this is the only reason. Many value the peace of mind and protection from significant loss that insurance provides. A significant price rise to the extent it becomes unaffordable was the only circumstance in which some thought they might stop getting

insurance. Awareness of flood risk, and the potential impact of flooding for businesses, appears to be limited. Even among those who are aware of their flood risk status, it is rare for this to cause problems in getting insurance. The businesses interviewed that were at risk of flooding had not installed flood protection measures in response to this status.

In line with Ipsos Mori (2015) for Defra's findings, other research suggests that access to flood insurance may be a problem for a minority of businesses. Based on an online survey of 1,200 small business members, the FSB found that 9% in flood risk areas reported difficulties accessing flood insurance and 6% reported that they have been refused cover. This equates to around 75,000 smaller businesses across the UK facing difficulties in finding affordable insurance and 50,000 being refused. Therefore access to flood insurance for small businesses appears to be an issue at only the margins currently, but there is the potential for this issue to affect a higher proportion of businesses due to future climate change.

There are isolated examples of the problems that adverse weather can create for smaller businesses in accessing insurance. Ingirige and Russell (2015) surveyed seven small firms in a single street in Braunton, Devon, an area which experienced several flood events over the last few years. The authors observed that:

- There was no consistency in the way people obtained flood insurance.
- There was a lack of knowledge on the role of insurance.
- There was a lack of awareness of the difficulties that insurance might present within the context of flooding.

The impacts of a severe flooding event on the seven firms' insurance varied:

- Two businesses had their excess increase from £200 and £500 to £10,000.
- Two businesses had their future excess changed from a fixed amount to a percentage of future flood damages.
- Two no longer have insurance which covers damage or losses as a result of flooding due to the increase in premiums.
- One had little change in their insurance details and received reasonable support.

### *Funding adaptation action*

Financial capital is projected to be a key input for successful planning and implementation of adaptation (IPCC, 2014). In the UK there is evidence that some companies experience difficulties in accessing finance for implementing their own adaptation and resilience measures. The water, energy, airports, rail and telecommunications sectors can be susceptible to regulatory restrictions that prevent investments in resilience to varying degrees. Reports from the English water sector have identified climatic and regulatory scenarios that could place a substantial strain for access to finance for water companies. For example, Southern Water states in their 2014 – 2015 annual report that significant changes in interest rates or a reduction in the availability of credit to the water industry could put their ability to efficiently finance their capital investment programme at risk in the future. Anglian Water, in turn, has published a Strategic Direction Statement 2010 – 2035 in which the company identifies the impact of climate change as "the biggest risk to our business over the next 25 years." Therefore, they recognise they must



“adapt the way we operate to maintain the level of services our customers expect of us, for example, by storing more winter rainfall for summer use, by groundwater recharging and by more sustainable drainage schemes” (Anglian Water, 2007).

There is also evidence that investment in adaptation appears less attractive to funders because of the uncertainty, magnitude and time horizon of climate impacts, often lacking immediate demonstrable benefits (West and Brereton, 2013; IPCC, 2014). A study examining the risks and opportunities that the Scottish public sector actors face when attempting to secure capital for their adaptation activities finds that “legal barriers, lack of experience or guidance and lack of capacity” may restrain accessing appropriate finance for resilience and adaptation projects (Roelich, 2015). The study suggests that many infrastructure and building activities fail to match the requirements of the forms of finance available: they can either be of an inappropriate scale or unable to guarantee financial returns in the short term.

### *Future*

#### *Banking and investment*

If banks start to internalise climate risks in their lending appraisals, it would have implications on the cost of capital for companies that are exposed to climate risks. Credit may become more expensive or limited for companies that are considered to be taking insufficient adaptation action (UKCIP, 2010). The extent to which businesses disclose the climate risks they are exposed to and how they are addressing these risks plays an important role, as banks will only be able to internalise risks with sufficient information. While there is little evidence that this is already being practised in the UK, there are signs that the financial market’s view of climate risk is changing. In anticipation of rising climate impacts the rating agency Standard & Poor’s have initiated the development of methodologies to systematically assess impacts of climate change and weather-related events on the creditworthiness, of businesses, as well as for risks to the creditworthiness of countries and sovereign entities or sovereign risks (Petkov et al., 2014; Standard & Poor’s Ratings Direct, 2014a, b, c, 2015).

CISL (2015) developed a new approach to understanding the short-term economic and financial impacts of climate risk in order to help investors identify how they could allocate capital to reduce their exposures to such risks over the next five years. Rather than focusing on the longer-term physical impacts of climate change, the study quantifies the potential financial impacts of a shorter-term shift in market sentiment about the future effects of climate change triggered by major policy agreements, technological breakthroughs or physical events themselves. Box 6.10 sets out the abstract of the executive summary from CISL (2015).

**Box 6.10.** Executive summary abstract from: '*Unhedgeable risk: How climate change sentiment impacts investment*', University of Cambridge Institute for Sustainability Leadership (2015)

Short-term shifts in market sentiment induced by awareness of future, as yet unrealised, climate risks could lead to economic shocks, causing substantial losses in financial portfolio value within timescales that are relevant to all investors.

Factors, including climate change policy, technological change, asset stranding, weather events and longer-term physical impacts may lead to financial tipping points for which investors are not presently prepared.

This research shows that changing asset allocations among various asset classes and regions, combined with investing in sectors exhibiting low climate risk, can offset only half of the negative impacts on financial portfolios brought about by climate change. Climate change thus entails 'unhedgeable risk' for investment portfolios.

While the response to action aimed at limiting warming below 2°C is shown to be negative in its short-term economic and financial impacts, the benefits of early action lead to significantly higher economic growth rates and returns over the long run, especially when compared to a worst-case scenario of inaction. The present study shows that certain types of portfolio benefit more than others.

Even in the short run, the perception of climate change represents an aggregate risk driver that must be taken into consideration when assessing the performance of asset portfolios.

**Source:** CISL (2015).

This research suggests what investors *believe* ('market sentiment', in the jargon) about the likelihood of different climate futures emerging can have material impacts in the short term. If such analysis is incorporated into investor decision-making, and risk mitigation strategies adopted to 'hedge' against the risk of shifts in market sentiment, the ease with which firms with greater exposure can access capital will be affected.

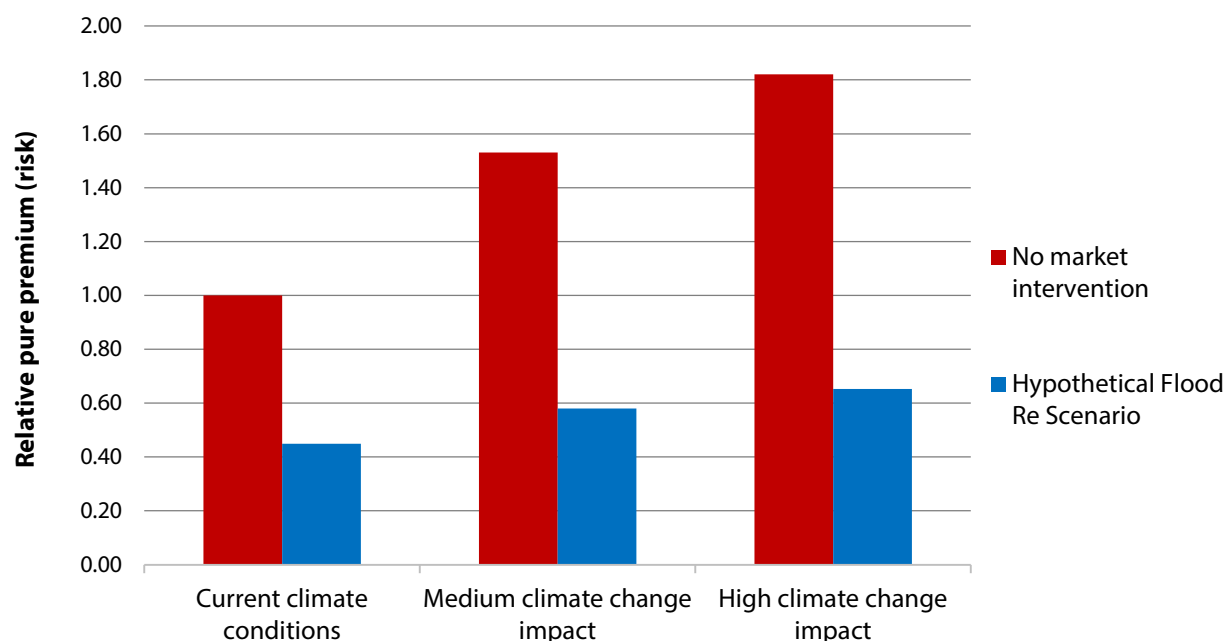
Examples of investor strategies that the research suggests are useful for hedging some of this risk include industrial sector diversification, investment in industries that exhibit few climate-related risks, or shifting to a portfolio with a higher percentage of fixed income assets. However, no strategy the research assesses is able to hedge more than 50% of the risk.

Equally, the research highlights that because investor confidence is central to the trajectory of economic growth, such shifts in market sentiment can affect access to capital more widely.

### *Insurance*

The impact of climate change on insurance provision is relatively well researched and assessed, and has gained increasing prominence within the sector, including a recent investigation from the regulator, the PRA. In their report, the PRA (2015) notes that "looking ahead, increasing levels of physical risks could present challenges, both to market-based risk transfer mechanisms and to the underlying assumptions behind general insurance business models". One example is the affordability of insurance. New research (Jenkins et al., 2016, cited in PRA, 2015) shows that climate change and socio-economic risk drivers are expected to widen the gap between 'affordable' flood insurance premiums and premiums that reflect the technical price of flood insurance (see Figure 6.5 below).

**Figure 6.5.** The pricing implications of climate change



**Source:** Based on Jenkins et.al. (2016), cited in PRA (2015).

Theory and evidence from existing insurance markets suggests that a “riskier and more uncertain world would be associated with an increase in insurance demand, at least until some local threshold were reached where the affordability of insurance or the insurability of risk were threatened” (Ranger and Surminski, 2013). However, the influence of climate change on insurance provision is expected to be multifaceted, complex and regionally variable, leaving those who provide insurance risk transfer with both risks and opportunities.

Increased losses from extreme storms and floods could raise the cost of financial capital and increase the volatility of insurance markets, if not properly anticipated. Risks to the UK insurance market include cash flow issues that could be caused by events that require large compensation pay-outs, potentially resulting in a capital shortage in the market (PwC, 2013). Research by the IPCC (Arent and Tol, 2014) suggests that more severe extreme weather events, and increased uncertainty, could result in higher insurance premiums and reduced cover with the insured, and the profitability of insurers losing out. In 2009, the ABI commissioned an assessment of the potential impacts that climate change could have on flood losses in the UK (MET Office and AIR Worldwide, 2009). Insured flood losses under a 4°C temperature rise in the UK could lead to insurance rate increases of 21%, and £1.9 billion could be added to the £5.9 billion capital requirement. Focusing on inland flooding and including both residential and business claims, this study found that by the 2080s:

- Annual insured flood losses could increase by 14% to £633 million (valid for a 4°C increase in global temperature).
- For 1-in-100-year-events, insured flood losses could increase by 30% to £5.4 billion (valid for a 4°C increase in global temperature).
- For 1-in-200-year-events, insured flood losses could increase by 32% to £7.9 billion (valid for a 4°C increase in global temperature).

And, for wind losses in the UK, they predicted that:

- Annual insured wind losses could increase by 25% to £827 million (valid for a slight southward shift in storm track).
- For 1-in-100-year-events, insured wind losses could increase by 14% to £7.3 billion (valid for a slight southward shift in storm track).
- For 1-in-200-year-events, insured wind losses could increase by 12% to £9.7 billion (valid for a slight southward shift in storm track).

Analysis by Aon Benfield (2015) also finds that weather catastrophe losses are on the increase, and are projected to continue to increase, in the future. The primary drivers of these increases are connected to economic growth. The value of insured assets is projected to increase as are the insurance premiums collected. Population migration to more coastal and more urban concentrations may also result in higher premiums. These effects account for about 85 percent of the loss trend. Additional factors, including weather and climate, contribute to the rest of the loss trend increase.

### 6.3.3 Adaptation responses and gaps for access to capital

#### *Banking and investment*

There are signs that investors are starting to consider a firm's ability to manage climate vulnerability in their finance appraisals, but it appears to be at an early piloting stage rather than common practice. The European Commission (2011) produced guidance on making vulnerable investments climate resilient. The Equator Principles is a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in projects. This framework enables lenders to internalise information on climate risk management, alongside information on social and environmental management. A range of supporting tools have been developed, to allow investors to assess potential impacts of climate change on a project or a business, for example UKCIP's BACLIAT framework. While some UK banks, such as Barclays and Lloyds, have adopted the Equator Principles, it remains unclear if and how climate risks are already factored in during a company's due diligence process.

More recently, legal firms have started to provide lenders with information about climate risks. In the UK, many legal companies emphasise in their reports that lenders ought to investigate the potential flood risk of their prospective property and consider these in their valuations (Maclay Murray & Spens LLP (MMS), 2013). The input from legal advisers could be seen as an early indicator that flood risk is gaining recognition in financial markets; however, it also highlights the potential business opportunities for advisory firms who might offer their climate risk advice to banks and lenders. A new financial model allows analysts to quantify corporate water risk and assess the potential impact of water stress on a company's credit ratios (Ridley and Boland, 2015). Fixed income analysts and portfolio managers can use the Corporate Bonds Water Credit Risk Tool to benchmark companies and assets in water-intensive industries, such as mining, power and beverages industries on exposure to water stress.

In an attempt to address the challenges that certain projects face in accessing finance for adaptation and resilience measures, new forms of finance are emerging. Green bonds are a case in point. Green bonds provide investment for projects that offer climate change solutions. They can be issued by governments, corporations and both international and domestic financial institutions, and are often held by investors that wish to devote their investment directly to

mitigation and adaptation projects. They can be made more attractive than standard bonds through tax incentives, which effectively lead to a lower interest rate (Climate Bonds Initiative, 2015a). The Climate Bond Initiative, an international non-profit that promotes the development of the bonds, has developed a climate bond standard to guarantee that the bonds target climate change and resilience projects (Climate Bonds Initiative, 2015b). Companies may see opportunities to sell and develop products and services needed in climate change solutions. For some projects, green bonds may not be a relevant source of finance, (Roelich, 2015). Another way of raising additional capital for resilience measures could be by extending Social Impact Bonds (SIB) to address adaptation (Roelich, 2015). SIBs are a form of finance that drives investment in preventative activities to improve social outcomes. They are performance-based and paid only when the desirable outcomes are achieved. The financial return to the investor thus depends on scale of the outcome: the greater the demonstrated improvement, the greater the financial return (Bridges Ventures, 2014). Roelich (2015) identified SIBs as a potential source of finance for Scottish infrastructure and building projects, and suggests that Scotland should examine the possibility of applying the SIBs to adaptation work.

This observation is supported by evidence from businesses that are seeking capital. Among other risk factors related to climate change, CDP also includes a section on access to capital in their reporting system. Although specifically asked about risks related to 'reduction in capital availability', none of the companies involved reported having considered potential limitations to their access to capital (CDP, 2012). In contrast, a report on private sector adaptation in Canada references some cases where demonstrating adaptation strategies was a prerequisite for accessing capital for private sector companies (National Round Table on the Environment and the Economy and Network for Business Sustainability (NRTEE and NBS), 2011).

However, many financial services companies have not assessed the risks from climate change to their investments. A survey commissioned by the Global Investor Coalition on Climate Change found only one-half of asset managers that responded to the survey had conducted a climate risk assessment of their portfolios. Similarly, a survey of 34 pension funds by the Asset Owners Disclosure Project found limited evidence of action being taken to assess and manage risks from climate change. In that survey, 24 of the pension funds were awarded the lowest two markings for disclosure, suggesting they had provided no or only some information on how they were managing climate risks. This may be a result of companies not disclosing this information if it is viewed as commercially sensitive.

### *Insurance*

The insurance industry has adopted a public advocacy and outreach role on climate risks. This is through sector initiatives such as ClimateWise, the Principles of Sustainable Insurance, the Chartered Insurance Institute, the Geneva Association and national trade bodies, as well as through the activities of individual companies such as adjusted products that offer incentives to policy-holders who invest in risk mitigation measures (Herweijer et al., 2009). The ABI has pointed out that demand for climate research and modelling by insurance companies could increase, as this can help governments and businesses understand their climate risk and identify actions to reduce their exposure (ABI, 2015). One example is the insurer QBE insurance encouraging SMEs to have flood plans (QBE Insurance, 2014). The industry has responded to the challenges of modelling future scenarios incorporating climate change, by focusing on improving the underlying risk data and their modelling capacity, often in close collaboration with public authorities. An example of this is the engagement of the ABI with public bodies such as the Environment Agency to improve the quality of flood maps in the UK.

Some UK insurers are reviewing their underwriting practice not just for residential, but also commercial customers in light of recent flood experiences. For example, the UK insurance company LV= has developed an equity release lending policy explicitly stating that they will not insure property that has suffered from damage due to environmental flooding in the past 15 years, and that they now map the flood risk of a subject property in their appraisal processes (LV=, 2015). In addition, the government and ABI have negotiated a new agreement for flood insurance in the residential sector, with the pool 'Flood Re', developed as a means for the insurance companies to protect themselves against large-scale damage from flooding to underwritten properties, while at the same time securing affordable cover to those at risk. This new scheme can be seen as a response to growing flood risk; however it is unclear if and how Flood Re has considered climate change in its risk assessment as well as design. In fact the government led impact assessment for Flood Re specifically excludes climate change from its calculation of future flood risk (Surminski and Eldridge, 2015). In a report published in 2014 Lloyds' of London acknowledges that catastrophe models used to consider UK flood risk do not explicitly model the impact of future climate change (Lloyds, 2014).

Overall the insurance industry is believed to have a very high adaptive capacity – primarily because of its experience with uncertainty, complex risks and the flexibility to review terms and conditions on an annual basis. As availability and affordability of insurance is important for businesses any changes to insurance provision is likely to have impacts on those sectors and their financial resilience (as reported above). The PRA's general view is that firms in the UK are reasonably well equipped to manage the current level of physical risks from climate change, however the regulator also warns against complacency (PRA, 2015). The insurance and financial services sector represents one of the largest climate change adaptation sectors in the UK, as measured by the number of jobs in the sector in 2011/12 (European Commission, 2014). Research by GHK (2010), a consultancy, identified key strengths that the industry can build on as: the existence of specialist firms across the value chain; a strong public/private research base; expertise in risk analysis; and an already existing diverse range of innovative products and existing expertise in communicating risk to consumers. PRA (2015) proposed certain actions as ways of reducing the industry's exposure:

- considering liability risks that may arise from 'failure to adapt' and 'failure to disclose' cases, as well as 'failure to mitigate';
- examining policy wording for potential exposures to future climate change claims, particularly for contracts written on a 'losses occurring' basis; and
- maintaining a forward-looking approach to managing risks in this area, including horizon scanning for potential climate litigation lawsuits and other evolving developments.

Several reports highlight opportunities for the insurance sector (K-Matrix, 2013; PwC, 2013; and GHK, 2010), such as increasing demand for reinsurance products, new products such as weather-indexed crop insurance and CAT Bonds. The industry is also investigating new approaches to flood insurance, here in the UK and elsewhere, with British insurers scoping business opportunities in emerging markets and those parts of the world with little insurance penetration. The industry itself is investigating this through a wide range of research collaboration. For example, through research groups such as ClimateWise, Willis Research Network, and the Geneva Association's research program. The Geneva Association investigated the consequence of climate change on risk profiles in its investigation of the warming of the oceans and the implications that may result for the (re)insurance industry (Geneva Association, 2013).



Internationally a number of UK-based insurers and reinsurers are involved in climate-related insurance solutions in developing countries: such as regional risk pools such as the Caribbean Catastrophe Risk Insurance Facility, African Risk Capacity, and Pacific Catastrophe Risk Assessment and Financing Initiative, as well as microinsurance and agricultural insurance. For all of those schemes there is limited evidence on if and how climate change has been accounted for when assessing current and future risks and calculating premiums. While private insurers have the ability to adjust pricing and underwriting on a yearly basis, there are significant reputational risks attached to a potential 'walk away' from these often high-profile pilot projects in developing countries (Surminski et al., 2016).

### 6.4 Climate risks and opportunities for workers and labour productivity

This section investigates the implications for the workforce in terms of higher temperatures in the working environment and disruptions from extreme weather.

#### Key messages

##### **Bu5: Risks to business from reduced employee productivity, due to infrastructure disruption and higher temperatures in working environments**

- Workers engaged in particular sectors or occupations, for example heavy outdoor manual labour, are likely to be at the greatest risk of heat stress.
- The limited evidence available suggests sustained periods of higher temperatures, for example the 2003 heatwave, result in large losses for the UK manufacturing sector.
- Very few studies have considered the impacts of higher temperatures on productivity in the UK and so there is considerable uncertainty about the magnitude of impacts.
- There is a lack of understanding around the effectiveness of planned or autonomous adaptation to manage the risk of higher temperatures, including the role of workplace temperature guidance.
- Extreme weather events can impact on productivity through denying workers access to sites, preventing them from working remotely, or causing them to have to take leave to deal with problems at home.
- A common response to extreme weather events from businesses is for staff to work remotely, which highlights business' dependency on resilient ICT and electricity infrastructure.
- Most businesses who have BCM plans report a wide range of benefits. However, many businesses do not develop these until affected by an extreme weather event. Smaller businesses in particular are less likely to have BCM plans.

#### 6.4.1 Policy framework

General policies and programmes related to promoting awareness of climate change risks and opportunities, including in the context of workers and productivity, are discussed under Section 6.2.1.

Key policy for climate risks and opportunities for employees and labour productivity relates to temperature in the working environment, for which the Health and Safety Executive (HSE) provide guidance (HSE, 2016).

*“Temperatures in the indoor workplace are covered by the Workplace (Health, Safety and Welfare) Regulations 1992, which place a legal obligation on employers to provide a ‘reasonable’ temperature in the workplace.*

*The **Approved Code of Practice** suggests the minimum temperature in a workplace should normally be at least 16°C. If the work involves rigorous physical effort, the temperature should be at least 13°C. These temperatures are not absolute legal requirements; the employer has a duty to determine what reasonable comfort will be in the particular circumstances.*

*A meaningful figure cannot be given at the upper end of the scale due to the high temperatures found in, for example, glass works or foundries. In such environments, it is still possible to work safely provided appropriate controls are present. Factors other than air temperature, i.e. radiant temperature, humidity and air velocity, become more significant and the interaction between them become more complex with rising temperatures.*

*In addition to the Workplace Regulations, the Management of Health and Safety at Work Regulations 1999 require employers to make a suitable assessment of the risks to the health and safety of their employees, and take action where necessary and where reasonably practicable.*

*The temperature of the workplace is one of the potential hazards that employers should address to meet their legal obligations. Employers should consult with employees or their representatives to establish sensible means to cope with high temperatures.”*

### 6.4.2 Current and future risks from higher temperatures in working environments

#### *Current risk*

The risk of overheating in a work environment is not just a function of temperature, but also of humidity, air speed, clothing and the activity of workers. Workers engaged in heavy outdoor manual labour, particularly in the agriculture, construction and heavy industry sectors, are likely to be at the greatest risk of heat stress. Employees working in offices built in the 1960s and 1970s could also be at risk of thermal discomfort. These types of building typically have poor ventilation systems and are often high-rise properties with single glazed windows that maximise solar gain (UKCIP, 2005). Modern factory buildings, due to their design characteristics, are more vulnerable to climate change, through increased ambient air temperatures, and reduced cloud cover (increasing UV radiation), as well as heat created by plant and machinery, IT equipment and lighting (Baglee et al., 2012).

Past events suggest extreme outdoor temperatures can have significant effects on production. The 2003 European heatwave is estimated to have resulted in a loss in manufacturing output in the UK of £400 to £500 million (2003 prices) (Martin et al., 2011). Other quantitative cross-country analyses (Park, 2015; Yildirim et al., 2009) have found a general negative relationship between labour productivity and temperature.

Baglee et al. (2012) attempted to quantify the impact of overheating on employee productivity in the UK by drawing on work by Capon and Oakley (2012) and data from the Inter-Departmental Business Register. Their analysis considered the number of days per year when the temperature exceeded a certain threshold by region. Using a 26°C (or 28°C) threshold, approximately five (or three) million staff days were lost in 2010, which is 0.1% (or 0.06%) of the staff time available. Based on an average staff cost of £150, this resulted in a loss of £770 million (or £460 million) for 2010.

Alshebani and Wedawatta (2014) highlight greater risks to the construction sector because of its specific characteristics and working practices. Hot weather can result in drier soils, and in turn more dust. The HSE has an information sheet on the risks to employee health from dust, which include life-changing lung diseases (HSE, 2013). Dusty conditions may also affect filters on vehicles, machinery and equipment. Premature breakdowns can occur and then delay projects. Hot and dry weather conditions can cause the water in concrete and masonry to evaporate too fast, resulting in lower quality products. Due to the physical activity associated with construction work, construction workers may risk being dehydrated in hot conditions. Decreases in productivity may be accompanied by worker absenteeism and turnover Crissinger (2005).

### *Future risks*

By the 2040s, half of all summers in Europe are expected to be as hot, or hotter, than in 2003 (Stott et al., 2004). Therefore, without further adaptation, similar losses to those seen in the 2003 heatwave may become more frequent.

OECD (2015) highlights that projected impacts on health such as mortality from heat exposure, morbidity from heat and cold exposure, and mortality and morbidity from infectious diseases, cardiovascular and respiratory diseases, may in turn lead to declines in labour productivity.

Baglee et al. (2012) project the increase in hot days to the 2080s. Using the same methodology as for their estimates of present day impacts and scaling up, this results in a cost of £3.6 billion by 2080 (medium emissions, central estimate), with a range of £1.1 to £15.2 billion (low emissions, lower estimate to high emission, upper estimate).

### **6.4.3 Adaptation responses and gaps from higher temperatures in working environments**

Businesses have an obligation under the health and safety at work regulations to ensure workplaces are adequately ventilated and temperatures during working hours are reasonable. To support businesses in meeting this requirement, the Health and Safety Executive has published workplace temperature guidance. This was simplified as part of the NAP (ASC, 2015).

Although there is now an understanding of the types of industries at risk, only a few studies have considered the impacts of heat stress on productivity in the UK. There is a lack of understanding around the types of employment at greatest risk, and the effectiveness of planned or autonomous adaptation to manage these risks, including the role of workplace temperature guidance (ASC, 2015).

The Chartered Institution of Building Services Engineers (CIBSE) organised an overheating task force. This was in response to the challenge of building comfortable, low-energy buildings. For example, increasing indoor winter temperatures can lead to lightweight, highly insulated buildings that respond poorly in the summer. One of the task force's outputs was a technical memorandum to inform designers, developers and others responsible for defining the indoor environment in buildings about predicting overheating (CIBSE, 2013).

Changes to management standards could encourage more firms to consider the potential benefits from adapting to heat stress and other climate risks. Management standards provide guidance and models for businesses to follow based on international and expert consensus. There are a number of initiatives currently underway. For example, the ISO published an updated version of ISO 14001 in 2015, setting out the criteria and mapping out a framework that

a company or organization, regardless of activity or sector, can follow to set up an effective environmental management system. The revisions to the standard included:

- The requirement to consider environmental performance in strategic operations: how the environment will affect an organisation's operations, activities, products and services as opposed to simply looking at aspects and impacts from your activities on the environment.
- Increased senior management involvement: are senior management teams fully up to speed with environmental and sustainability matters relating to their organisation and its environmental management system?
- Giving consideration to risks and opportunities, i.e., climate change adaption and resource security and scarcity, and moving beyond standard aspects and impact assessments.
- Managing impacts across the whole value chain using a life-cycle perspective, i.e., giving consideration to the procurement of goods and services.
- An extension of the requirements to evaluate compliance, i.e., to specify frequency and show knowledge and understanding.
- Ensuring the quality and credibility of environmental information.

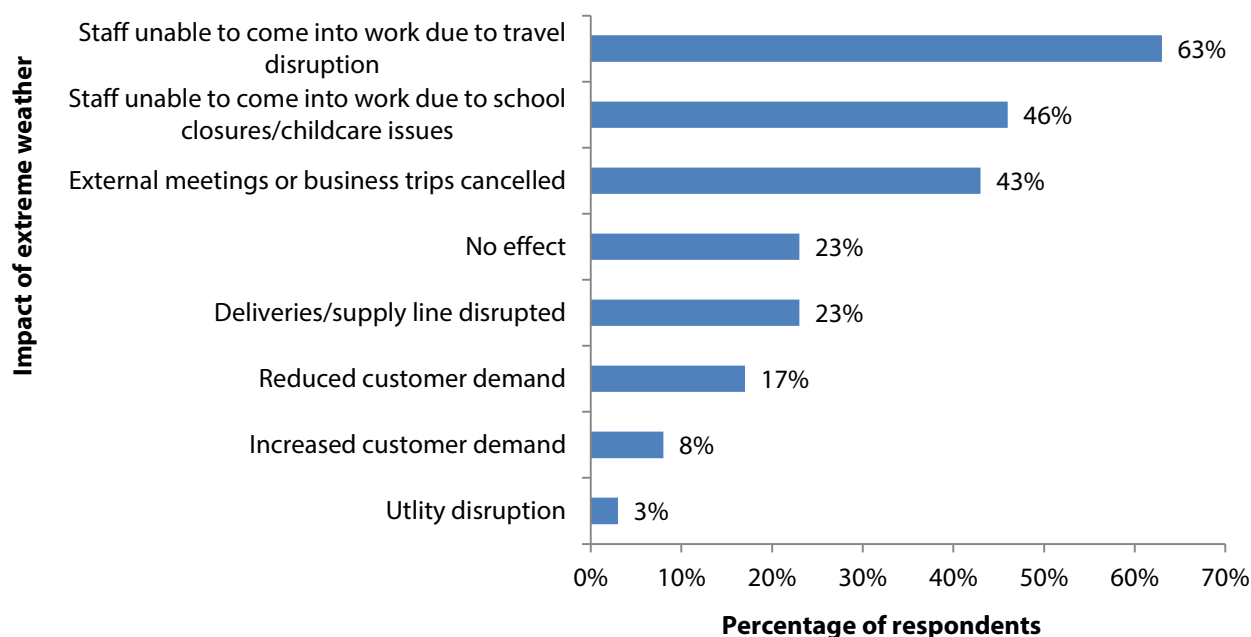
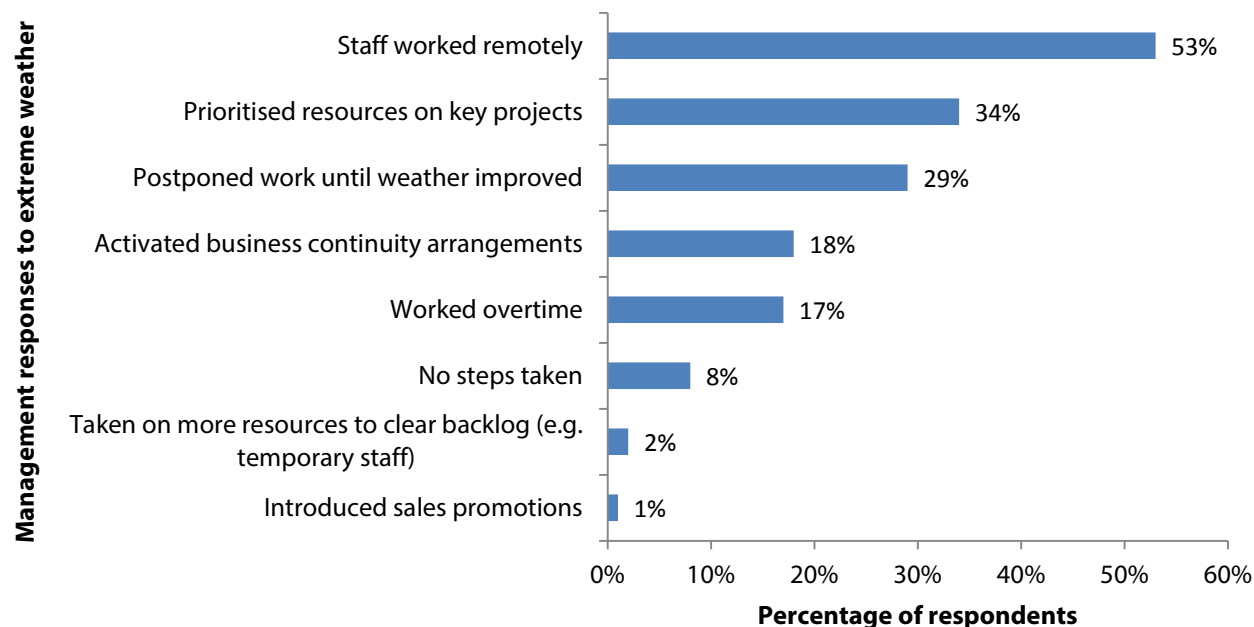
Companies will have three years to demonstrate they meet the new requirements. Around 16,900 businesses in the UK are certified to ISO 14001, and this number has been increasing at a rate of around 1,000 businesses per year (ASC, 2015).

### **6.4.4 Current and future risks for workers and productivity from extreme weather**

#### *Current risk*

Extreme weather events can affect workers and labour productivity through preventing employees from accessing a business site or working remotely if ICT infrastructure is disrupted, as well as through absenteeism if employees are directly affected. There are therefore significant crossovers with the resilience of ICT, electricity and transport infrastructure as discussed in Chapter 4 and with the impacts of extreme weather on people as discussed in Chapter 5.

According to survey research by the Chartered Management Institute (CMI, 2013), staff being unable to come into the office either due to travel disruption (63% of respondents) or school closures/child care costs (46%) were the most common impacts of extreme weather on surveyed organisations, followed by external meetings or business trips being cancelled (43%). The most common measures taken by surveyed organisations in response to extreme weather were to allow staff to work remotely (53%), to prioritise resources on key projects (34%) and to postpone work until the weather improved (29%). Figure 6.6 sets out these results in full.

**Figure 6.6. Organisational impact of extreme weather and management responses, 2013**
**Organisational impact of extreme weather**

**Management responses to extreme weather**


**Source:** CMI (2013).

**Notes:** The sample was selected from CMI's membership, with 25,000 individuals sent a link to the survey by email. A total of 637 responses were received. The sample group represents general managers across UK organisations, rather than those with specific responsibility for BCM. Only a sub-group including those managers who reported that their organisation has BCM were asked more detailed questions.

Resilient ICT and electricity supplies are critical for effective management responses to extreme weather events, particularly remote working. Baglee et al. (2012) assessed that major ICT disruption due to climate change is considered to be relatively low for large businesses. Risks for smaller companies could be greater, particularly if they are located in relatively remote areas where they may be dependent on single electricity and telecommunications connections. Many homeworkers depend on ICT infrastructure to allow them to work remotely. Of people in work between January and March 2014, 4.2 million or 13.9% were homeworkers (ONS, 2014), two-thirds of whom were self-employed. Homeworking was most prevalent within the agriculture and construction industries. It is not known what proportion of those classified as homeworkers would be affected by weather-related disruptions to ICT infrastructure.

However, in some cases responses such as remote working may not be possible and staff may be given or take leave. Using survey results from those living in flood risk areas in Scotland, Werrity et al. (2007) found that the mean work days lost by those affected ranged between 6 and 10 days depending on if annual, compassionate or unpaid leave was taken. The mean work days lost per household ranged from 0.7 to 1.4.

Localise West Midlands (2015) found that very few businesses reported impacts from staff being affected by the floods that hit the Calder Valley in June and July 2012, for example, taking time off to deal with a flooded home. The largest employer did report a small rise in sickness levels in the months after the floods. Of those surveyed, all of whom had experienced domestic flooding, 8% had taken time off work to deal with their own flooding situations.

Impacts on workers and labour productivity are likely to vary significantly among sectors and occupations. For example, businesses operating in the construction sector are considered particularly vulnerable to the impacts of extreme weather due to the nature of their operations (Mills, 2003). Research by Wedawatta et al. (2011) found that the most common effect of an extreme weather event on surveyed SMEs in the construction sector was non-attendance of employees (53%), followed by loss of sales or production, with roughly a third also reporting a reduction in employee productivity and disruptions to access to premises (33%).

### *Future risks*

We were not able to find useful evidence that considered future risks to workers and labour productivity from extreme weather events. Potential increases in exposure to and the frequency and intensity of extreme weather events mean the impacts discussed under *Current risks* may be experienced by more businesses and workers, or the same businesses and workers may experience these impacts more often. Key determinants of the future risk to workers and labour productivity are the resilience of ICT, electricity and transport infrastructure (Chapter 4) and the effects of extreme weather events on people (Chapter 5).

### **6.4.5 Adaptation responses and gaps for workers and productivity from extreme weather**

Business Continuity plans can help businesses and workers minimise disruptions to productivity from extreme weather events. They can also have a range of co-benefits to organisations besides improving business resilience (CMI, 2013):

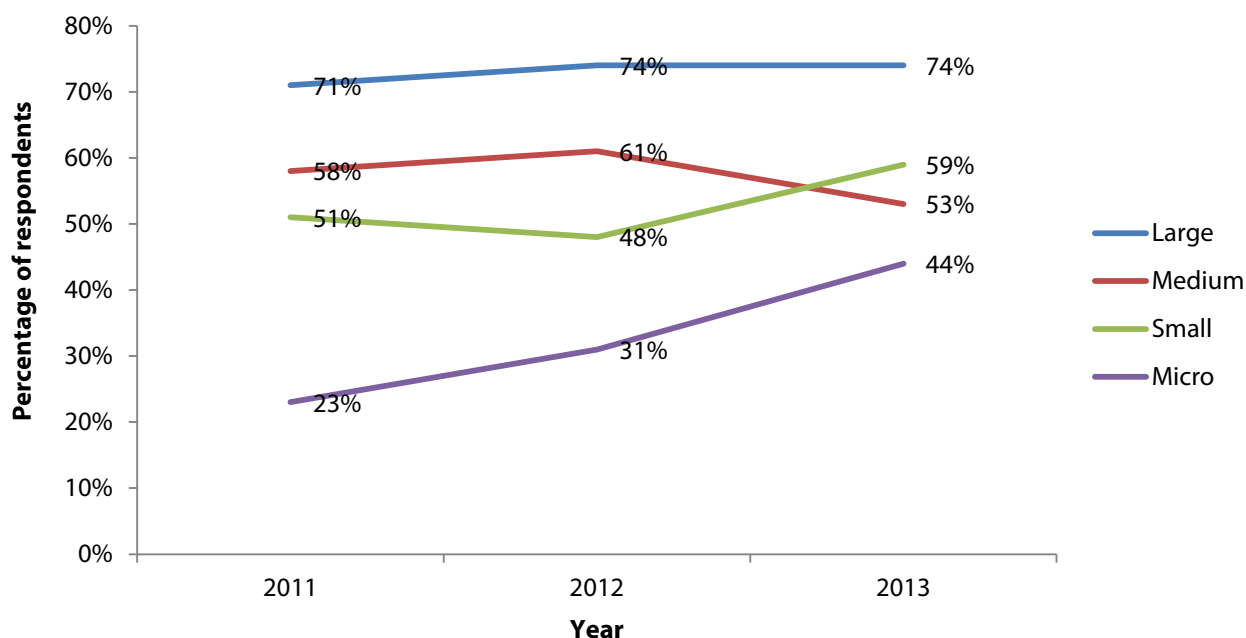
- reputation protection;
- customer retention;



- safeguarding staff;
- improved understanding of risk;
- fulfilling regulatory or statutory requirements; and
- safeguarding communities.

Around four-fifths of surveyed businesses reported one or more of these benefits. Despite this, significant numbers of businesses do not have BCM plans in place. Evidence suggests that in general the smaller the business, the less chance there is that they have a plan in place. Figure 6.7 sets out the percentage of surveyed businesses by size with BCM plans in place between 2011 and 2013.

**Figure 6.7.** Percentage of surveyed businesses with Business Continuity Management plans in place by size of organisation, 2011 to 2013



**Source:** CMI (2013).

**Note:** Based on the following definitions of organisation size: Micro = 1 – 10 employees; Small = 11 – 50 employees; Medium = 51 – 250 employees; Large = over 250 employees. The sample was selected from CMI's membership, with 25,000 individuals sent a link to the survey by email. A total of 637 responses were received. The sample group represents general managers across UK organisations, rather than those with specific responsibility for BCM. Only a sub-group including those managers who reported that their organisation has BCM were asked more detailed questions on topics such as its scope, its integration into the organisation and its effectiveness.

Evidence suggests that organisations often develop BCM plans only after they have been impacted by an extreme weather event. Extreme weather was the most commonly cited reason for activating a BCM plan, cited by 69% of managers surveyed with BCM plans in their organisation. In line with this finding, the most commonly cited reasons for not implementing a BCM were "We rarely get significant levels of disruption in our business", "We deal with disruption as and when it happens" and "Not a priority," respectively cited by 45, 43 and 37% of

surveyed managers without a BCM in their organisation. Therefore, BCM plans may increase in future as organisations become more likely to experience extreme weather events. However, the costs of these extreme weather events will be incurred when they could be avoided if BCM plans were established in advance.

As an example of adaptation responses to a particular event, a business support scheme was announced by the UK government at the beginning of 2014 in response to the flooding of that winter (HM Government, 2014). The scheme, worth up to £10 million, provided hardship funding for SME businesses in areas affected by the flooding. An initiative by Enterprise Nation, a campaigning voice for small business with the Government, brought together big businesses to offer assistance to small firms affected by the floods (Enterprise Nation, 2014). Pledges of support included:

- Vodafone donated 1,000 dongles to businesses that lost broadband which Royal Mail agreed to deliver.
- Toshiba donated a number of laptops and light bulbs to UK storm victims.
- Regus opened its 220 centres across the UK to offer free workspace until 21 February to business owners that needed space in which to meet clients and keep operating. Those who could not work in their normal location – whether an office or home – were given free access to the business lounge within any Regus centre, providing professional workspace, WiFi and complementary refreshments.
- Citrix offered free three months access to its ‘Go To Meeting’ product for businesses and workers who could not meet with each other or customers physically to at least communicate via the web.
- Call-answering service, Moneypenny, offered a free call pick-up service to allow businesses to focus on getting back into business, without worrying if calls were being answered.
- Constant Contact offered one free month access to its email service to enable businesses to maintain contact with customers.
- EDF Energy asked affected customers to make contact so they could make adjustments to usual payment terms and offer flexibility to those who needed time to pay.

While not necessarily linked to disruption from extreme weather events, increasing numbers of businesses have been offering workers the option of teleworking. The Confederation of British Industry and Harvey Nash (CBI and Harvey Nash, 2011) report that “Five years ago, just 13% of firms offered teleworking for employees in at least certain roles some of the time, but now nearly six in ten (59%) do so. This increase has been made possible by improved technology, allowing people to work more effectively away from the workplace. It is most common in the smallest firms (64%), where it offers the greatest business potential to reduce fixed costs.” While technology may allow this trend to continue there are reasons why the increase in home working may plateau, for example a perceived negative relationship between home working and productivity, and the suitability for particular occupations. The Advisory, Conciliation and Arbitration Service (Acas) has published guidance (2014) for employers and employees on when home working may or may not be beneficial. One of the stated benefits for employers is that “homeworkers can be less affected by bad weather or travel disruption.”

## 6.5 Climate risks and opportunities to supply chains and distribution networks

This section explores risks and opportunities to businesses from climate-related disruptions to domestic and international supply chains and distribution networks.

### Key messages

#### Bu6: Risks to business from disruption to distribution networks and supply chains

- Adverse weather is already one of the most commonly cited reasons for interruptions of supply chains. Increases in extreme weather events could see such disruptions become more frequent without further adaptation.
- Large amounts of freight are transported around the UK highlighting the importance to business of resilient transport infrastructure and ports.
- UK businesses' reliance on overseas markets as part of their supply chain makes companies vulnerable to climate change impacts abroad.
- Many large companies are considering the risks from climate change to their supply chains and distribution networks and collaborating with their suppliers. This can have positive wider effects and increases the resilience of smaller businesses in their supply chains.
- Smaller companies are less likely to take action to make their supply chain resilient even while acknowledging the risk of disruption from adverse weather.
- Despite the range of surveys and case studies, data are mostly limited to those reported by larger multi-national companies and it is difficult to evaluate the impact and effectiveness of existing adaptation measures, and existing guidance and tools.

### 6.5.1 Policy framework

General policies and programmes related to promoting awareness of climate change risks and opportunities, including in the context of supply-chains and distribution networks, are discussed under Section 6.2.1.

There is a specific objective in the UK NAP which relates to supply chains.

- **Objective 26:** To help businesses better understand and manage climate change risks to their supply chains.

BIS supports a range of sectors. This often includes investment in capital equipment, associated research and development and improved skills and training support. This type of support is often relevant to suppliers and supply chains that need to adapt to a changing climate.

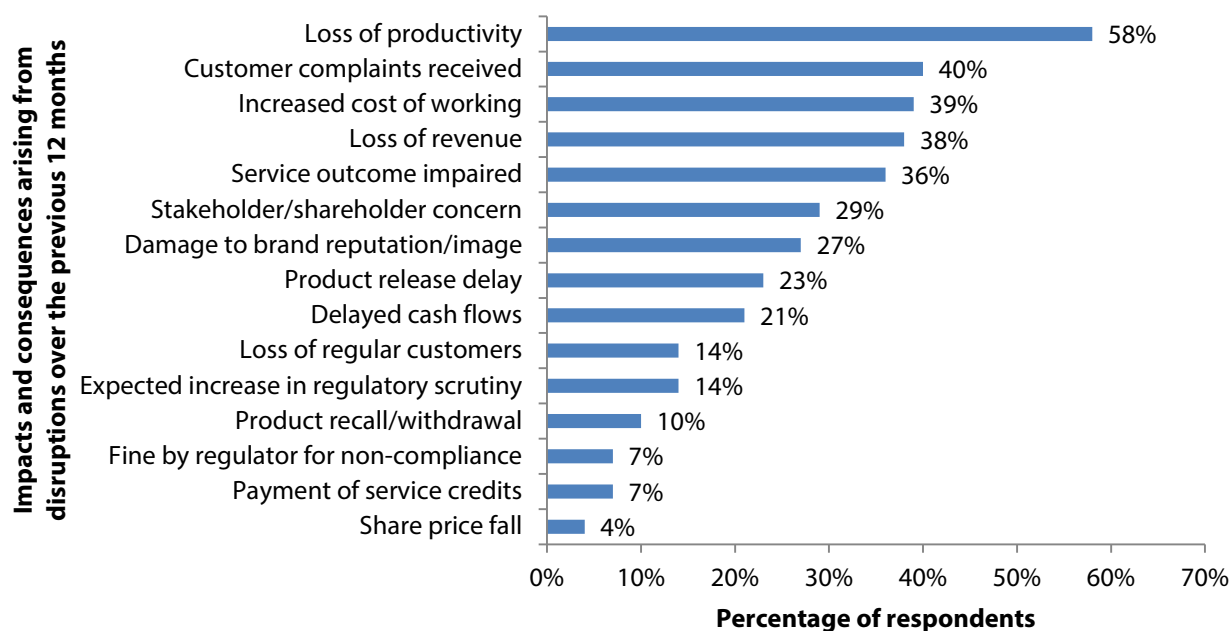
The Environment Agency's Climate Ready Support Service developed guidance to help UK businesses understand and manage domestic and international climate change risks to their supply chains, and has been working with a number of retail organisations to pilot the guidance and test how retail supply chains can be made more resilient.

## 6.5.2 Current and future risks for supply chains and distribution networks

### *Frequency and impact of supply chain disruption*

The Business Continuity Institute's (BCI) Supply Chain Resilience Report for 2015 found that adverse weather was the second most cited reason for supply chain disruption over the previous 12 months, with 43% of surveyed UK businesses reporting it (BCI, 2015). Disruption to supply chains can have various negative impacts. Figure 6.8 sets out the impacts arising from disruption over the previous 12 months as reported by surveyed UK and non-UK businesses. Impacts can be both short-term, like a loss of productivity, service outcome impaired and share price fall, and long-term, such as damage to brand reputation and image, expected increase in regulatory scrutiny and loss of regular customers. The numbers responding suggest that more than half the time, supply chain disruptions cause a loss of productivity, and more than a quarter of the time, they result in some damage to brand reputation and image.

**Figure 6.8.** Consequences of supply chain disruption



Source: BCI (2015).

### *Reliance of supply chains and distribution networks on transport infrastructure*

Growing interconnectedness means that certain types of sectors could be at high risk. For example, those sectors that use just-in-time production methods, trade in perishable products (for example, retail) or rely on a single port due to infrastructure reasons. Domestically, the effects of climate change on UK transport infrastructure are significant. Assuming no population growth and a continuation of current levels of adaptation, the length of railway line located in areas exposed to flooding more frequently than 1:75 years (on average) increases in the 2080s by 53% and 160% for a 2°C or 4°C scenario; the length of major roads by 41% and 120%; the

number of railway stations by 10% and 28%. The resilience of UK transport infrastructure is described in more detail in Chapter 4.

Road transport is the most used form of transport in the UK economy, with 87% of inland freight transport using the road network in 2014 (Eurostat, 2016). While motorways and trunk A roads are usually appropriately dimensioned (e.g. they have sufficient drainage capacity) to withstand weather events and climate extremes (ASC, 2015), secondary (B and C roads) might experience issues especially in relation to drainage and erosion. This results from differences in pavement design, characteristics, age and maintenance regimes between secondary roads and motorways. Between 2006 and 2014, 11% of road disruptions in England were attributed to weather-related incidents (ASC, 2014).

Rail transport is an increasingly important feature of freight transport in the UK. In 2011/12 rail freight transported 101.7 million tonnes of goods worth over £30 billion (Network Rail, 2015). Over the next decade, it is estimated that rail freight demand may grow by at least 30%, the equivalent of 240 additional freight trains a day, and by as much as 140% over the next 30 years (Network Rail, 2015). Between 2006 and 2013, 24% of rail disruptions in England and Wales were attributed to weather-related incidents (ASC, 2014).

In 2014, UK ports handled 503 million tonnes of freight (DfT, 2015), with approximately 80% of this being international traffic. In 2015, UK airports handled 2.3 million tonnes of freight, with London area airports accounting for around 79% of this volume (Civil Aviation Authority, 2015).

Chapter 4 describes risks to shipping, oil and gas and offshore renewable energy infrastructure, which may affect 'downstream' business operations and supply chains. Impacts on shipping and navigation, including ferry services that connect islands around the UK, could arise as a result of sea level rise, changes in high winds and wave action. Offshore infrastructure, including oil and gas production and distribution sites as well as offshore wind and wave generation are vulnerable to high wind speeds, large wave heights, strong currents, fog and lightning. This can cause disruptions to maintenance, operations and movements of supplies and personnel (HSE, 2005).

Landslide disruptions have been noted to block roads and cause disruption to business in Scotland. For example, the Stob Coire Sgriodain landslide in June 2012 resulted in a goods train being derailed. The British Geological Survey (2016) has also documented landslides in the past 10 years at Glen Ogle, Penicuik and the 'Rest-And-Be-Thankful Pass'. High tides and stormy seas can disrupt ferry services to islands for several weeks each year causing raw material delivery problems, fuel supply issues and difficulty in shipping finished goods.

### *International supply chains*

Through their international supply chains, UK businesses are exposed to extreme weather risks from around the world. The value of UK imports has risen from £150 billion in 1990 to £548 billion (nominal prices) in 2014 (ONS, 2016b). Exports have increased from £139 billion in 1990 to £511 billion (nominal prices) over the same time period. As a proportion of GDP, UK international trade (imports plus exports) increased from 47% in 1990 to 57% in 2015. This demonstrates that UK businesses have become increasingly exposed over the last 25 years through overseas markets as part of their supply chains and distribution networks. Table 6.6 sets out regional trade statistics for each UK nation.

**Table 6.6.** Regional trade statistics, 2005 and 2015 (£ billion)

Nation	Exports		Imports	
	2005	2015	2005	2015
England	159	211	224	335
Northern Ireland	5	6	4	6
Scotland	13	17	9	13
Wales	9	12	6	7

**Sources:** HMRC (2008) and HMRC (2016).

**Notes:** Figures are rounded to the nearest billion. Estimates for 2015 are provisional and subject to change.

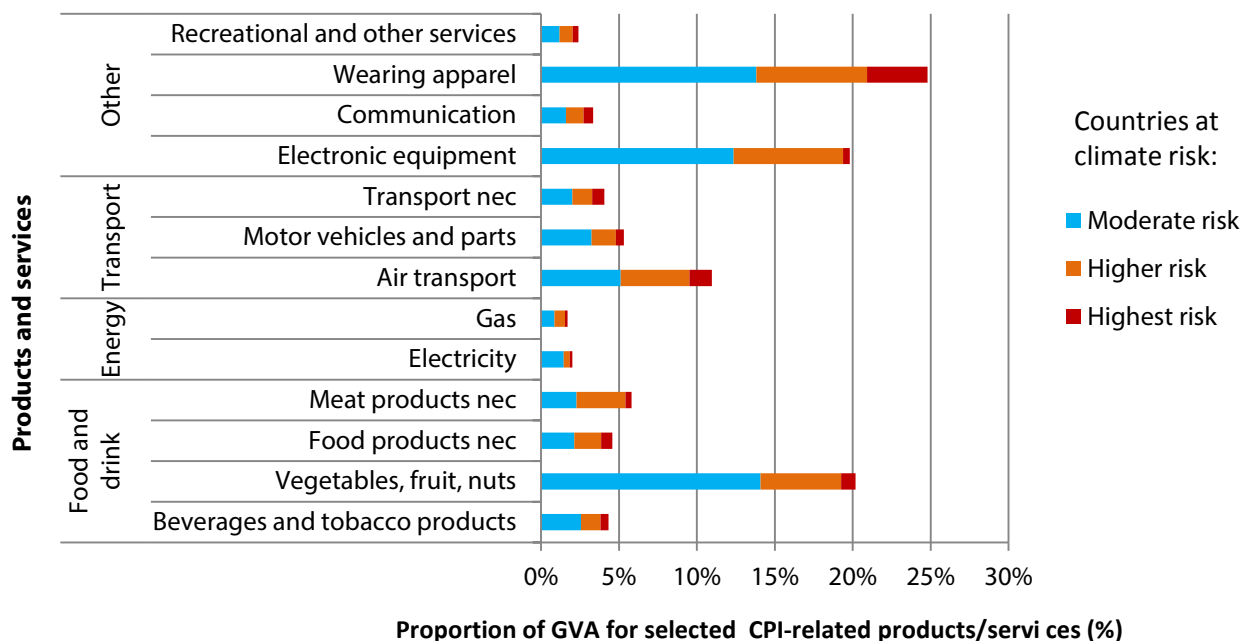
According to University of Leeds (2014), food, clothes and electronic equipment are important UK consumption goods, which appear to be at comparatively high risk from international supply chain interruptions. Figure 6.9 highlights the ‘embedded climate risks’ for a range of sectors. For each sector, the chart shows the extent to which UK consumption is reliant on countries likely to be among the most affected by climate change.

The largest climate risks to supply chains appear to be in the earlier stages of product manufacture. These tiers of the supply chain are less likely to be understood and managed by UK businesses. According to the analysis by the University of Leeds (2014), a larger proportion of value in the earlier stages of production is generated in countries that are at a moderate or higher risk from climate change. A survey of UK and non-UK businesses also suggests that disruptions in the earlier stages of supply chain are common. 50% of surveyed businesses stated that the predominant cause of disruption was with their immediate supplier, 21% with their suppliers’ supplier and 8% lower down the supply chain. However, 31% said they did not analyse their full supply chain to identify the source of the disruption (BCI, 2015).



**Figure 6.9.** Risks to the UK from disruption to international supply chains, 2014

**Gross Value Added (GVA) for products/services consumed in the UK arising from countries most at risk of climate impacts**



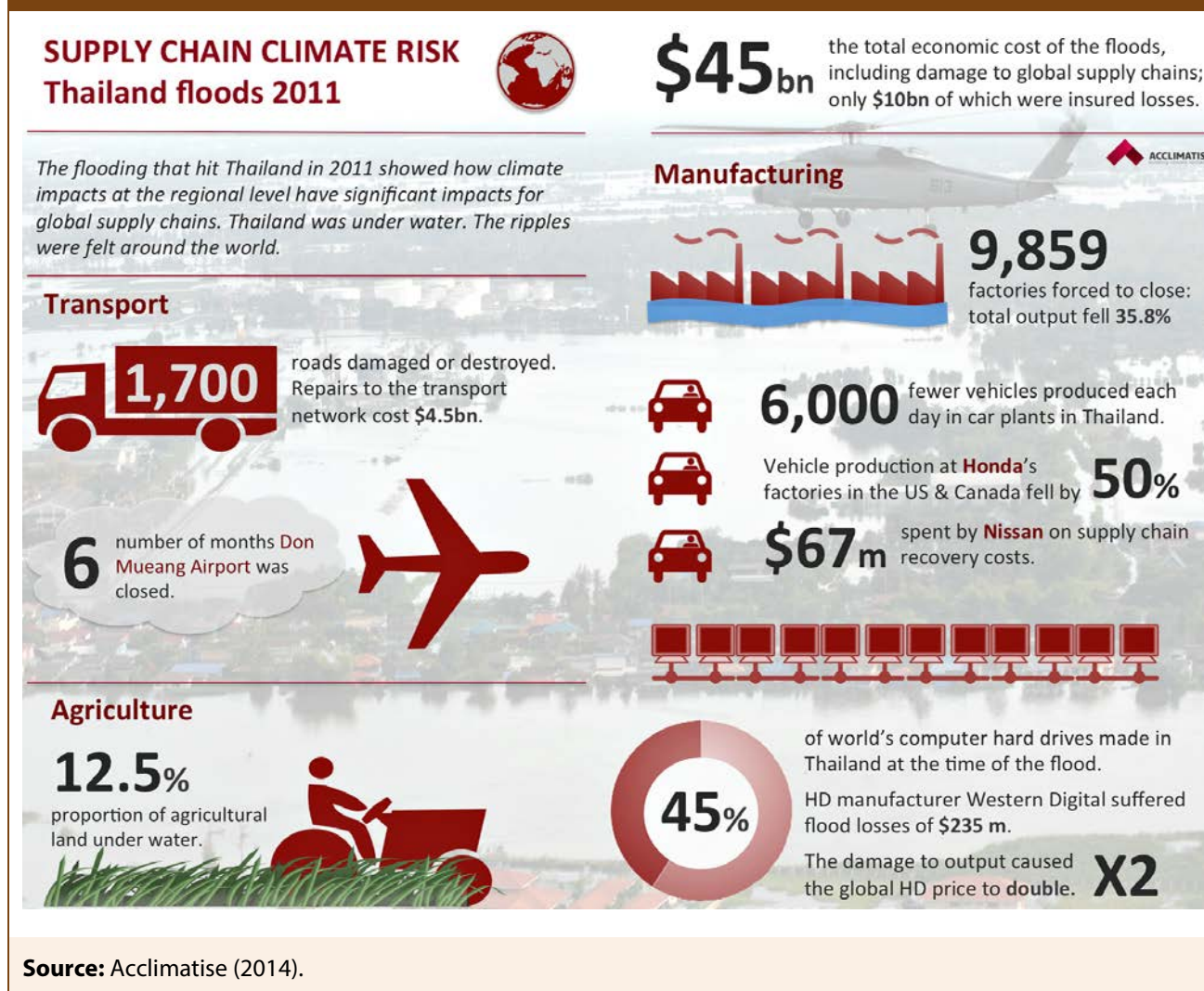
**Source:** University of Leeds (2014) for the ASC.

**Notes:** The figure shows the percentage of the total GVA for goods and services consumed in the UK arising in countries assessed as being more exposed or vulnerable to climate impacts than others. The goods and services listed are intended to align with those included in the calculation of the Consumer Prices Index (CPI). Together the goods and services shown form about 20% of total GVA from UK consumption. The risk assessment for countries is based on a number of indicators (see main text). Countries were ranked according to their average 'risk' score, and then divided into quintiles. The share of total GVA generated in the countries at highest risk (5<sup>th</sup> quintile), higher risk (4<sup>th</sup> quintile) and moderate risk (3<sup>rd</sup> quintile) are shown. Adjustments to some regions were made to reflect similarities in their average risk score. For example, the four advanced Asian economies of Hong Kong, Japan, Singapore and South Korea were aggregated to a group as they consistently were within the first quintile of countries at risk, unlike other Asian economies. As an example, the figure shows that approximately 12% of total GVA for electronic equipment bought in the UK is generated in countries assessed as being at moderate risk of climate impacts (that is, in the third quintile of all countries). 'nec' means 'not elsewhere classified'.

The Economist (2011) documented some of the implications for manufacturing supply chains from the 2011 Tōhoku earthquake and tsunami. It revealed the reliance of many firms on a few specialist suppliers. For example Mitsubishi Gas Chemical and Hitachi Chemical, controlled about 90% of the market for a specialty resin used to bond parts of microchips that go in to smartphones and other devices, while the compact battery in Apple's iPods relied on a polymer made by Kureha, which holds 70% of the market. It also noted how trends in leaner production techniques had resulted in firms becoming more exposed to supply chain disruption. "Over the past decade or so the just-in-time concept of having supplies delivered at the last minute, so as to keep inventories down, has spread down the global manufacturing chain. Now, say economists at HSBC, this chain may be fortified with 'just-in-case' systems to limit the damage from disruptions." Figure 6.10 is an infographic created by Acclimatise (2014) to show how

climate impacts at the regional level can have significant impacts for global supply chains. As a result of extensive flooding in Thailand in 2011, vehicle production in factories in Canada and the US fell, and the global price of hard-disc drives doubled as a result of the impacts on output.

**Figure 6.10.** Supply chain climate risk demonstrated by 2011 Thailand floods



### Future risks

There is limited information on future risks to supply chains. Climate change may increase the risk of weather-related disruptions, particularly for supply chains that involve more vulnerable countries, such as in South and South East Asia, along with sub-Saharan Africa (ASC, 2014). As the impacts of the Thailand floods in 2011 demonstrate, weather-related disruptions can have large and far-reaching impacts, which could be exacerbated further if supply chains become increasingly globalised and inter-connected.

A PwC report on the international dimensions of climate change concludes that "indicative evidence suggests that the international threats and opportunities of climate change to the UK could be an 'order of magnitude' larger than domestic threats and opportunities for some thematic areas, in particular business (trade and investment) and food (supply chains)" (PwC

2013). The study also identified several key risks and opportunities and estimated the magnitude of those impacts for 2020, 2050 and 2080. Reduced access to imports or exports as a result of failure in transportation and distribution networks is identified with a low negative magnitude until 2020s, rising to a medium negative magnitude for the 2050s and 2080s. A similar picture emerges for reduced availability of imports or volatility in prices as a result of climate-induced shortages. The study finds medium positive magnitude for reduced shipping costs from Arctic opening (2020s and 2050s), expected to rise to a high positive magnitude in 2080s.

Certain industries and sectors have considered the future implications of climate change on their international supply chains. Seafish (2015) identified a number of future international risks and opportunities to the UK seafood industry resulting from air or sea temperature change, both at home and further afield. These risks and opportunities included projected changes in inputs such as species distribution, catch potential and production of fisheries elsewhere in the world, and risks to infrastructure from more intense and more frequent storms. Box 6.11 sets out some examples of the report's findings.

**Box 6.11.** Examples from 'Understanding and responding to climate change in the UK seafood industry: Climate change risk adaptation for wild seafood capture'

- The Arctic and North Atlantic oceans are the key source region for cold-water prawns but also cod, with import sources for UK consumption being Greenland (via Denmark), Iceland and Canada (prawns) and Norway and Iceland (cod). These commercial fisheries have been subject to substantial changes in recent years, including stock and quota reductions for prawns but massive increases in commercial catches of arctic cod. Although not yet feasible to estimate the scale of the cold-water prawn resource from primary production forecasts only, it may be possible to indicate where prawn and cod stocks will be located in future decades by looking at habitat requirements of these species. The availability of the Barents Sea prawn stock is expected to fall as it moves east out of 'shared' waters into Russian waters. By 2100 Russia may see a 55% increase in stocks. By contrast, Barents Sea cod stocks, in particular those off Norway, are anticipated to increase in future decades, and could become even more important for UK supply chains than at present.
- On damage to ports, harbours and onshore infrastructure or facilities as a consequence of more intense storms and/or more frequent flooding events, this is likely to be most relevant to importers that have an integrated supply chain and operate facilities at vulnerable overseas locations. For those making investment decisions, there is clearly merit in awareness raising and importantly in developing 'early warning systems' concerning the consequences of climate change for key infrastructure. The purpose is to give the industry 'time to prepare' and intelligence on where or where not to locate critical onshore and port facilities, for example, ensuring that commercial buildings are located away from quayside areas that have been identified as particularly vulnerable. For UK businesses, this intelligence may be useful in promoting local stakeholder investment in enhancing resilience of port and harbour operations and processing plants located in third countries.

**Source:** Seafish (2015).

Adverse weather was the third most cited concern for supply chain disruption over the next 12 months, with 45% of surveyed businesses highlighting it as one of the biggest risks in a 2015 survey of UK and non-UK businesses (BCI, 2015). The proportion highlighting adverse weather as one of the biggest risks over the next five years fell to 35%, although it was still one of the most

frequently cited concerns, alongside potentially related concerns about unplanned IT or telecommunications outage and new laws or regulations.

### **6.5.3 Adaptation responses and gaps for supply chains and distribution networks**

The importance of supply chain resilience has been recognised by governments as an issue that requires support:

- The Welsh Government recommends a range of actions that companies can undertake to increase their supply chain resilience – including the creation of new logistics models and building in resilience to unexpected changes (Welsh Government, 2015c). One of the key messages from the Commission on Climate Change’s Business and Tourism Sectoral Adaptation Plan workshop was that businesses need to address their climate vulnerability in ensuring the resilience of their wider supply and distribution chains.
- In England, the Environment Agency has published guidance on managing risks from climate change to supply chains (Climate Ready, 2013). Self-reported data is available through the CDP and the BCI. This suggests that some large multinational companies are managing the risks of disruption to suppliers but that there has been a focus on identifying alternative suppliers (so called ‘footloose’ products, that can be sourced from a range of origins, rather than ‘in origin’ that have a specific or limited source, for example, West Country cheddar, Suffolk pork, Welsh lamb and Scottish whisky). However, this is an essentially short-term solution with finite possibilities as an adaptation strategy, since it does not address the issue of the long-term resilience of a wider supply chain base.
- The Cabinet Office, in partnership with the Business Continuity Institute and Emergency Planning Society produced ‘Business Continuity for Dummies’, a survival guide intended for SMEs.

The UK is leading on the development of climate change adaptation standards at both the international (ISO) and European (CEN) level. Effective standards may help lead to more resilient domestic and international supply chains for UK businesses.

Some large retailers and manufacturers, including Tesco, Morrisons, The Co-operative, Waitrose, Marks & Spencer, Asda and Dyson are known to be using weather data and forecasting services to reduce the risk of severe weather-related disruption along their supply chains and provide information on future demand trends (MetraWeather, 2015). Box 6.12 sets out examples of companies taking adaptation actions in the UK and overseas to ensure the resilience of their supply chains.



### Box 6.12. Climate adaptation of supply chains by UK companies

- Asda has recently worked with PwC to map the risks to its supply chain from climate change. The supermarket chain has identified risks – in terms of sourcing, processing and logistics – to 95% of its fresh produce. Its work has included an assessment of risks both to its own operations as well as those of its suppliers. Following this exercise, the company plans to look in more detail at the products identified as the most vulnerable and to provide targeted training where it is needed.
- In reports to the CDP, Nestlé has highlighted action being taken as it seeks to reduce the amount of water abstracted per tonne of product by 40% (on 2005 levels) by 2015. Nestlé is also working with suppliers to improve the resilience of its cocoa supplies. Cocoa is grown on relatively fragile plants in a small number of countries, meaning that it is at a comparatively high risk from climate change. Some of the actions being taken by Nestlé include: training for soil preparation, water conservation and responsible use of fertiliser; techniques for more efficient land use; and distribution of plants that are more resilient to drought and disease.
- Unilever has an objective to significantly reduce the water used by its global factory network (halving water abstraction in new factories, when compared with its 2008 baseline). Actions include metering of water usage, water audits and rainwater harvesting. To date the company reports reducing water abstraction by 13 million cubic metres in its global factory network between 2008 and 2012 (a 25% reduction per tonne of production). The company has also recognised the need to improve water efficiency through to external suppliers of raw agricultural product. It seeks to minimise water use among suppliers as part of its goal to source 100% of products sustainably by 2020.
- In a report published by Climate Ready, Camira Fabrics highlighted action to increase its supply chain resilience. Actions include: building a network of many small suppliers across different geographic localities; developing effective two-way communications with suppliers (to pinpoint risks to supply and demand-side trends); developing a full risk and opportunity assessment to feed into a climate change resilience plan; and diversifying products to include more resilient and sustainable materials.
- A number of car manufacturers have collaborated with Achilles to map their supply chains and share information. One particular output, Supply Chain Mapping, a tool led by Toyota Motor Europe, invites suppliers to join a programme that creates a link between product codes sold and product codes bought. The programme allows a buyer at any point of a supply chain to view their suppliers and associated tiers of sub-suppliers to identify which manufacturing sites are at risk from natural disasters, as well as broader supply chain risks. Toyota Motor Europe has highlighted the benefits of collective action on the supply chain, and the difficulties associated with interdependency which make individual action challenging.

**Sources:** ASC discussions with individual companies, CDP (2013), Nestlé (2012), Unilever (2013), Climate Ready (2013), Achilles (2013), Asda (2014). First presented in ASC (2014).

IEMA, with the support of 300 of their members, produced guidance to help practitioners to understand scope and build support for the Climate Change Adaptation 'business case' (IEMA, 2013). Within this they highlighted examples of companies taking action to make their supply chains resilient and therefore achieve a competitive advantage:

- An alternative corporate approach on supply chain concerns has been to secure resilience and continuity by diversifying suppliers and building in contingency (this approach from a large corporate with international production and sales).

- A further large corporate had addressed risks through a significantly localised supply chain where its suppliers effectively guarantee delivery (that is, responsibility for contingency in this case was put on to the supplier).
- One medium-sized company decided to internalise (own and manage) delivery logistics to better ensure continuity of service to customers. The company also ensured sufficient 'held stock', for a continuity of supply out to its critical and valued clients. This approach is seen by the company as providing comparative advantage over competitors who operate more mainstream 'just in time' systems for outward deliveries and internal supplies (an approach seen by the adapted company as being increasingly vulnerable to extreme weather incidents both in the UK and also in its international supply chain).

A wide variety of tools and resources are available, including guidelines on good practice (BCI, 2016) and becoming climate resilient (AECOM, 2015).

However, despite the availability of guidance tools and reporting, it is difficult to determine to what extent these are being used by businesses to make supply chains and distribution networks resilient. Despite the range of surveys and case studies, data are mostly limited to those reported by larger multi-national companies and it is difficult to evaluate impact and effectiveness as well as whether actions relate to short-term resilience or long-term adaptation (Averchenkova et al., 2016). Findings from the Chartered Institute of Purchasing and Supply (CIPS) suggest that many British firms do not fully understand supply chain complexity and that "inadequately trained supply chain professionals" amounts to a skills gap (CIPS, 2014). Box 6.13 sets out international analysis by the CDP of awareness of the physical risks of climate change and the proportion of respondents who have climate risk assessment and management procedures in place. Less than half of respondents demonstrated an awareness of the physical risks of climate change, and just over a third did not have climate risk assessment and management procedures. Water risks to supply chains may be a particular gap. Of those businesses who agreed to participate in CDP's supply chain water program, only 41% reported actually assessing water risks to their supply chain.



### Box 6.13. Awareness of supply chain risks

#### **Climate risks are significant – yet perceptions are slow to change**

A large majority of suppliers participating in CDP's supply chain program acknowledge climate risks: 72% identified inherent physical, regulatory and/or other climate change risks that may significantly affect their business operations, revenue or expenditures.

A smaller but still sizeable percentage of suppliers (46%) highlighted the physical risks of climate change to their business, including sea level rise, change in precipitation or temperatures and/or the occurrence of tropical cyclones. Additionally, 40% of suppliers identified a wide range of other climate risks, from changing consumer behaviours and uncertain market signals to company reputational risks.

A significant percentage of suppliers lack climate risk assessment and management procedures. While 60% of those disclosing to CDP have such procedures in place, at least 35% do not; and it is assumed that suppliers who did not respond to CDP are even less likely to have procedures in place.

Given that so few suppliers have risk assessment and management procedures in place, it is likely that reported risks are under-estimates.

Water risks are among the most notable physical impacts of climate change, and these are particularly under-evaluated and under-reported. Only 826 of the 1,969 suppliers (42%) invited to participate in the CDP supply chain water program actually did so. Among suppliers that participated in the program, 41% actually assess their water risks, 45% integrate water into their business strategy and 36% have a water policy setting out clear goals and guidelines for action.

**Source:** CDP (2016).

As with BCM plans, evidence suggests smaller businesses are less likely to have taken action to make their supply chains more resilient. A recent study into 'a more resilient small business community' found that two-thirds of the surveyed small businesses were impacted by severe weather during the last three years and about 93% of them believed that severe weather poses a risk to some part of their business (FSB, 2015). However, only 19% of small businesses have taken action to manage the impact of severe weather on their supply chain.

It may be that businesses consider existing risk management practices, such as business interruption insurance and contingent business interruption insurance, which covers losses stemming from damage to the premises of a supplier or customer, are sufficient to cover against potential disruption to distribution networks. Business interruption insurance is often included in business insurance packages, which combine a number of different policies under one premium, or it can also be offered as an optional extra to buildings and contents insurance policies (ABI, 2014). However, an international study by AXA in 2011, found that only 39% of SMEs claim to have business interruption cover to protect against lost income resulting from unforeseen events (AXA, 2011).

One mechanism for engaging businesses in the issues of resilience and business continuity has been through government-led resilience forums, which include infrastructure resilience, community resilience, business continuity and corporate resilience forums (Cabinet Office, 2014). These forums include emergency responders and representatives from the business community. For example, the City of London Resilience Forum includes representatives from a wide range of City businesses, covering banking, insurance and legal services, among others. The forum meets on a quarterly basis mainly to exchange information and update each other on

emergency planning and business continuity issues, including severe weather disruption, electricity reliability and telecommunications failure (City of London, 2014). Other local resilience forums exist across the UK, typically structured by county boundaries (Cabinet Office, 2015), and actively seek to include representatives from the private sector.

### 6.6 Climate risks and opportunities for products and services

This section explores risks and opportunities for businesses due to climate-related changes in markets.

#### Key messages

##### **Bu7: Risks and opportunities for business from changes in demand for goods and services**

- The provision of products and services can be impacted by climate both directly and indirectly through changes in costs or operating expenditure; changes in demand; and through regulatory and other public policy responses.
- There is evidence of risks and opportunities for designing products and services in the following sectors: adaptation goods and services including engineering and manufacturing products to manage climate risks; tourism; insurance and other finance products (see Section 6.3); as well as agriculture (see Chapter 3) and food products (see Chapter 3 and Chapter 7).
- In the same context, the adaptation action of one sector could have negative implications for other sectors or society at large – for example the potential withdrawal of insurance cover, or misguided flood defence investments.
- To date literature and recent analysis provides limited evidence of the scope and scale of opportunities.
- Identifying market opportunities and managing risks are core business activities. Unless prevented by regulation or hampered by low adaptive capacity it is expected that companies will respond to growing risks and opportunities.
- There is a risk that businesses will be unable to overcome adaptive capacity constraints. Small businesses are generally likely to have lower adaptive capacity so are least likely to take adaptation action.

#### 6.6.1 Policy framework

General policies and programmes related to promoting awareness of climate change risks and opportunities, including in the context of products and services, are discussed under Section 6.2.1.

Defra and UK Trade & Investment, together with the Foreign and Commonwealth Office and the Department for Business, Innovation & Skills, have responsibility within the NAP to promote and facilitate international commercial opportunities for UK companies with adaptation expertise.

UK products will need to continue to meet standards set out in the Sales of Goods Act 1979, General Product Safety Regulations 2005 and international standards which could change with higher temperatures and environmental law (BIS, 2015b).

## 6.6.2 Current and future risks and opportunities for products and services

### *Current risks*

The BACLIAT vulnerability assessment (UKCIP, 2014a) sets out some common climate impacts for products and services (referred to as 'markets').

- Increasing or decreasing demand for some products and services.
- New properties required of existing products and services.
- Emerging markets for new products and services.
- Changing customer behaviour.
- Marketing opportunities.
- Unable to satisfy increased demand or segments of the market.
- Competitors' position enhanced or reduced by climate change.
- Advantages for early movers in response to changed markets and lifestyles.

These impacts are expected to occur to varying extents across sectors and regions, as well as internationally, with mixed implications for UK businesses. For example the finance and insurance sectors in the UK may face changes in demand for their existing products and services both in the UK and abroad. If the frequency or intensity of extreme weather events increases due to climate change those companies have to make subsequent decisions about changes in prices. These impacts are discussed with other issues for the finance and insurance sectors in Section 6.3 of this chapter on access to capital. This is because of the potentially significant implications for all UK businesses, given the pivotal roles of the finance and insurance sectors in lending and transferring risk in the UK economy. Another example is the energy sector (see also Chapter 4), with the UK being a net importer of energy. Disruption to infrastructure for energy transportation could affect the prices and availability of UK energy and fuel imports (Foresight Report, 2011). Changes to the market would have implications for a wide range of sectors.

Examples of new characteristics and design features required of existing products and services include those within the construction sector, and requirements for more resilient buildings (See Section 6.4.2). The impacts of climate change on customer behaviour are uncertain, but particular sectors, such as food and beverages and retail, are already dependent on certain weather conditions and seasonal adjustments, which is likely to make them more vulnerable to sudden changes. In the utilities sector rising temperatures may result in reduced energy demand for heating but an increase in energy demand for cooling (PwC, 2013). The aggregate effect on the energy market is unknown.

Other examples include risks for UK businesses in the agriculture sector, who may lose traditional markets, local competitive advantage and face new competition in existing markets from global climate change (UKCIP, 2014a). This and further examples of risks to products and services are covered in other CCRA2 chapters: risks (and opportunities) to agriculture are discussed in Chapter 3, while risks for utility and infrastructure providers is covered in Chapter 4.

### *Opportunities for growth in sales of adaptation goods and services*

Increases in the frequency and the awareness of climate-related events are likely to lead to a rise in the demand for adaptation goods and services both at home and abroad. The extent to which

climate change offers new opportunities was explored in 2016 in a report by Acclimatise for the Environment Agency. Using 2013 and 2014 CDP data, this report found that 62% of the market opportunities identified by companies related to increased demand for existing and new products and services. Of the opportunities reported, 33% were expected to arise within three years.

National statistics agencies do not collect data on sales of adaptation goods and services. This makes it difficult to determine the size of the market using publicly available data. Based on the best of the limited data available, global sales of adaptation goods and services were estimated to be £69 billion in 2011/12. The UK is the seventh largest producer of adaptation goods and services globally, with sales by UK companies in 2011/12 of £2.1 billion, of which £0.3 billion were exports. Sales of adaptation goods and services grew by 2.6% per annum between 2009/10 and 2011/12. However, in real terms they remained constant over the short period of time data are available.

The sector remains small – in total, adaptation goods and services sales represent less than 0.1% of all sales by businesses in the UK – and sales by UK companies appear to have grown more slowly than those of competitors in other countries (ASC, 2014). Table 6.7 sets out estimated sales of adaptation goods and services by UK companies in 2011/12. Qualitative assessments by PwC (2013) and GHK (2010) based on consultation with business experts found the UK is already a key provider of some adaptation goods and services, particularly in climate modelling, professional services including architecture and engineering, and finance and insurance products. Businesses in the UK already export goods and services that require similar skills and technologies to adaptation goods and services. For example, the UK's exports of financial services in 2011 were £40 billion and accounted for one-fifth of all financial services exports globally. The UK has a comparative advantage relative to other countries in this sector and this is true across many of the sectors requiring similar skills and technologies to the adaptation goods and services sector.

**Table 6.7.** Estimated sales of adaptation goods and services by UK companies in 2011/12 (£ million)

Adaptation goods and services	Estimated sales by UK companies in 2011/12 (£ million)
Architectural	270
Climate change management	80
Construction and retrofit	660
Enviro-finance	220
Finance investment and insurance	190
Risk management and business continuity	100
Sustainable drainage and water management	120
Transport infrastructure	490
Water irrigation	10
<p><b>Sources:</b> K-Matrix for BIS (2013), PwC (2013) and GHK (2010). First presented in ASC (2014).</p> <p><b>Notes:</b> The adaptation goods and services sectors used in this table use the K-Matrix definitions. The sales figures in the second column are total sales by UK companies of adaptation goods and services, including sales to customers in the UK as well as exports.</p>	

Companies report that they are already investing in technologies and products to address climate change. Responses to CDP suggest on the highest proportion of investment is to address risks associated with higher temperatures, followed by investments to reduce water use and address flood risks (Acclimatise, 2016, for the Environment Agency). These investments are reported to benefit companies in one or more of several different ways: improving business continuity, cost saving, enhancing reputation and providing competitive advantage. Acclimatise (2012) for UK Trade and Investment (UKTI) found that 70% of the infrastructure and construction companies surveyed see climate change presenting opportunities including the need for flood defence, more robust buildings, and reservoir strengthening. The same study concludes that more than 60% of businesses surveyed by UKTI consider climate resilience to be a commercial opportunity. Based on 2013 and 2014 CDP responses and experience of working in this area, Acclimatise (2016) for the Environment Agency assessed that the manufacturing, finance and insurance, construction and professional, scientific and technical activities sectors are noticeably seizing market opportunities related to climate change.

There appear to be several areas of opportunity which result from existing strengths in the UK economy. These areas include water resources and hydrology (water storage, harvesting and treatments); hard structures against flooding and engineering; health (vaccination and medical technology); and climate sensitive building design including air conditioning and disaster communication and response systems (PWC, 2013). The particular strengths that create these opportunities are climate modelling, water and wastewater treatment, and R&D in areas such as on biotechnology and civil engineering. Similarly, the UK is considered a world leader in coastal

engineering and management. This suggests that both national and international demand for UK services in this area is likely to increase (Nicholls, 2012).

Opportunities in the UK transport sector could increase exports of UK products into global markets (GHK, 2010). This includes building and upgrading transport networks with ICT to aid monitoring and maintenance, and innovation in durable materials. R&D in low carbon technology development, climate modelling and forecasting, and ICT in the transport sector are particularly identified as some of the most advanced in the world. UK consultancies and financial and business services are therefore well placed to capture opportunities across sectors and respond to a potential increase in demand for these services. Existing expertise in the UK includes providing blended consultancy approaches (for example, linking risk assessments with hydrological modelling, scenario building and impact mapping, adaptation and mitigation measures simultaneously). These services are expected to expand with adaptation to climate change, with the potential for further innovation and introduction of new and related services.

### *Future risks and opportunities*

It is difficult to predict how markets and consumer behaviour may change over time and therefore assess how representative current risks and opportunities may be of those in the future

Qualitative assessments suggest that there may be future opportunities from climate change for a range of sectors. Table 6.8 sets out the assessment of growth potential for climate-related products and services from Acclimatise (2016) for the Environment Agency. The sectors with more expertise are assessed to be the electricity, gas, steam and air conditioning supply, financial and insurance activities, and water supply including sewerage, waste management and remediation activities. Those with less expertise are administrative and support services, education and transportation and storage. The sectors assessed as having more expertise tend to also be the sectors assessed as having a high growth potential.



**Table 6.8.** Assessment of growth potential for climate-related products and services by economic sector

Sector	Example products and services	Example company	Level of expertise	Assessment of growth potential
Accommodation and food services	Increasingly popular tourism destinations and services (e.g. in the UK and northern Europe)	Thomas Cook		
	Supplying food products and services that respond to a shifting customer demand for alfresco-orientated food experiences			
Administrative and support services	Climate-related disaster and emergency response services	G4S		
	Building and infrastructure management services ensuring climate resilience (e.g. water management, pest control)			
Agriculture, forestry and fishing	Development of drought resistant seeds and opportunity to diversify into new crop varieties	Bayer		
	Advisory services to support growers in UK and internationally			
Construction	Climate resilient solutions for existing and new buildings / infrastructure, including insulation, ventilation, flood protection and water saving	Balfour Beatty		
Education	Learning services to support increased awareness and knowledge of climate change and management courses to train public and private sectors on how to respond to a changing climate	Ashridge Business School		
Electricity, gas, steam and air conditioning supply	Opportunity to supply space cooling technologies, and particularly for domestic use	SSE		
	Energy efficient heating and cooling			

**Table 6.8.** Assessment of growth potential for climate-related products and services by economic sector

Sector	Example products and services	Example company	Level of expertise	Assessment of growth potential
Financial and insurance activities	Climate-related disaster and emergency response services	Catlin group		
	Building and infrastructure management services ensuring climate resilience (e.g. water management and pest control)			
Information and communication	Complex data harvesting, management and information provision (e.g. tracking of climate trends and their impacts on business performance)	BT Group		
	Design and management of support networks and applications for on-premises and cloud-based computing			
Manufacturing	Water efficiency technology	Johnson Matthey		
	Chemical products (e.g. fertilisers and home products)			
	Development of climate resistant materials			
Mining (including oil and gas)	Provision of raw materials and derived products to supply climate compatible developments (e.g. infrastructure projects)	Aggregate Industries Ltd		
Professional, scientific and technical activities	Architectural and engineering services around the design of new developments and retrofitting existing building stock	Amec Foster Wheeler		
	Management consultancies providing advice to public, private and third-sector clients on climate resilience			
Real estate activities	Real estate with higher "sustainability credentials" for climate conscious clients	Unite Students		

**Table 6.8.** Assessment of growth potential for climate-related products and services by economic sector

Sector	Example products and services	Example company	Level of expertise	Assessment of growth potential
Transportation and storage	Cold storage and increased provision of chill chain logistics	Dearman		
Water supply; sewerage, waste management and remediation activities	Provision of water saving technologies	United Utilities		
	Water reuse and recycling technologies			
	Trading agreements between water suppliers			

**Source:** Acclimatise (2016) for the Environment Agency.

Businesses in the UK agricultural sector may benefit subject to the health of the natural environment, as described in Chapter 3. Further evidence exists for future risks and opportunities for flood protection products and the tourism sector, as described below.

The demand for adaptation products is expected to grow in the future, partly fuelled by public demand for weather-protection products. The UK Government has pledged to spend £2.3bn over the next six years on capital flood and coastal risk management activity (Defra, 2014) with a further increase of £700 million announced in the 2016 Budget. The Environment Agency's Long Term Investment Scenarios (LTIS) for flood and coastal erosion risk management estimate that the optimal investment profile in the first 10 years (to 2024) is around £750 to £800 million a year in present day costs. They expect this to rise from the 2020s to the 2040s to £850 to £900 million a year, although this could be influenced by the choice of different risk management approaches. Once discounted to present values, the cost of funding all activity to manage flood and coastal erosion risk where benefits are greater than costs is around £25 billion over the next 100 years (Environment Agency, 2014).

Evidence suggests that UK tourism overall may experience increased demand due to climate change. Hotter drier summers could improve leisure activities across the country leading to an increase in demand and a potential increase in supply through new or expanded services. There are opportunities to expand services close to outdoor leisure facilities, such as sports grounds, gardens and natural parks or beaches (UKCIP, 2010). These opportunities are described more in Chapter 5. Opportunities for the UK hospitality industry are particularly expected at the fringes of the season (e.g. March and October) and in more northern destinations. Some types of tourism or tourism in specific areas could be negatively affected by climate change (Coombes and Jones, 2010). For example, access may be affected if sea levels rise and erode beaches. This could lead to a reduction of services in some coastal areas. There may also be challenges for tourism dependent on heritage buildings or sites as these may be more difficult to retrofit as described in Chapter 5. Natural England (2014) estimated the value and impact of heritage to

England. The report found that in 2011, built heritage tourism in the UK provided 134,000 jobs and economic output of £5.1 billion. 54% of overseas tourists visited historic buildings in England in 2011. The value of heritage tourism is expected to increase between 2013 and 2025, as the economic output in tourism is expected to rise from £58 billion (4.1% of the UK economy) to £119 billion (4.6% of the UK economy), with the number of tourism jobs rising from 1.75 million jobs to 2.10 million jobs over the same period (Deloitte, 2013).

The tourism sector has been identified as a key climate sector in Wales, with expected expansion of tourist destinations due to milder weather (Welsh Government, 2015b). Some impacts are uncertain. In Scotland, the Glenshee Tourism Association has been reported as targeting ramblers, cyclists, historians and sightseers due to concerns about sustainability of the skiing industry (SCCIP, 2010). However, evidence from Harrison et al. (1999) suggests Scotland may benefit from an improved summer climate and coast, conducive to outdoor activities, and access roads to ski resorts may be less prone to blockage by snow and ice.

### **6.6.3 Adaptation responses and gaps for products and services**

Adjusting the types of products and services offered in response to or anticipation of changing markets is at the core of any corporate strategy. Considering if and how demand could increase or decrease with a changing climate can lead to an entrepreneurial approach to adaptation, in order to exploit opportunities arising in existing or new markets. Frontier Economics et al. (2013) for Defra investigated the potential for business model innovation in response to climate change impacts as well as strategic changes in the portfolios of products and services offered. See Box 6.2. One example would be to lower reliance on core commodities that have limited sources of supply, such as through efficiency improvements or by expanding the product portfolio to include products not reliant on that commodity (Frontier Economics et al., 2013, for Defra).

Businesses continuously adjust to changes in market conditions and can be expected to do so to mitigate risks and take advantage of opportunities. In some cases, however, there may be a role for government policy in addressing potential barriers to growth. Actions in the NAP (HM Government, 2013) focus on improving the evidence base on the size and composition of the adaptation goods and services sector, and promoting both domestic and international opportunities identified through this research (ASC, 2015).

In order to build on the evidence base from CCRA1, Defra commissioned the Office for National Statistics (ONS) to conduct a feasibility study on whether information on the adaptation economy could be collected by a survey (ONS, 2016c). The ONS produced a draft questionnaire following feasibility research with stakeholders, users and experts. The feasibility study found there were issues in respondents differentiating between adaptation for climate change and everyday weather, and in how adaptation products and opportunities are defined. Defra and ONS determined that, resource allowing, they would seek to review user requirements whilst assessing the quality of available data and have more detailed discussions with potential data providers, and data sources, such as those reported through EU mechanisms.

Defra is also working with BIS, the Environment Agency, and UK Trade and Investment (UKTI), to identify sectors that are best placed to take advantage of growth in adaptation goods and services and where government support may be required (ASC, 2015). UKTI is continuing to promote exports of goods and services, which will include adaptation goods and services. In 2010 the Department for Culture Media and Sport published its Strategic Framework for

tourism. This sets out a number of actions that will be taken to increase the resilience of the sector to climate change risks and grow the visitor economy.

There are also efforts to better explore future risks and opportunities both in the UK and in Europe (Bristol University, 2015; European Commission, 2015, 2016) and to raise awareness (Carbon Clear, 2016). However, there are potential barriers to an increase in demand for climate change related services, as these include model and scenario projections and observations, forecasts, climate information, trends, economic analyses, counselling on best practices, development and evaluation of solutions UKCIP (2014b). Current demand for these services is low due to a lack of awareness of the potential benefits (as climate change is not seen as an imminent issue by many businesses) as well as a lack of awareness that these services are available. Additionally, there is a lack of understanding from service providers of their target market. Climate information is often not tailored to specific localities or sectors. Instead it provides mostly generic information and is therefore less useful to customers. For opportunities in this sector to materialise, it will be important for businesses to address these barriers.

### 6.7 The importance of adaptive capacity

Businesses have an incentive to be efficient, manage the risks they face, and identify market opportunities. Thus, many businesses are taking a range of actions to help them limit the consequences of extreme weather and to improve their readiness to maximise future opportunities, which might implicitly increase their resilience to climate change (Averchenkova et al., 2016). Stenek et al. (2013) highlighted key factors that influence private sector adaptation:

- data and information;
- institutional arrangements;
- policies;
- economic incentives; and
- communication, technology and knowledge.

If and how business respond to climate risks and opportunities depends on whether they have adaptive capacity and are able to implement adaptive management. Adaptation action is limited by uncertainty over the degree of risk a business faces, the costs and benefits of action, and how these may change over time. This includes not having accessible and usable information about the nature of current and projected local climate risks; or asymmetric information such as if the landlord knows more than the business tenant about climate risks to the premises. To manage uncertainty, an adaptive management approach is advocated. This allows parties to learn over time and for new information to be reflected in decision-making processes. The intention is to maintain as much flexibility as possible for future options. The essence of the approach is to be clear on the direction of travel, or the vision for the desired outcomes or management goals, and the uncertainties about how to achieve these outcomes (Downing, 2012; Murray and Marmorek, 2004).

However, there are barriers and trade-offs that inhibit businesses' ability to understand their climate-related risks and take appropriate action, particularly in small and medium sized organisations. Business planning is often short-term and might not recognise the value of building adaptive capacity now to provide flexibility and respond well in the future. Businesses may fear the opportunity cost of adaptation measures taking them away from their core

business, especially if uncertain about the benefits these measures may deliver. IPPR (2016) proposed that markets do not currently take sufficient account of these risks because:

- they are seen as too distant to be a financial consideration;
- the nature, scale and timing of risk events is unknown; and
- there is a widespread belief that climate change is primarily an ethical concern and a matter for public policymaking rather than institutional decision-making.

IEMA surveyed around 400 climate change professionals in the UK and internationally. When asked the question “How good is your understanding of the term ‘Climate Change Adaptation’ and of the associated impacts, risks and opportunities for your organisation (or for client organisations)?”, only about 63% responded that they had a full or good understanding. Considering this group is more likely to be informed than the average business, this highlights the importance of guidance and tools which can help educate. In a 2015 survey of their members, IEMA found that 88% stated support for the government to maintain its central role in providing environmental advice to businesses (many stating that this guidance should be net-benefit and help businesses to save money). When asked “Considering the resources and tools already available to you, where do you believe the biggest gap exists (i.e. what would most help future work on adaptation and resilience)?”, 26% of respondents said improved information on the costs and benefits and 25% said more sector specific guidance on adapting to climate change.

The Climate Change Commission for Wales held a workshop for their Business and Tourism Sectoral Adaptation Plan in May 2015. Key messages relevant to adaptive capacity from this workshop included:

- Climate change communication is confused and contradictory; it needs to be presented in terms that are relevant to business. The UKCIP Business Areas Climate Impact Assessment tool (BACLIAT) and the IEMA guidance on building the business case are very useful in this respect.
- Climate adaptation requires significant financial investment, which may be best delivered through a partnership approach, involving all beneficiaries. Financial institutions have a key role in providing the right incentives.
- Small businesses in particular lack capacity to address climate adaptation and need to be provided with realistic business support.
- Welsh Government can catalyse action by providing support to business and by embedding climate adaptation throughout its own activities; public sector procurement is key to developing adapted businesses in Wales.
- Climate adaptation requires a partnership approach response involving business networks embedded within wider community networks.

The Economics of Climate Resilience (Frontier Economics et al., 2013, for Defra) assessed adaptive capacity and adaptation responses in detail for businesses and organisations across a number of sectors in the UK. Key findings were that adaptive capacity of specific firms varies depending on a number of key characteristics. Factors that appear to support adaptive capacity are: good understanding of risks; few indirect exposures and interdependencies; strong organisational structure and leadership; a stable, supportive and transparent policy environment; flexible planning processes; and having previously been impacted by an extreme



weather event (although this can also weaken adaptive capacity). Adaptive capacity for business also includes their ability to identify and manage the interdependencies between business functions, recognising the influence of individual business functions and adaptive responses. Another important aspect is public policy, and its role in determining if and how companies respond to risks and opportunities. Below we highlight key factors that determine adaptive capacity of businesses in the UK.

### *The size of a company*

For the UK, evidence suggests businesses are increasingly putting in place plans to respond and recover from flood events. However, there is relatively little evidence available of actions to reduce damages through flood resistance or resilience measures, particularly among SMEs (ASC, 2015). Research in the United Kingdom indicates that SMEs have a lower degree of formalisation in their crisis plans and low levels of business interruption insurance to cover some (but not all) of the costs incurred as a result of an operational outage. Herbane (2010) found that SME owner-managers frame risks in two ways – a ‘growth vulnerability paradox’ (where growth and diversification are perceived to reduce risk) and the ‘risk elastic’ (where a growth opportunity is eschewed in order to reduce financial uncertainty).

A recent FSB report has investigated this and surveyed SMEs about their experience with severe weather and their efforts to increase resilience. Box 6.14 sets out findings from this research. The survey also suggests that financial incentives, such as tax relief, discounts in business rates, or lower insurance premiums, would encourage companies to take action. However, the study also indicates a need for a better understanding of business-specific risks and risk management options. Asked which factors would encourage them to become more resilient to severe weather the top three factors identified by SMEs were ‘understanding the extent to which my business is at risk’, ‘understanding what plans I can make to help my business adapt’, and ‘knowing what specific products are available to help increase my resilience’. The survey also suggests that financial incentives, such as tax relief, discounts in business rates, or lower insurance premiums would encourage companies to take action. However, the study also indicates a need for a better understanding of business-specific risks and risk management options. Asked which factors would encourage them to become more resilient to severe weather the top three factors identified by SMEs were ‘understanding the extent to which my business is at risk’, ‘understanding what plans I can make to help my business adapt’, and ‘knowing what specific products are available to help increase my resilience’.

# Box 6.14. SMEs and extreme weather, survey evidence from the Federation of Small Businesses and AXA

Two thirds of small businesses say they have been negatively affected by severe weather in the last three years. Responses from these businesses suggest that the average cost (both direct and indirect impacts) of these severe weather events was £7,000. Table 6.9 sets out the type of weather impacts experienced by small businesses over the last three years, how widespread these effects were, and the average cost of each (as estimated by survey participants). Many businesses have been affected on more than one occasion in the last three years, and many highlight a combination of impacts related to severe weather events.

**Table 6.9.** Severe weather impacts on small businesses, 2011 to 2014

Impact type ( <i>examples</i> )	Costs	% of respondents affected
People ( <i>disruption for customers or staff</i> )	£3,810	45%
Logistics ( <i>disruption to suppliers, utilities or transport arrangements</i> )	£1,944	32%
Processes ( <i>impacts on production processes and service delivery</i> )	£6,888	17%
Premises ( <i>impacts on maintenance, facilities management or building design and construction</i> )	£5,410	15%
Markets ( <i>changing demand for goods and services</i> )	£6,150	14%
Other ( <i>impacts on investment, productivity, insurance, reputation</i> )	£3,035	9%

**Source:** FSB (2015).

A previous FSB survey of their members estimated the cost to small businesses affected by flooding in the winter of 2013/14 at around £831 million in total or £1,500 per small business. It also found that 32% of respondents experienced reduced demand and 16% had staffing issues (FSB, 2014).

Disruption to business activity in the form of lost working days can be substantial. An AXA survey of small businesses from 2006 found that flooded businesses lost over 50 working days as a result of flooding. The average cost of lost working time, damage to stock and premises and loss of custom was reported as:

- Businesses with 1 to 3 employees: £7,900.

### **Box 6.14.** SMEs and extreme weather, survey evidence from the Federation of Small Businesses and AXA

- Businesses with 4 to 10 employees: £18,070.
- Businesses with 11 to 50 employees: £27,480.

Despite these potential costs, small businesses often do not have adequate plans in place. For example, FSB research suggests 93% of small businesses believe severe weather poses a risk to some part of their business but only 64% of small businesses have taken some action to manage the risk of severe weather to some part of their business.

All this suggests that damage to businesses can be significant and in some cases put the survival of businesses, small ones in particular, at risk.

**Sources:** FSB (2015), FSB (2014) and Crichton (2006).

A recent survey indicates that a large proportion of SMEs feel vulnerable to climate change impacts. 70% of the SMEs in developed countries<sup>12</sup> surveyed believe that climate change poses a long term risk to their business, but only a quarter have implemented adaptation actions (AXA and UNEP FI PSI, 2015). The survey also highlights the challenges of increasing adaptive capacity of SMEs. Only 25% of the SMEs in developing countries surveyed say that they follow national or local government recommendations on managing climate change risk, while 20% say they participate in local or city planning efforts on resilience. Fewer than one in five share good practices with peers or interact with the government or wider society on climate change.

While the AXA survey focuses on the notion of 'climate change', the FSB study looks at severe weather. What might appear as semantic details can play a significant role in determining if and how companies perceive and respond to risks. Earlier studies indicate that SMEs do not necessarily associate weather events with climate change, and that many activities undertaken by SMEs in response to climate change stem from the personal beliefs and views of directors, managers or employees (Norrington and Underwood, 2008). While resilience to current weather events is an important element of adaptive capacity, a reflection on future trends and uncertainties when making decisions today is a far bigger challenge, not just for SMEs.

The Cabinet Office highlighted three reasons why SME resilience was important under its SME Resilience Strategy:

- Community resilience is enhanced when local businesses are able to keep running in emergencies. The US 9/11 Commission found, during a time of disruption, or local area crisis, the 'first' first responders are, in most cases, the local businesses themselves that are heavily relied upon within the community.
- SMEs are also important elements of the supply chain for large organisations, including critical infrastructure operators and government departments, which in turn provide services essential to society.
- SMEs may also be entrusted to undertake business critical activities, frequently having privileged access to large amounts of sensitive data on behalf of larger organisations.

---

<sup>12</sup> Developed countries in this survey included Belgium, France, Italy, UK and US.

The SME Resilience Strategy also identified a number of reasons why SMEs may be unwilling or unable to conduct effective business continuity planning:

- There is no compulsion or incentive for business continuity practice.
- The current British Standard in this area, which applies to smaller businesses, is impractical in many cases.
- At present, there is nothing in place to improve this position.
- Information on the risks to business continuity has until recently been hard to come by.

### *Differences among regions and sectors*

Highlighted in IPPR (2015), Baglee et al. (2012) identified a number of bellwether sectors that are particularly vulnerable to climate risk in the UK:

- tourism (making up roughly 9% of GDP);
- financial services (around 8%);
- food and beverages (around 7%);
- primary extractives, including oil, gas and mining (within this, energy is 3.5% of GDP); and
- chemical manufacturing (1.5% GDP).

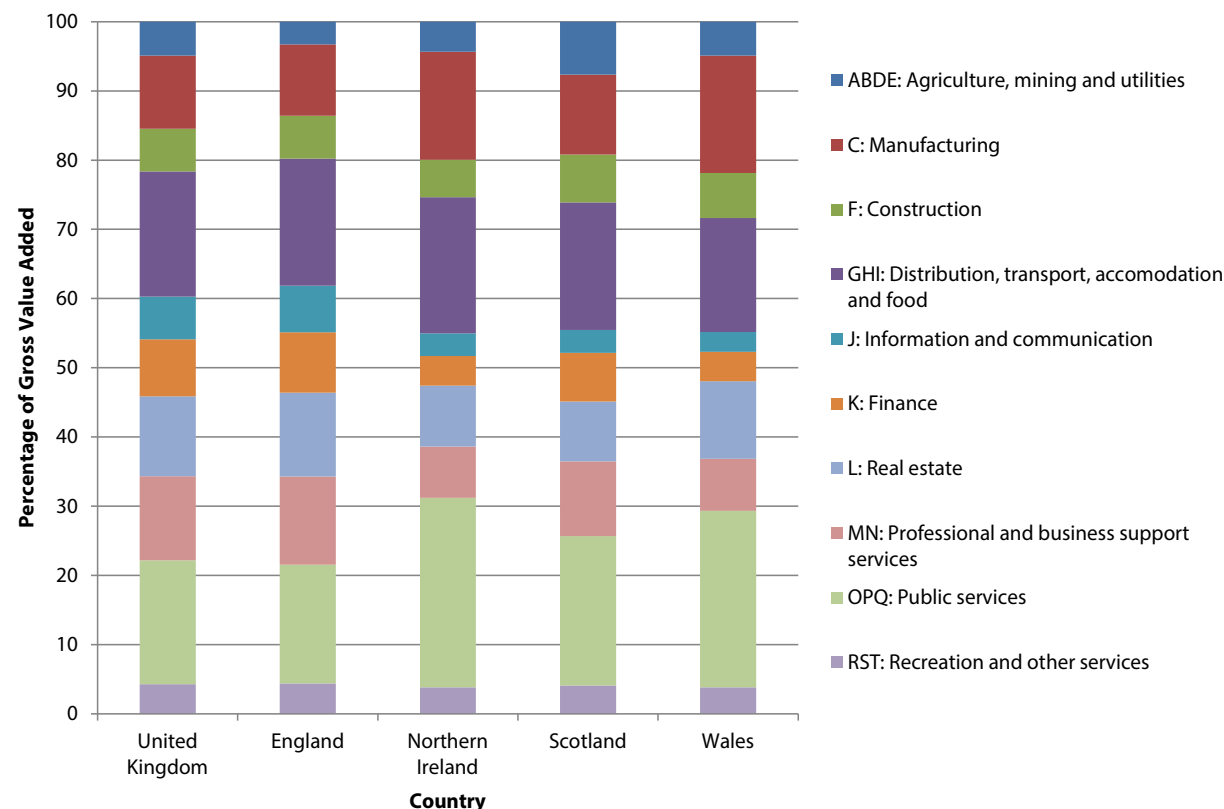
The vulnerability of these sectors stems from the following facts:

- Reliance on large, fixed assets – for example, chemical manufacturing sites near major rivers or the coast.
- Complex supply chains – for example, food and beverages or electronic goods.
- Reliance on natural assets – for example, tourism.
- Broad exposure to climate risk. This is especially the case for financial services, which are the focus of the following section.

However, there is a limited understanding of sector-specific needs for climate adaptation beyond those sectors assessed by Baglee et al. (2012), Frontier Economics et al. (2013) for Defra or that feature prominently throughout this report (such as insurance or tourism). This is an important gap. In order to decide on the need for government intervention the relative strategic importance of different business sectors, together with the climate risk and opportunities they face, needs to be assessed.

Regional differences can apply to location risks and the type of business activity and sectoral split. As indicated above risks depend to a large degree on where business operations are located, particularly for flooding and water scarcity. Overlaying hazard maps with maps of regional business activities would provide a simple first indication of particular hotspots. To our knowledge this has not been done for climate risks to businesses in the UK and its regions in a systematic way. Figure 6.11 compares the distribution of GVA among sectors by UK country for 2014. The relative contributions can differ substantially. For example, the relative contribution to GVA of the finance sector is much higher in England and Scotland, whereas the relative contribution of manufacturing is higher in Northern Ireland and Wales. Table 6.10 compares the percentage of workforce jobs by industry section. Like for GVA, there are differences between countries. For example, the proportion of workforce jobs in agriculture, forestry and fishing is higher in Northern Ireland, Scotland and Wales than the UK average.

Figure 6.11. Distribution of Gross Value Added among sectors by UK country, 2014



Source: ONS (2015).

**Table 6.10.** Percentage of workforce jobs by industry section, 2015

Industry	United Kingdom	England	Northern Ireland	Scotland	Wales
A : Agriculture, Forestry And Fishing	1.2	1.0	3.5	2.1	2.6
B : Mining And Quarrying	0.2	0.1	0.2	1.4	0.1
C : Manufacturing	7.8	7.7	10.0	7.6	11.0
D : Electricity, Gas, Steam And Air Conditioning	0.4	0.3	0.4	0.7	0.6
E : Water Supply; Sewerage, Waste Management	0.6	0.6	0.6	0.7	0.7
F : Construction	6.6	6.6	6.5	6.9	7.4
G : Wholesale And Retail Trade; Repair Of Vehicles	14.7	14.7	16.6	14.4	13.2
H : Transportation And Storage	4.6	4.7	3.8	4.4	3.6
I : Accommodation And Food Service Activities	6.7	6.7	6.1	7.2	7.4
J : Information And Communication	4.0	4.2	2.5	2.4	2.0
K : Financial And Insurance Activities	3.4	3.5	2.5	3.2	2.3
L : Real Estate Activities	1.6	1.6	0.8	1.3	1.4
M : Professional, Scientific And Technical Activities	8.7	9.1	4.5	6.5	6.3
N : Administrative And Support Service Activities	8.4	8.6	6.4	7.8	6.5
O : Public Administration And Defence	4.4	4.1	6.6	5.7	6.1
P : Education	8.7	8.8	8.8	7.9	9.0
Q : Human Health And Social Work Activities	12.4	12.1	15.7	14.6	13.9



**Table 6.10.** Percentage of workforce jobs by industry section, 2015

Industry	United Kingdom	England	Northern Ireland	Scotland	Wales
R : Arts, Entertainment And Recreation	2.9	2.9	2.1	3.0	3.2
S : Other Service Activities	2.6	2.7	2.4	1.8	2.5
T : Activities Of Households As Employers;...	0.2	0.2	0.0	0.2	0.1
Total (%)	100	100	100	100	100
Total (Thousands)	33,783	28,772	849	2,697	1,452

**Source:** ONS (2016d) accessed through NOMIS.

**Notes:** Data are seasonally adjusted. Workforce jobs are the sum of: employee jobs, self-employment jobs, HM Armed Forces and government-supported trainees. The number of people with jobs is not the same as the number of jobs as some people have several jobs. Industry sections are classified according to the Standard Industrial Classification (SIC) 2007.

### *The role of policy and regulation*

All businesses operate within government policy and regulation frameworks. These can influence the ability of businesses to adapt, the timing of action, and the effectiveness of actions. The most obvious impact comes through direct, sector-specific regulation, while there are also a range of indirect policies that can determine if and how a company responds to climate risks and opportunities (Frontier Economics et al., 2013). While a systematic review of all relevant policies and regulations and their impact on private sector adaptation is missing, there is some evidence that planning regulation and building codes play an important role in determining the resilience of companies (see also Chapter 5). Most new buildings or major changes to existing buildings or premises need consent via planning permission and must comply with building codes. If and how local planners consider climate risks when granting planning approval remains unclear (ASC, 2015). Furthermore, any adaptation action which would require planning permission would be subject to these considerations and may affect the design, timing and costs of action. For heavily regulated sectors, such as food, utilities (covered respectively in Chapter 3 and Chapter 5) and finance, the adaptation response of the regulator can be very important. While to date there is no evidence that regulators are imposing adaptation and climate change resilience measures onto companies, there are some signals that climate risks are starting to be considered in terms of companies' ability to deliver services to customers. A number of central banks and financial regulators around the world are now starting to look at the concept of environmental stress testing, which both indicates that they believe there is sufficient cause for concern and that regulation may have a role to play.

For example, Basel III (BCBS, 2011) requires banks to increase their reserves against risks such as natural disasters and systems glitches by measuring their liquidity coverage ratio and meeting the net funding stability ratio. The Prudential Sourcebook for Banks, Building Societies and Investment Firms also has standards and requirements aimed at improving the risk absorption

capacity and risk management practices of banks. While these regulations do not take it into account climate change explicitly they do influence the approach to current risks (Mercer, 2015).

There is evidence that the insurance industry is exposed to indirect risks, from policy and regulatory responses. Ranger and Surminski (2013) identify positive and negative scenarios for insurance resulting from differences in policy responses to climate change, regulatory levels, company strategy, risk awareness and willingness-to-pay. Regulations within the industry also act to protect insurance companies against insolvency from weather-related losses. For example, it is by convention that insurance companies should have enough capital to remain solvent in 99.5% of years. In addition, the Prudential Regulation Authority (PRA) has requirements set in its Prudential Sourcebook for Insurers (INSPRU) to ensure that various risks such as liquidity risks and operational risks are managed. One example is the Individual Capital Adequacy Standard (FSA, 2003), which includes an Internal Capital Assessment (ICA) that insurance companies have to calculate based on individual risks. Furthermore, the enforcement of the Solvency II Directive (European Commission, 2009) that came into effect on 1 January 2016 requires insurance companies to meet certain financial requirements, conduct an ORSA, and disclose information on capital adequacy and risk management. The enforcement of regulation, coupled with better understanding of weather-related events, can aid the industry in dealing with current risks and help prepare for future risks (Douglas, 2014).

A further area where climate risks and regulation could have an impact on companies' behaviour is environmental regulation. Many businesses are regulated given the potential harm their activities pose to the environment. Climate change may affect the nature of this environmental damage. For example, extreme weather causes damage to premises, leading to leaks or environmental contamination. Adaptation action may therefore be required to ensure compliance with regulatory limits on pollutants. Internal capacity is likely to be required to monitor activities and ensure appropriate permits (for example, under Environmental Permitting Regulations), licences (for example, abstraction licences) or requirements to demonstrate standards. OECD (2015) estimates that the direct climate impacts on industrial sectors are smaller than the potential effects from policies aimed at a transition to a low-carbon economy. Overall service sectors were projected to benefit from those mitigation policies as their activities are less likely to result in emissions.

### *Information disclosure and reporting*

The analysis in this chapter has been reliant on survey responses and information voluntarily disclosed by businesses. Even if investors accept the need to take account of climate risks, financial analysts can only take decisions if the relevant information is available to them (IPPR, 2015). Organisations such as the CDP have helped to keep this sort of information available and up to date (Economist Intelligence Unit, 2015). In the UK, 95% of companies in the FTSE 100 provided this data voluntarily, through CDP, as did 79% of the FTSE 350. Initially intended to disclose climate emissions and mitigation activities, these surveys have started to include more questions on climate risks and adaptation.

Disclosure initiatives do also have clear limitations (IPPR, 2016). Given that 99.8% of UK businesses are SMEs, the adaptation actions or lack thereof, of many businesses will not be captured. The lack of business continuity planning (FSB, 2015) particularly among SMEs suggests that this is an area that may require further research, also to determine if regulation would be the most appropriate form of intervention. There are regulatory and non-regulatory measures that could be implemented to increase the number of companies disclosing information on

climate risks. The EU non-financial reporting directive requires businesses to disclose information on policies, risks and outcomes with regards to environmental matters. The directive focusses on the impact of businesses on the environment, but there is scope for firms to provide additional reporting (ASC, 2015). One of the recommendations from IPPR (2016) was that, building on existing UK carbon reporting, MPs should consider whether to require disclosure of climate risks and, if so, over what time period. This could be followed by regular climate-related stress testing of listed companies and financial institutions in Britain (IPPR, 2016).

Given the existing statutory requirements and information disclosures that listed companies have to comply with, further reporting on climate risks and adaptation may create little additional burden. Corporate sustainability matters and sustainability matters are included in annual reports, although currently the statutory requirements are relatively high-level. Box 6.15 sets out requirements for annual reports by listed companies.

### **Box 6.15.** Corporate sustainability and sustainability matters in the annual report of a listed company

The statutory requirements for disclosing corporate sustainability matters in an Annual Report are relatively brief.

A company's directors have a statutory duty under section 172 "to promote the success of the company for the benefit of its members as a whole." In order to do this they are asked to report on the following corporate responsibility and sustainability-focused matters:

- the interests of the company's employees;
- the need to foster the company's business relationships with suppliers, customers and others;
- the impact of the company's operations on the community and the environment; and
- the desirability of the company maintaining a reputation of high standards of business conduct.

Disclosures are only required "to the extent necessary for an understanding of the development, performance or position of the company's business."

**Source:** Addleshaw Goddard (2015).

There are a variety of additional guidelines and sources of information regarding reporting corporate sustainability. Examples include Business in the Community, Defra's Environmental Key Performance Indicators, FTSE4Good Indices, Global Reporting Initiative G4 Guidelines, the Pension and Lifetime Savings Association (PLSA) and UN Global Compact and Guiding Principles on Business and Human Rights.

Mark Carney, the Governor of the Bank of England, has expressed his support for enhancing disclosure of climate risks and to ensure that the information is both higher quality and more usable (IPPR, 2016). One body that is currently exploring this is the Financial Stability Board, which has been established to coordinate at the international level the work of national financial authorities and international standard setting bodies. The aim is to develop and promote the implementation of effective regulatory, supervisory and other financial sector policies in the interest of financial stability. Under the Financial Stability Board an industry-led Task Force on Climate-related Financial Disclosures (TCFD) is now considering the physical, liability and transition risks associated with climate change and what constitutes effective corporate financial disclosures in this area. They published their Phase I report in March 2016 which set out the

scope and objectives of the Task Force and fundamental disclosure principles. In their Phase II report, the TCFD will develop a set of recommendations for consistent, comparable, reliable, clear and efficient climate-related disclosures (TCFD, 2016).

### 6.8 Conclusions

The UK Government has outlined a vision for private sector adaptation in the NAP: “UK businesses are resilient to extreme weather and prepared for future risks and opportunities from climate change” (HM Government, 2013). In this section we conclude our assessment with recommendations on priorities to be considered in the next NAP and adaptation programmes of the devolved administrations to achieve this vision.

Our assessment shows that businesses in the UK face a number of risks and opportunities as a result of extreme weather and longer-term climate change, as described for the different business functions above. Overall those risks and opportunities identified in the CCRA2 Evidence Report are broadly in line with those outlined in the earlier CCRA1. However, importantly CCRA2 marks a major shift away from CCRA1 as it focuses on the question ‘based on the latest understanding of current, and future, climate risks/opportunities, vulnerability and adaptation, what should the priorities be for the next UK National Adaptation Programme and the adaptation programmes of the devolved administrations?’

It emerges that addressing barriers that are implicitly limiting the assessment and potential implementation of effective actions should be a priority. Managing the identified risks and making the most of opportunities is not likely, or even possible, unless businesses have appropriate adaptive capacity. Further evidence gathering, including evaluation of the costs and benefits of adaptation measures in practice, to improve the understanding of adaptation actions and barriers, is an important area for further research and investigation.

Actions with different timings will be required. These include actions which address the existing adaptation deficit, those that build resilience through decisions being taken in the short term, and ones that start to plan for long-term climate change challenges. A key determinant for the urgency classification in this CCRA exercise is the question of whether action is necessary and justified now or can be left for a later date. Possible reasons to act now include avoiding ‘locking in’ vulnerability by taking decisions now that are hard to reverse; to secure early and robust benefits through low-regret actions being taken, and if the necessary actions have a long lead time. Businesses should consider these questions in investment appraisals in order to improve the quality of decision making. Enhancing knowledge exchange, sharing of best practice and practical examples between companies including through trade associations will enhance adaptive capacity further.

Additionally, interdependencies between different risk drivers and the responses that businesses can take are often not understood. It is important to recognise that adaptation responses taken by one sector may have implications for others. Another key priority is the review of existing policies and regulations in terms of their potential to support or inhibit private sector adaptation.

#### 6.8.1 Priorities for government action in the next five years

In line with the urgency scoring method for CCRA2 (see Chapter 2), risks and opportunities for business and industry have each been assigned an urgency score for government action in the

next five years. In this section, we recap the risks and opportunities for business and industry under each type of government action over the next five years:

### More action needed

- Bu1 Risks to business sites from flooding (England)

Current and planned adaptation is not sufficient to meet projected increases in the level of flood risk in England. More action is needed to ensure that businesses have the right incentives, information and tools to adapt. An enhanced response is required from both government and the private sector, to avoid continuing development on the floodplain (see Chapter 5), adopt sustainable drainage systems, ensure access to resilient infrastructure, and implement other business continuity efforts. Measures such as business continuity plans are cost-effective to implement, while other measures will help to reduce vulnerability now and to retain flexibility given the uncertain increase in future flood risk.

### Research priority

Most risks to business are scored as a research priority - a reflection of the current evidence base as discussed in Section 6.1.5 of this chapter.

- Bu1: Risks to business sites from flooding (Northern Ireland, Scotland and Wales)

While the projections of the increase in risk are similar to those for England, more research is needed to understand future spending plans and the uptake and impact of flood protection measures in Northern Ireland, Scotland and Wales.

- Bu2: Risks to business from loss of coastal locations and infrastructure

Businesses located or operating in coastal locations face additional risks from sea level rise. Flooding and coastal erosion can lead to loss of coastal business locations or access to them and disrupt infrastructure provision. Research is required to understand the costs and benefits of different adaptation responses to loss of coastal locations for business, and therefore provide the early steps for cost-effective adaptation.

- Bu5: Risks to business from reduced employee productivity, due to infrastructure disruption and higher temperatures in working environments

There is a need for further research to better understand key interdependencies between business and infrastructure, the types of employment at greatest risk, and the effectiveness or unintended consequences of planned or autonomous adaptation. Research will provide the early steps to understanding these interdependencies, and in the case of higher temperatures, adapting workplace temperature guidance and building standards. For example, how building temperatures can be kept in a tolerable range for thermal stress or thermal discomfort reflecting the building's use.

### Sustain current action

- Bu3: Risks to business operations from water scarcity

Reduced water availability is a risk that is expected to increase across the country, with the exception of some catchments in northern Scotland, and some central and west midlands catchments in England. This will impact on water-intensive industries with implications for other sectors across their supply chains. All four UK nations are taking action to increase flexibility and address future water scarcity. National-level reforms and strategies were published or consulted on within the last two years. There is also evidence that businesses, particularly in the food and

drink industry, are taking steps to reduce their water use. Sustained effort will be needed to ensure that abstraction regimes are sufficiently flexible and that businesses are able to build on their existing progress in becoming more water efficient.

- Bu6: Risks to business from disruptions to supply chains and distribution networks

International elements of UK businesses' distribution and supply chains are already impacted, and expected to be more at risk as they may take place in countries deemed highly vulnerable to climate change and less able to adapt. Despite the range of surveys and case studies, data are mostly limited to those reported by larger multi-national companies and it is difficult to evaluate the impact and effectiveness of existing adaptation measures, and existing guidance and tools. Therefore it is important to sustain action in this area to continue increasing understanding and enabling businesses with guidance and tools which are proven to be effective.

### Watching brief

- Bu4: Risks to business from reduced access to capital

There is a large amount of research on the impacts of climate change on the insurance industry and insurers are advanced in modelling climate change risks. However, there is less understanding of the impacts on banking and investment, and the potential implications for access to capital, particularly for smaller businesses. Therefore it is important to monitor the affordability of insurance, access to adaptation funding and to investigate potential tipping points in companies' access to capital that might require intervention.

- Bu7: Risks and opportunities for business from changes in demand for goods and services

Identifying market opportunities and managing risks are core business activities – unless prevented by access to capital or hampered by low adaptive capacity, it is expected that companies will respond to growing risks and opportunities. There is a risk that businesses will be unable to overcome adaptive capacity constraints and relatively little is known about UK companies' sales of adaptation goods and services and the potential for future growth. Therefore ongoing monitoring is important. Small businesses are generally likely to have lower adaptive capacity so would be the least likely to take adaptation action.

### 6.8.2 Knowledge gaps

This Chapter has assessed the current understanding of climate risks and opportunities to businesses and industry in the UK. We have also explored to what extent companies, policy makers and regulators are already responding to these. A key challenge for this exercise is the limited evidence base, particularly with regards to systematic quantitative assessments, but also with regards to relatively simple visualisations of risk and opportunity 'hot spots', as well as in understanding regional concerns and challenges.

While further research will be needed, there is also a strong case for better access to and use of existing data and modelling capabilities. One example is the 1 in 100 initiative (Climate Summit, 2014), which posits that the risk analysis used in the insurance industry could be transferred to other parts of the financial sector and beyond.

Our stakeholder engagement has provided important insights, but the process of engagement should be reviewed for CCRA3. Our investigation shows a significant disconnect between companies, sectors, and across the different government levels in sharing information. Portals such as UKCIP and the regional climate change partnerships are helping to address this, but more needs to be done to foster greater collaboration between sectoral trade bodies, trade



unions and government agencies. Exchanging data and knowledge across government and sharing it with broader stakeholders could also be improved.

A particular knowledge gap exists with regards to the interdependencies arising from climate impacts. These can occur as a result of supply chains (information relating to the risks faced by others is rarely available or accessible); co-located or clustered businesses that share particular infrastructure assets where the resilience of that shared asset is often not known; and reliance on service infrastructure (such as transport or communications) over which a business has no control but could incur costs if it is not operational, for example if a key transport route was flooded and closed. Lack of awareness and understanding of how these complex processes can impact a particular business poses clear risks. Further analysis and investigation, in close collaboration with businesses across different sectors should be a priority.

Similarly, there is only limited understanding of the role of public policy and regulation for private sector adaptation. Investigating if and how policy and regulatory measures can influence the ability of businesses to adapt, the timing of action, and the effectiveness of actions taken by removing barriers and incentivising action should be a research priority. This should also recognise regional differences, as the policy responses may vary.

Finally, there is a lack of evaluation of adaptation measures in practice. Improving understanding of the costs and benefits of these measures is important in enabling businesses to make informed decisions about adaptation.

## Annex 6.A Policy frameworks

**Table 6.A1.** Policy frameworks relevant to business and industry

Policy reference	UK Nation	Key effects of this policy in addressing climate risks
National Adaptation Programme	England	<p>The UK Government stated five objectives in the UK National Adaptation Programme (NAP) (2013) which are relevant to at least some extent for climate risks and opportunities across business functions:</p> <p>Objective 23: To raise awareness and understanding among businesses about climate change risks.</p> <p>Objective 24: To increase the extent to which businesses are actively considering climate change impacts in their risk management and resilience planning and decision-making processes and taking appropriate adaptive action.</p> <p>Objective 25: To raise awareness and understanding among businesses about domestic and international adaptation opportunities.</p> <p>Objective 26: To help businesses better understand and manage climate change risks to their supply chains.</p> <p>Objective 27: To undertake research to increase the understanding of climate change impacts on growth and the economy, working with investors, insurers and other industry partners.</p>
Shoreline Management Plans	England	The Environment Agency in England manages risks of coastal erosion and flooding in conjunction with local authorities. It also oversees the Shoreline Management Plans (SMPs). SMPs provide an assessment of the risks associated with coastal processes and present a long-term policy framework to reduce these risks. They are managed operationally at the local level by the relevant local authorities.
Northern Ireland Executive's 'Preparing for a Changing Climate in Northern Ireland' (Northern Ireland Executive, 2007)	Northern Ireland	Through the Northern Ireland Executive's 'Preparing for a Changing Climate in Northern Ireland' (Northern Ireland Executive, 2007) potential adaptation strategies have been identified that aim to develop specific tools and guidance for various sectors. Through its Climate Change Unit, the DoE is developing climate change adaptation policies that will ultimately lead to a Northern Ireland Adaptation Programme.
Climate Change (Scotland) Act (2009)	Scotland	Through the Climate Change (Scotland) Act (2009) the Scottish Government is committed to implementing a climate change adaptation strategy. The Act places a responsibility on Scottish ministers to produce an 'adaptation programme' to address the risks identified by the CCRA.

Table 6.A1. Policy frameworks relevant to business and industry		
Policy reference	UK Nation	Key effects of this policy in addressing climate risks
		The Climate Change Adaptation Framework (2009) is a non-statutory forerunner to the adaptation programme. The Framework aims to help integrate climate change adaptation and increase resilience across the 12 key sector plans developed under the Adaptation Framework, including a 'Business and Industry Sector Action Plan' (SCCIP, 2010).
Business and Industry Sector Action Plan' (SCCIP, 2010).	Scotland	Under these plans, the Scottish Government and its agencies (particularly the Highlands and Islands Enterprise, Scottish Enterprise and the Scottish Environment Protection Agency) in collaboration with the Scottish Climate Change Impacts Partnership are tasked with helping businesses understand the consequences of climate change and acquiring the necessary skills and knowledge to make adapt. This includes the provision of training and support to various areas of the economy as well as providing tailored, sector-specific advice through guidance, specifically ' <i>Adapting to Climate Change: A guide for businesses in Scotland</i> , 2010'.
The Climate Change Strategy for Wales (2010)	Wales	The Climate Change Strategy for Wales (2010) outlines the country's mitigation plans and the Assembly Government's Adaptation Framework. This Framework develops Sector Adaptation Plans that aim to establish practices that promote adaptation in several key areas. These Sector Adaptation Plans help build consideration of climate change impacts into business planning in Wales and establish support mechanisms to help businesses.
The Adaptation Delivery Plan for Wales's Climate Change Strategy (2010)	Wales	The Adaptation Delivery Plan for Wales's Climate Change Strategy (2010) sets out the policies and programmes that the Assembly Government is expected to implement through its Adaptation Framework, these include 24 actions that help address 6 key areas, including 'business and tourism' (Welsh Government, 2010). Under the Delivery Plan, training for business support advisors and the provision of guidance information through various sources are outlined as specific action points to improve adaptation in Welsh businesses (Welsh Government, 2010).
Adaptation Reporting Power	UK-wide	Reporting on adaptation activities is required by government policy from some sectors. In the first round of reporting over 100 organisations, primarily from the energy, transport and water sectors provided reports under the Adaptation Reporting Power were submitted to Defra. This is in response to Directions to report under the Climate Change Act (2008).
Basel III (BCBS, 2012) stability	UK-wide	Basel III requires regulators to challenge banks more in the construction of their models and broadens regulatory authority under Pillar 2 to require banks to undergo more frequent and demanding

Table 6.A1. Policy frameworks relevant to business and industry		
Policy reference	UK Nation	Key effects of this policy in addressing climate risks
ratio.		stress tests. The Pillar 2 review also consists of a supervisory review enhancement process (SREP) that includes separate assessments of bank capital and governance. The SREP can be utilised to forecast the bank's exposure to systemic risks and related macro-prudential risks (CISL and UNEP FI, 2014).
Business resilience health check tool	UK-wide	Tool rather than policy. An interactive online tool for businesses that uses a questionnaire to help identify businesses vulnerability to a number of risks, including severe weather events and climate change. The tool generates a personal, colour-coded action plan with the actions to prioritise to help increase resilience. Developed in collaboration with Climate UK and Business in the Community. <a href="http://businessresiliencehealthcheck.co.uk/">http://businessresiliencehealthcheck.co.uk/</a>
Sale of Goods Act 1979 and General Product Safety Regulations 2005	UK-wide	Under the Sale of Goods Act 1979, all products must be 'fit for purpose', be of satisfactory quality and fit its description. This means that your products must fulfil the purpose the customer has been led to expect and the reasons that led them to buy it.  General product safety is regulated by the General Product Safety Regulations 2005 (GPS Regulations). They apply to all products (new and second-hand) used by consumers. Product-specific legislation continues to take precedence in areas where the provisions have similar objectives to the GPS Regulations.  The GPS Regulations recognise certain technical standards as carrying a presumption of conformity with the general safety requirement, meaning that products that comply with them are deemed to be safe..
Solvency II Directive (2009) and its statutory receipt (2016)	UK-wide	Solvency rules stipulate the minimum amounts of financial resources that insurers and reinsurers must have in order to cover the risks to which they are exposed. The rules also lay down the principles that should guide insurers' overall risk management so that they can better anticipate any adverse events and better handle such situations. For example, all (re)insurance undertakings must have a regular practice of assessing their overall solvency needs with a view to their specific risk profile, known as 'Own Risk and Solvency Assessment' (ORSA) (European Commission, 2007).
Supply chains adaptation guidance	UK-wide	Guidance rather than policy. The EA's Climate Ready Support Service developed guidance to help UK business supply chains understand and manage domestic and international climate change risks. Several companies, including ASDA, were asked to pilot the guidance. <a href="http://climateuk.net/resource/supply-chains-adaptation-guidance">http://climateuk.net/resource/supply-chains-adaptation-guidance</a>  BIS supports a range of sectors. This often includes investment in

**Table 6.A1.** Policy frameworks relevant to business and industry

Policy reference	UK Nation	Key effects of this policy in addressing climate risks
		capital equipment, associated research and development and improved skills and training support. This type of support is often relevant to suppliers and supply chains that need to adapt to a changing climate.
UK Climate Impacts Programme	UK-wide	Tools rather than policy. The UK Climate Impacts Programme (UKCIP) has also developed a number of tools that help business in this regard. UKCIP's Business Areas Climate Assessment Tool (BACLIAT), for example, is a simple checklist that can be used to assess the potential impacts of climate change at an organisational level.
UK Government's Adapting to Climate Change Programme in 2009	UK-wide	The resilience of infrastructure will also become increasingly important. The Infrastructure & Adaptation project was set up by the UK Government's Adapting to Climate Change Programme in 2009. It examines how to improve the climate resilience of infrastructure. One of the four areas it looked at was ICT. The main threats identified were damage to infrastructure from flooding and extreme weather. Protection against these threats can be seen in the policy frameworks for managing flooding and planning. (Baglee et al., 2012)
Workplace Regulations 1992	UK-wide	<p>Temperatures in the indoor workplace are covered by the Workplace (Health, Safety and Welfare) Regulations 1992, which place a legal obligation on employers to provide a 'reasonable' temperature in the workplace.</p> <p><b>Minimum workplace temperature</b></p> <p>The Approved Code of Practice suggests the minimum temperature in a workplace should normally be at least 16 degrees Celsius. If the work involves rigorous physical effort, the temperature should be at least 13 degrees Celsius. These temperatures are not absolute legal requirements; the employer has a duty to determine what reasonable comfort will be in the particular circumstances.</p> <p><b>Higher workplace temperatures</b></p> <p>A meaningful figure cannot be given at the upper end of the scale due to the high temperatures found in, for example, glass works or foundries. In such environments it is still possible to work safely provided appropriate controls are present. Factors other than air temperature, i.e. radiant temperature, humidity and air velocity, become more significant and the interaction between them become more complex with rising temperatures.</p> <p><b>Risk assessment</b></p> <p>In addition to the Workplace Regulations, the Management of Health and Safety at Work Regulations 1999 require employers to make a suitable assessment of the risks to the health and safety of their</p>

**Table 6.A1.** Policy frameworks relevant to business and industry

Policy reference	UK Nation	Key effects of this policy in addressing climate risks
		<p>employees, and take action where necessary and where reasonably practicable.</p> <p>The temperature of the workplace is one of the potential hazards that employers should address to meet their legal obligations. Employers should consult with employees or their representatives to establish sensible means to cope with high temperatures.</p>



## References

- ABI (Association of British Insurers) (2014) Business interruption insurance.  
<https://www.abi.org.uk/Insurance-and-savings/Products/Business-insurance/Business-interruption-insurance>
- ABI (2015) How the insurance industry supports action on climate change.  
<https://www.abi.org.uk/~media/Files/Documents/Events/2015/Climate%20Change%20data%20flyer.pdf>
- Acas (2014) Homeworking: A Guide for Employers and Employees.  
<http://www.acas.org.uk/media/pdf/o/3/Homeworking-a-guide-for-employers-and-employees.pdf>
- Acclimatise (2012) Adapting to an Uncertain Climate: A World of Commercial Opportunities. Report for UKTI.  
[http://www.acclimatise.uk.com/login/uploaded/resources/The\\_Economist\\_Intelligence\\_Unit\\_adaptation\\_report\\_22\\_03\\_11\\_David\\_Symons.pdf](http://www.acclimatise.uk.com/login/uploaded/resources/The_Economist_Intelligence_Unit_adaptation_report_22_03_11_David_Symons.pdf)
- Acclimatise (2014) Infographic: In 2011 Thailand was under water; but the ripples were felt across the world. <http://www.acclimatise.uk.com/network/article/infographic-in-2011-thailand-was-under-water-but-the-ripples-were-felt-across-the-world>
- Acclimatise (2016) Business Opportunities in a Changing Climate: Managing Impacts and Market Opportunities. Report for the Environment Agency.  
<http://www.acclimatise.uk.com/resources?resource=261>
- Achilles (2013) Supply Chain Mapping. <http://www.achilles.co.uk/en/for-buyers/supply-chain-solutions-portfolio/supply-chain-mapping>
- Addleshaw Goddard (2015) Company Secretary's Checklist – The annual report of a listed company. <https://www.addleshawgoddard.com/en/insights/insights-briefings/2015/corporate/cqc-the-company-secretarys-checklist/>
- AECOM (2015) Becoming Climate Resilient: An Executive Business Case for Climate Resilience.  
<http://www.aecom.com/documents/becoming-climate-resilient/>
- Agrawala, S., Carraro, M., Kingsmill, N., Lanzi, E., Mullan, M. and Prudent-Richard, G., (2011) Private Sector Engagement in Adaptation to Climate Change: Approaches to Managing Climate Risks. OECD Environment Working Papers No.39. OECD Publishing, p. 56.
- Alshebani, M. N. and Wedawatta, G. (2014). Making the construction industry resilient to extreme weather: lessons from construction in hot weather conditions. *Procedia Economics and Finance*, 18, 635-642, doi: 10.1016/S2212-5671(14)00985-X.
- Anglian Water (2007) Strategic Direction Statement 2010-2035.  
[https://www.anglianwater.co.uk/\\_assets/media/strategic-direction-statement.pdf](https://www.anglianwater.co.uk/_assets/media/strategic-direction-statement.pdf)
- Aon Benfield (2015) 2014 Annual Global Climate and Catastrophe Report.  
[http://thoughtleadership.aonbenfield.com/Documents/20150113\\_ab\\_if\\_annual\\_climate\\_catastrophe\\_report.pdf](http://thoughtleadership.aonbenfield.com/Documents/20150113_ab_if_annual_climate_catastrophe_report.pdf)

- Arent, D. and Tol, R. S. J. (2014) Key Economic Sectors and Services. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White, eds.). Cambridge University Press, Cambridge, UK and New York, NY, USA, Chapter 10. [https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/drafts/fd/WGIIAR5-Chap10\\_FGDall.pdf](https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/drafts/fd/WGIIAR5-Chap10_FGDall.pdf)
- ASC (Adaptation Sub-Committee) (2014) Managing Climate Risks to Well-being and the Economy. <https://www.theccc.org.uk/publication/managing-climate-risks-to-well-being-and-the-economy-asc-progress-report-2014/>
- ASC (Adaptation Sub-Committee) (2015) Progress in Preparing for Climate Change. <https://www.theccc.org.uk/publication/reducing-emissions-and-preparing-for-climate-change-2015-progress-report-to-parliament/>
- Asda (2014) The Challenge of a Changing Climate. <http://your.asda.com/press-centre/pwc-climate-change-report>
- Averchenkova, A., Crick, F., Kocornik-Mina, A., Leck, H. and Surminski, S. (2016) Multinational and large national corporations and climate adaptation: are we asking the right questions? A review of current knowledge and a new research perspective. Wiley Interdisciplinary Reviews: Climate Change (in press).
- AXA (2011) AXA International Small Business Report 2011. [https://www.axa.es/documents/1119421/1525386/estudiopymesgrupoaxa\\_tcm5-6687.pdf/ea61ca4a-c78d-4daf-a897-106ff048529b](https://www.axa.es/documents/1119421/1525386/estudiopymesgrupoaxa_tcm5-6687.pdf/ea61ca4a-c78d-4daf-a897-106ff048529b)
- AXA and UNEP FI PSI (United Nations Environment Programme Finance Initiatives Principle for Sustainable Insurance) (2015) Business Unusual: Why the Climate is Changing the Rules for our Cities and SMEs. [http://www.unepfi.org/fileadmin/documents/business\\_unusual.pdf](http://www.unepfi.org/fileadmin/documents/business_unusual.pdf)
- Baglee, A., Haworth, A. and Anastasi, S. (2012) Climate Change Risk Assessment for the Business, Industry and Services Sector. <http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=15747#RelatedDocuments>
- BCBS (Basel Committee on Banking Supervision) (2011) International Regulatory Framework for Banks (Basel III). <http://www.bis.org/bcbs/basel3.htm>
- BCI (Business Continuity Institute) (2015) Supply Chain Resilience Report 2015. [http://www.thebci.org/index.php/businesscontinuity/cat\\_view/24-supply-chain-continuity/33-supply-chain-continuity/140-bci-resources](http://www.thebci.org/index.php/businesscontinuity/cat_view/24-supply-chain-continuity/33-supply-chain-continuity/140-bci-resources)
- BCI (2016) The Good Practice Guidelines. <http://www.thebci.org/index.php/resources/the-good-practice-guidelines>
- Bhattacharya-Mis, N. and Lamond, J. (2014) An investigation of patterns of response and recovery among flood affected businesses in the UK: Case study in Sheffield and Wakefield. In: Flood Recovery, Innovation and Response IV (Proverbs, D. and Brebbia, C., eds.). WIT Press, Ashurst. <http://eprints.uwe.ac.uk/23471>

- BIS (Department for Business, Innovation and Skills) (2012) SME Access to External Finance. BIS ECONOMICS PAPER NO. 16.  
[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/32263/12-539-sme-access-external-finance.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/32263/12-539-sme-access-external-finance.pdf)
- BIS (2015a) Business population estimates 2015.  
<https://www.gov.uk/government/statistics/business-population-estimates-2015>
- BIS (2015b) Product safety for manufacturers. <https://www.gov.uk/guidance/product-safety-for-manufacturers>
- BMG Research (2011) Cumbria Business Survey 2010 - Research report. Cumbria, Cumbria Intelligence Observatory.  
<http://www.cumbriaobservatory.org.uk/elibrary/Content/Internet/536/675/1764/1778/4056194836.pdf>
- Bosher, L. (2013) Flood Risk Management and the Roles of the Private Sector in England.  
<http://www.preventionweb.net/english/hyogo/gar/2013/en/bgdocs/Bosher,%202012.pdf>
- Botzen, J., Aerts, J. and van den Bergh, J. (2009) Willingness of homeowners to mitigate climate risk through insurance. *Ecological Economics*, 2265-2277.  
<http://www.sciencedirect.com/science/article/pii/S092180090900072X>
- Bridges Ventures (2014) Bridges Social Impact Bond Fund. <http://bridgesventures.com/social-sector-funds/social-impact-bond-fund>
- Bristol University (2015) Consortium wins grant to explore climate change and possible risk to health. <http://www.bristol.ac.uk/news/2015/november/climate-change-health.html>
- British Geological Survey (2016) Landslide Case Studies.  
<http://www.bgs.ac.uk/landslides/casestudies.html>
- Cabinet Office (2014) Resilience in Society: Infrastructure, Communities and Businesses.  
<https://www.gov.uk/guidance/resilience-in-society-infrastructure-communities-and-businesses>
- Cabinet Office (2015) Local resilience forums: contact details.  
<https://www.gov.uk/guidance/local-resilience-forums-contact-details>
- Capon, R. and Oakley, G. (2012) Climate Change Risk Assessment for the Built Environment Sector. UK 2012 Climate Change Risk Assessment.  
<http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=15747#RelatedDocuments>
- Carbon Clear (2016) Fact Sheet: Climate Risks and Opportunities. <http://carbon-clear.com/what-we-do/carbon-strategy/operational-climate-adaptation-programme-ocap/>
- CBI (Confederation of British Industry) and Harvey Nash (2011) Navigating choppy waters – CBI/Harvey Nash employment trends survey 2011.  
[http://www.cbi.org.uk/media/955608/2011.06-navigating\\_choppy\\_waters\\_-\\_employment\\_trends\\_survey.pdf](http://www.cbi.org.uk/media/955608/2011.06-navigating_choppy_waters_-_employment_trends_survey.pdf)
- CDP (2012) Insights into Climate Change Adaptation by UK Companies. CDP for Department for Environment, Food and Rural Affairs. <https://www.cdp.net/CDPResults/insights-into-climate-change-adaptation-by-uk-companies.pdf>

- CDP (2013) Investor CDP 2013 Information Request: Nestlé. <https://www.cdp.net/en-US/Results/Pages/overview.aspx>
- CDP (2014) Climate Change Resilience in Europe. <https://www.cdp.net/CDPResults/climate-change-resilience-europe.pdf>
- CDP (2016) From Agreement to Action: Mobilizing suppliers toward a climate resilient world. <https://www.cdp.net/CDPResults/CDP-Supply-Chain-Report-2016.pdf>
- Chatterton, J., Viavattene, C., Morris, J., Penning-Rowsell, E. and Tapsell, S. (2010) The Costs of the Summer 2007 Floods in England. Report to the Environment Agency. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/291190/sch\\_o1109brja-e-e.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/291190/sch_o1109brja-e-e.pdf)
- Chatterton, J., Clarke, C., Daly, E., Dawks, S., Elding, C., Fenn, T., Hick, E., Miller, J., Morris, J., Ogunyoye, F. and Salado, R. (2016) The Costs and Impacts of the Winter 2013 to 2014 Floods. Report for the Environment Agency. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/501784/The\\_costs\\_and\\_impacts\\_of\\_the\\_winter\\_2013\\_to\\_2014\\_floods\\_-\\_report.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/501784/The_costs_and_impacts_of_the_winter_2013_to_2014_floods_-_report.pdf)
- CIBSE (Chartered Institute of Building Services Engineers) (2013) TM52 limits of thermal comfort: Avoiding overheating. <http://www.cibse.org/knowledge/cibse-tm/tm52-limits-of-thermal-comfort-avoiding-overheating>
- CIPS (Chartered Institute of Purchasing and Supply) (2014) CIPS Risk Index. <http://www.cips.org/en-GB/News/news/CIPS-Risk-Index/>
- CISL (University of Cambridge Institute for Sustainability Leadership) (2015) Unhedgeable Risk: How Climate Change Sentiment Impacts Investment. <http://www.cisl.cam.ac.uk/publications/publication-pdfs/unhedgeable-risk.pdf>
- CISL and UNEP FI (United Nations Environment Programme Finance Initiatives) (2014) Stability and Sustainability in Banking Reform: Are Environmental Risks Missing in Basel III? <http://www.cisl.cam.ac.uk/publications/publication-pdfs/stability-and-sustainability-basel-iii-final-repor.pdf>
- City of London (2014) Business Resilience: Planning Considerations. <http://www.cityoflondon.gov.uk/business/support-promotion-and-advice/business-continuity-advisory-centre/city-of-london-resilience-forum/Documents/business-resilience-planning-considerations.pdf>
- Civil Aviation Authority (2015) Airport data 2015: Table 13.2 Freight 2005—2015. [https://www.caa.co.uk/uploadedFiles/CAA/Content/Standard\\_Content/Data\\_and\\_analysis/Datasets/Airport\\_stats/Airport\\_data\\_2015/Table\\_13\\_2\\_Freight\\_2005\\_2015.pdf](https://www.caa.co.uk/uploadedFiles/CAA/Content/Standard_Content/Data_and_analysis/Datasets/Airport_stats/Airport_data_2015/Table_13_2_Freight_2005_2015.pdf)
- CJC Consulting (2002) Evaluating the economic impact of abstraction controls on high and medium volume water users in Scotland. Report for the Scottish Executive Environment and Rural Affairs Department Water Environment Unit. <http://www.gov.scot/resource/doc/46997/0014803.pdf>
- Climate Bonds Initiative (2015a) Tax Incentives for Issuers and Investors. <https://www.climatebonds.net/policy/policy-areas/tax-incentives>
- Climate Bonds Initiative (2015b) Standards. <http://www.climatebonds.net/standards>

- Climate Ready (2013) Assessing and Managing Climate Change Risks in Supply Chains. <http://climateuk.net/sites/default/files/Supply%20Chains.pdf>
- Climate Summit (2014) Integrating Risks into the Financial System: The 1-in-100 Initiative. <http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/RESILIENCE-1-in-100-initiative.pdf>
- Climatewise (2015a) Climate Change Risk Roundtable One: A level playing field for incorporating future climate risk into business practice – what’s the ‘new normal’? <http://www.cisl.cam.ac.uk/business-action/sustainable-finance/climatewise/pdfs/Climate%20Risk%20Roundtable%201%20Summary%20Note%20-%20Feb%202015.pdf>
- Climatewise (2015b) Climate Risk Roundtable Two: Market Implications of Climate Risk with a Focus on the Property Sector. <http://www.cisl.cam.ac.uk/business-action/sustainable-finance/climatewise/pdfs/climate-change-risk-roundtable-two-summary.pdf>
- CMI (Chartered Management Institute) (2013) Weathering the Storm: 2013 Business Continuity Management Survey. <http://www.managers.org.uk/insights/research/current-research/2013/march/weathering-the-storm>
- CML (Council of Mortgage Lenders). CML lenders’ handbook for conveyances. <https://www.cml.org.uk/lenders-handbook/>
- Collier, B.L. (2014) Natural Disasters and Credit Supply Shocks. Wharton working paper. [http://opim.wharton.upenn.edu/risk/library/WP201402\\_BLC\\_Disasters+CreditSupply.pdf](http://opim.wharton.upenn.edu/risk/library/WP201402_BLC_Disasters+CreditSupply.pdf)
- Coombes, E. G. and Jones, A. P. (2010) Assessing the impact of climate change on visitor behaviour and habitat use at the coast: A UK case study. *Global Environmental Change*, 20, 303-313. <http://wordpress.reilumatkailu.fi/wp-content/uploads/2012/04/artikkeli23.pdf>
- Crichton, D. (2006) Climate Change and its Effects on Small Businesses in the UK. AXA Insurance UK plc. <http://nationalfloodforum.org.uk/wp-content/uploads/AXA-Climate-Change-and-its-effects-on-small-businesses-in-the-UK.pdf>
- Crissinger, J. (2005) Design and Construction vs Weather. <http://www.rcionline.org/interface-articles-2005.html>
- Cumbria Intelligence Observatory (2010) Cumbria Floods November 2009: An Impact Assessment. <http://www.cumbria.gov.uk/eLibrary/Content/Internet/536/671/4674/4026717419.pdf>
- DAERA (Department of Agriculture, Environment and Rural Affairs) (2014) Northern Ireland Climate Change Adaptation Programme. [http://www.nienvironmentlink.org/cmsfiles/policy-hub/files/documentation/Climate/ni\\_climate\\_change\\_adaptation\\_programme\\_\\_niap\\_\\_-\\_pdf\\_for\\_web\\_page\\_-\\_jan\\_2014.pdf](http://www.nienvironmentlink.org/cmsfiles/policy-hub/files/documentation/Climate/ni_climate_change_adaptation_programme__niap__-_pdf_for_web_page_-_jan_2014.pdf)
- Defra (Department for Environment, Food and Rural Affairs) (2011a) Flood and Coastal Resilience Partnership Funding Defra Policy Statement on an Outcome-Focused, Partnership Approach to Funding Flood and Coastal Erosion Risk Management. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/221094/pb13896-flood-coastal-resilience-policy.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221094/pb13896-flood-coastal-resilience-policy.pdf)
- Defra (2011b) Introducing Retail Competition in the Water Sector. IA No: Defra 1346. [http://www.legislation.gov.uk/ukia/2011/304/pdfs/ukia\\_20110304\\_en.pdf](http://www.legislation.gov.uk/ukia/2011/304/pdfs/ukia_20110304_en.pdf)



- Defra (2014) £2.3 billion to be spent on new flood defences.  
<https://www.gov.uk/government/news/23-billion-to-be-spent-on-new-flood-defences>
- Defra (2015) 2010 to 2015 Government Policy: Climate Change Adaptation.  
<https://www.gov.uk/government/publications/2010-to-2015-government-policy-climate-change-adaptation/2010-to-2015-government-policy-climate-change-adaptation#appendix-1-adaptation-reporting-power>
- Defra (2016) Reforming the Water Abstraction Management System: Making the Most of Every Drop. <https://www.gov.uk/government/consultations/reforming-the-water-abstraction-management-system-making-the-most-of-every-drop#history>
- Deloitte (2013) Tourism: jobs and growth – The economic contribution of the tourism economy in the UK. [https://www.visitbritain.org/sites/default/files/vb-corporate/Documents-Library/documents/Tourism\\_Jobs\\_and\\_Growth\\_2013.pdf](https://www.visitbritain.org/sites/default/files/vb-corporate/Documents-Library/documents/Tourism_Jobs_and_Growth_2013.pdf)
- DfI (Department for Infrastructure) (2010) Regional Development Strategy: RDS 2035.  
[https://www.infrastructure-ni.gov.uk/sites/default/files/publications/drd/Regional%20Development%20Strategy%202035\\_0.pdf](https://www.infrastructure-ni.gov.uk/sites/default/files/publications/drd/Regional%20Development%20Strategy%202035_0.pdf)
- DfI (2016) Sustainable Water: A Long-Term Water Strategy for Northern Ireland (2015-2040).  
<https://www.infrastructure-ni.gov.uk/publications/sustainable-water-long-term-water-strategy-northern-ireland-2015-2040>
- DfT (Department for Transport) (2015) Maritime statistics tables: Table TSGB0501 (PORT0102).  
<https://www.gov.uk/government/statistical-data-sets/tsgb05-maritime>
- Douglas, R. (2014) Integrating Natural Disaster Risks & Resilience into the Financial System. Willis Research Network. <http://www.willis.com/Articles/storypage/Climate1/>
- Downing, T. E. (2012) Views of the frontiers of climate change adaptation economics. WIREs Climate Change. <http://onlinelibrary.wiley.com/doi/10.1002/wcc.157/abstract>
- Enterprise Nation (2014) Big business steps up to help those in need.  
<https://www.enterprisenation.com/blog/posts/big-business-steps-up-to-help-those-in-need>
- Environment Agency (2011) Understanding the Risks, Empowering Communities, Building Resilience: The National Flood and Coastal Erosion Risk Management Strategy for England.  
[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/228898/9780108510366.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228898/9780108510366.pdf)
- Environment Agency (2013) Current and Future Water Availability – addendum: A refresh of the Case for Change Analysis.  
<http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/geho1111bvep-e-e.pdf>
- Environment Agency (2014) Flood and Coastal Erosion Risk Management: Long-term Investment Scenarios (LTIS) 2014.  
[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/381939/FCRM\\_Long\\_term\\_investment\\_scenarios.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/381939/FCRM_Long_term_investment_scenarios.pdf)
- Environment Agency (2016) Estimated abstractions from all sources except tidal by purpose and Environment Agency/NRW charge region: 2000 to 2014.  
<https://www.gov.uk/government/statistical-data-sets/env15-water-abstraction-tables>



- European Commission (2007) 'SOLVENCY II': Frequently Asked Questions (FAQs).  
[http://europa.eu/rapid/press-release\\_MEMO-07-286\\_en.htm?locale=en](http://europa.eu/rapid/press-release_MEMO-07-286_en.htm?locale=en)
- European Commission (2009) Solvency II Directive 2009/138/EC.  
[http://ec.europa.eu/finance/insurance/solvency/solvency2/index\\_en.htm](http://ec.europa.eu/finance/insurance/solvency/solvency2/index_en.htm)
- European Commission (2011) Guidelines for Project Managers: Making vulnerable investments climate resilient.  
[http://ec.europa.eu/clima/policies/adaptation/what/docs/non\\_paper\\_guidelines\\_project\\_managers\\_en.pdf](http://ec.europa.eu/clima/policies/adaptation/what/docs/non_paper_guidelines_project_managers_en.pdf)
- European Commission (2014) Assessing the Implications of Climate Change Adaptation on Employment in the EU.  
[http://ec.europa.eu/clima/policies/adaptation/what/docs/climate\\_change\\_employment\\_eu\\_en.pdf](http://ec.europa.eu/clima/policies/adaptation/what/docs/climate_change_employment_eu_en.pdf)
- European Commission (2015) A European Research and Innovation Roadmap for Climate Services. <http://bookshop.europa.eu/en/a-european-research-and-innovation-roadmap-for-climate-services-pbKI0614177/>
- European Commission (2016) Horizon 2020 Work Programme 2016 – 2017: 12. Climate Action, Environment, Resource Efficiency and Raw Materials.  
[http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016\\_2017/main/h2020-wp1617-climate\\_en.pdf#page=7](http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-climate_en.pdf#page=7)
- Eurostat (2016) Modal split of freight transport. <http://ec.europa.eu/eurostat/web/products-datasets/-/tsdtr220>
- Food and Drink Federation (2015) Five-fold Environmental Ambition: Progress Summary 2015.  
[https://www.fdf.org.uk/environment\\_progress\\_report.aspx](https://www.fdf.org.uk/environment_progress_report.aspx)
- Foresight Report (2011) Foresight International Dimensions of Climate Change: Final Project Report. The Government Office for Science.  
<https://www.gov.uk/government/publications/international-dimensions-of-climate-change>
- Frontier Economics (2014) Flood and Coastal Erosion Risk Management and the Local Economy. Report to Defra and the Environment Agency.  
<http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=18690&FromSearch=Y&Publisher=1&SearchText=Fd2662&SortString=ProjectCode&SortOrder=Asc&Paging=10#TimeScaleAndCost>
- Frontier Economics, Irbaris and Ecofys (2013) The Economics of Climate Resilience. Report to Defra.  
<http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=18016>
- FSA (Financial Services Authority) (2003) Individual Capital Adequacy Standard.  
<http://www.fsa.gov.uk/pubs/policy/ps136.pdf>
- FSB (Federation of Small Businesses) (2014) Floods Cost Small Firms £831 million.  
<http://www.fsb.org.uk/news.aspx?rec=8544>
- FSB (2015) Severe Weather: A More Resilient Small Business Community.  
<http://www.fsb.org.uk/frontpage/assets/fsb-severe-weather-report-final.pdf>

- Geneva Association (2013) Warming of the Oceans and Implications for the (Re)insurance Industry. [https://www.genevaassociation.org/media/616661/ga2013-warming\\_of\\_the\\_oceans.pdf](https://www.genevaassociation.org/media/616661/ga2013-warming_of_the_oceans.pdf)
- GHK (2010) Opportunities for UK Business from Climate Change Adaptation. <http://www.greensuffolk.org/assets/Greenest-County/Adaptation/General/Business/Business-opportunities-from-climate-adaptation.pdf>
- Glenigan and CITB (2015) UK Industry Performance Report: Based on the UK Construction Industry Key Performance Indicators. Report to BIS. [https://www.glenigan.com/sites/default/files/UK\\_Industry\\_Performance\\_Report\\_2015\\_883.pdf](https://www.glenigan.com/sites/default/files/UK_Industry_Performance_Report_2015_883.pdf)
- Gregory, D. (2013) Private equity and financial stability. Bank of England Quarterly Bulletin, 2013, Q1. <http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2013/qb130104.pdf>
- Harrison, S. J., Winterbottom, S. J. and Sheppard, C. (1999) The potential Effects of Climate Change on the Scottish Tourist Industry. <http://www.sciencedirect.com/science/article/pii/S0261517798000727>
- Herbane, B. (2010) Small Business Research: Time for a Crisis-Based View. <http://isb.sagepub.com/content/28/1/43.abstract>
- Herweijer, C., Ranger, N. and Ward, R. (2009) Adaptation to Climate Change: Threats and Opportunities for the Insurance Industry. The Geneva Papers (2009), 34, 360-380. doi:10.1057/gpp.2009.13
- HM Government (2009) Shoreline Management Plans. <https://www.gov.uk/government/publications/shoreline-management-plans-smpls>
- HM Government (2012) National Planning Policy Framework. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/6077/2116950.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf)
- HM Government (2013) The National Adaptation Programme: Making the country resilient to a changing climate. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/209866/pb13942-nap-20130701.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209866/pb13942-nap-20130701.pdf)
- HM Government (2014) UK Floods: £10 million Support Scheme for Flood Affected Businesses. <https://www.gov.uk/government/news/uk-floods-10-million-support-scheme-for-flood-affected-businesses>
- HM Government (2016) Finance and Support for your Business. <https://www.gov.uk/business-finance-support-finder>
- HMRC (HM Revenue and Customs) (2008) UK Regional trade statistics: First quarter 2008. <https://www.uktradeinfo.com/Statistics/RTS/Pages/RTSArchive.aspx>
- HMRC (2016) UK Regional trade statistics: Fourth quarter 2015. <https://www.uktradeinfo.com/Statistics/RTS/Pages/default.aspx>
- Hosono, K. and Miykawa, D. (2014) Natural Disasters, Firm Activity, and Damage to Banks. <http://voxeu.org/article/natural-disasters-firm-activity-and-damage-banks>

- HR Wallingford, Centre for Ecology and Hydrology, British Geological Survey and Amec Foster Wheeler (2015) CCRA2: Updated Projections for Water Availability for the UK: Final Report for the Adaptation Sub-Committee. <https://www.theccc.org.uk/publication/climate-change-risk-assessment-ii-updated-projections-for-water-availability-for-the-uk/>
- HSE (2005) Findings of an expert panel engaged to conduct a scoping study on survival design of floating production storage and offloading vessels against extreme metocean conditions. Research Report 357. PAFA Consulting for the Health and Safety Executive, London, UK.
- HSE (2013) Construction Dust. <http://www.hse.gov.uk/pubns/cis36.pdf>
- HSE (Health and Safety Executive) (2016) Temperature – Law. <http://www.hse.gov.uk/temperature/law.htm>
- Humber Local Enterprise Partnership (2014) Humber Local Enterprise Partnership: Working to Reduce the Risk of Flooding. <http://www.humberlep.org/news159/>
- ICAEW (2010) External Debt Financing of UK Business. July 2010 Research report. <https://www.icaew.com/~media/corporate/files/about%20icaew/what%20we%20do/business%20confidence%20monitor/special%20reports/business%20opinion%20report%20july%202010%20external%20debt%20financing%20of%20uk%20businesses.ashx>
- IEMA (Institute of Environmental Management and Assessment) (2013) CCA Business Case Guidance. <http://www.oldsite.iema.net/readingroom/articles/cca-business-case-guidance>
- Ingirige, B. and Russell, R. (2015) Investigating SME resilience to flooding – the Braunton Report. <http://www.nationalfloodforum.org.uk/wp-content/uploads/SME-resilience-Braunton-Dec2015.pdf>
- IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White, eds.). Cambridge University Press, Cambridge, UK and New York, NY, USA. <http://www.ipcc.ch/report/ar5/wg2/>
- IPPR (2016) Known Unknowns: The Hidden Threats that Climate Risks Pose to British Prosperity (2nd edn). <http://www.ippr.org/publications/known-unknowns-the-hidden-threats-that-climate-risks-pose-to-british-prosperity>
- Ipsos Mori (2015) Affordability and Availability of Flood Insurance Findings from Research with Businesses. Report to Defra. [https://www.ipsos-mori.com/Assets/Docs/Publications/SRI\\_Availability-and-Affordability-of-Flood-Insurance-Business\\_26112015.pdf](https://www.ipsos-mori.com/Assets/Docs/Publications/SRI_Availability-and-Affordability-of-Flood-Insurance-Business_26112015.pdf)
- JBA Consulting (2014) Assessing the Flood Risk Management Benefits of Property Level Protection. Report to Scottish Government. <http://www.gov.scot/Resource/0046/00466210.pdf>
- Jenco Consultancy Ltd and Climate Resilience Ltd (2014) Research to ascertain the proportion of block paving sales in England that are permeable. Report to ASC. [https://www.theccc.org.uk/wp-content/uploads/2014/07/7-ASC-paving-survey-report\\_for-publication.pdf](https://www.theccc.org.uk/wp-content/uploads/2014/07/7-ASC-paving-survey-report_for-publication.pdf)

- Jenkins, K., Surminski, S., Hall, J. and Crick, F. (2016) Assessing Surface Water Flood Risk and Management Strategies under Future Climate Change: An Agent-Based Model approach. Centre for Climate Change Economics and Policy Working Paper No.252. Grantham Research Institute on Climate Change and the Environment Working Paper No.223.
- J Sainsbury plc (2016) Creating a Water Sustainable Business. <http://www.j-sainsbury.co.uk/responsibility/case-studies/2015/creating-a-water-sustainable-business/>
- K-Matrix (2013) Adaptation and Resilience to Climate Change (ARCC): Report for BIS, 2011/12.
- Lamond, J. E., Wilkinson, S. J., Rose, C. B. and Proverbs, D. G. (2014) Sustainable urban drainage – Retrofitting for improved flood mitigation in city centres. Report for the Royal Institution of Chartered Surveyors. <http://www.rics.org/uk/knowledge/research/research-reports/sustainable-urban-drainage/>
- Large, A. and Oliver Wyman (2013) RBS Independent Lending Review. [www.independentlendingreview.co.uk](http://www.independentlendingreview.co.uk)
- Linnenluecke, M. and Griffiths, A. (2010) Beyond adaptation: Resilience for business in light of climate change and weather extremes. *Business and Society*, 49, 3, 477-511. <http://bas.sagepub.com/content/49/3/477.abstract>
- Linnenluecke, M. K., Griffiths, A. and Winn, M. (2012) Extreme weather events and the critical importance of anticipatory adaptation and organizational resilience in responding to impacts. *Business Strategy and the Environment*, 21, 17-32. <http://onlinelibrary.wiley.com/doi/10.1002/bse.708/abstract>
- Lloyds (2014) Catastrophe Modelling and Climate Change. <https://www.lloyds.com/~media/lloyds/reports/emerging%20risk%20reports/cc%20and%20modelling%20template%20v6.pdf>
- Localise West Midlands (2015) Impact of Flooding and Flood Risk on Community Economic Resilience in the Upper Calder Valley. Report to Calderdale Council and Defra. <http://www.nationalfloodforum.org.uk/wp-content/uploads/Calderdale-flooding-community-economic-resilience-final-Jan-2015.pdf>
- LV= (2015) Equity Release lending policy. <https://www.lv.com/lifeassets/assets/documents/lv-equity-release-lending-policy.pdf>
- Marks and Spencer and WWF (2014) Case study - Freshwater Stewardship. [https://corporate.marksandspencer.com/documents/plan-a-2015/wwf\\_freshwater.pdf](https://corporate.marksandspencer.com/documents/plan-a-2015/wwf_freshwater.pdf)
- Martin, R., Muûls, M. and Ward, A. (2011) The Sensitivity of UK Manufacturing Firms to Extreme Weather Events. [http://archive.theccc.org.uk/aws2/ASC%202nd%20Report/LSE\\_final.pdf](http://archive.theccc.org.uk/aws2/ASC%202nd%20Report/LSE_final.pdf)
- Mercer (2015) Investing in a Time of Climate Change. <http://www.mercer.com/our-thinking/investing-in-a-time-of-climate-change.html>
- MET Office and AIR Worldwide (2009) The Financial Risks of Climate Change. Report for the Association of British Insurers. <http://www.metoffice.gov.uk/services/finance/abi-report>
- MetraWeather (2015) Powerful weather intelligence. <http://www.weathercommerce.net/>
- Mills, E. (2003) Climate change, insurance and the buildings sector: Technological synergisms between adaptation and mitigation. *Building Research and Information*, 31, 3, 257-277. <http://www.tandfonline.com/doi/abs/10.1080/0961321032000097674#.V0HSqfkrLIU>

- MMS (MacLay Murray & Spens LLP) (2013) Evaluating Flood Risk: Buyers and Lenders.  
<http://www.mms.co.uk/MMSKnowledge/email-news.aspx?pageid=75474>
- Murray, C. and Marmorek, D. R. (2004) Adaptive Management: A spoonful of rigour helps the uncertainty go down. In: Proceedings of the 16th Annual Society for Ecological Restoration Conference, Victoria, BC, August 24–26 2004.  
[http://www.essa.com/media/Murray\\_Marmorek\\_adaptive\\_management\\_SER\\_conference.pdf](http://www.essa.com/media/Murray_Marmorek_adaptive_management_SER_conference.pdf)
- Natural England (2014) Heritage Counts 2014: The value and impact of heritage.  
<http://hc.historicengland.org.uk/content/pub/2190644/value-impact-chapter.pdf>
- Nestlé (2012) Nestlé Helps Farmers Prepare for Climate Change.  
<http://www.nestle.co.uk/Media/NewsFeatures/Nestle-helps-farmers-adapt-to-climate-change->
- Network Rail (2015) Britain relies on rail freight. <http://www.networkrail.co.uk/asp/10439.aspx>
- Nicholls, R. J. (2012) Indirect Impacts of Coastal Climate Change and Sea-level Rise: The UK Example. <http://www.tandfonline.com/doi/pdf/10.1080/14693062.2012.728792>
- Northern Ireland Executive (2007) Preparing for a Changing Climate in Northern Ireland.  
[http://www.ukcip.org.uk/wp-content/PDFs/Preparing\\_CC\\_NI.pdf](http://www.ukcip.org.uk/wp-content/PDFs/Preparing_CC_NI.pdf)
- Northern Ireland Executive (2012) Economic strategy: Priorities for sustainable growth and prosperity. <http://www.northernireland.gov.uk/ni-economic-strategy-revised-130312.pdf>
- Norrington, H. and Underwood, K. (2008) Climate change and small businesses: How directors are responding to the challenges of climate change. Research Findings 2008, Climate South East, Guildford.
- NRTEE and NBS (National Round Table on the Environment and the Economy and Network for Business Sustainability) (2011) Managing the Business Risks and Opportunities of a Changing Climate. A Primer for Executives on Adaptation to Climate Change. <http://nbs.net/wp-content/uploads/Adaptation-to-Climate-Change-Primer.pdf> (accessed 8 August 2014).
- OECD (Organisation for Economic Co-operation and Development) (2015) The Economic Consequences of Climate Change. [http://www.oecd-ilibrary.org/environment/the-economic-consequences-of-climate-change\\_9789264235410-en](http://www.oecd-ilibrary.org/environment/the-economic-consequences-of-climate-change_9789264235410-en)
- OECD (2016) Glossary of statistical terms: Non-residential buildings - UN.  
<https://stats.oecd.org/glossary/detail.asp?ID=1833>
- ONS (Office for National Statistics) (2014) Characteristics of home workers, 2014.  
<http://www.ons.gov.uk/ons/rel/lmac/characteristics-of-home-workers/2014/rpt-home-workers.html>
- ONS (2015) Figure 7: Industrial variation in total GVA in the UK countries. Regional Gross Value Added (Income Approach): December 2015.  
<http://www.ons.gov.uk/economy/grossvalueaddedgva/bulletins/regionalgrossvalueaddedincomeapproach/december2015>
- ONS (2016a) Gross Domestic Product: chained volume measures: Seasonally adjusted £m.  
<https://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/abmi>



- ONS (2016b) Balance of Payments: Trade in Goods & Services: Total exports: CP SA £m, Balance of Payments: Trade in Goods & Services: Total imports: CP SA £m and Gross Domestic Product (GDP) – CP. CDIDs: IKBH, IKBI and YBHA.
- ONS (2016c) Climate Change Survey Consultation.  
<https://www.ons.gov.uk/aboutus/whatwedo/statistics/consultationsandsurveys/allconsultationsandsurveys/climatechangesurveyconsultation>
- ONS (2016d) Workforce jobs by industry section (SIC 2007) - seasonally adjusted (December 2015). Accessed through NOMIS. <https://www.nomisweb.co.uk/>
- Park, J. (2015) The Labor Productivity Impacts of Climate Change: Implications for Global Poverty.  
[http://www.worldbank.org/content/dam/Worldbank/document/Climate/Climate%20and%20Poverty%20Conference/D2S3\\_Park\\_Labor%20Productivity%20Impacts%20from%20Climate%20Change%20-%20Feb%2010%202015%20v13short.pdf](http://www.worldbank.org/content/dam/Worldbank/document/Climate/Climate%20and%20Poverty%20Conference/D2S3_Park_Labor%20Productivity%20Impacts%20from%20Climate%20Change%20-%20Feb%2010%202015%20v13short.pdf)
- Pattani, A., Vera, G. and Wackett, J. (2011) Going Public: UK Companies' Use of Capital Markets.  
<http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb110403.pdf>
- Petkov, M., Coleman, M. and Sugrue, D. (2014) Climate Change Could Sting Reinsurers That Underestimate its Impact," in Standard & Poor's Rating Services' Global Insurance Highlights.  
[https://www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1356905&SctArtId=260148&from=CM&nsI\\_code=LIME&sourceObjectId=8706036&sourceRevId=1&fee\\_ind=N&exp\\_date=20240902-15:44:53](https://www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1356905&SctArtId=260148&from=CM&nsI_code=LIME&sourceObjectId=8706036&sourceRevId=1&fee_ind=N&exp_date=20240902-15:44:53)
- Pottinger, G. and Tanton, A. (2014) Flooding and UK commercial property investment: what is the risk? *Qualitative Research in Financial Markets*, 6, 2, 211-226.  
<http://www.emeraldinsight.com/doi/abs/10.1108/QRFM-10-2012-0029>
- PRA (Prudential Regulation Authority) (2015) The Impact of Climate Change on the UK Insurance Sector: A Climate Change Adaptation Report by the Prudential Regulation Authority.  
<http://www.bankofengland.co.uk/pradocuments/supervision/activities/pradefra0915.pdf>
- PwC (2013) International Threats and Opportunities of Climate Change for the UK.  
<http://pwc.blogs.com/files/international-threats-and-opportunities-of-climate-change-to-the-uk.pdf>
- QBE Insurance (2014) Flood Emergency Response.  
<http://www.qbeurope.com/documents/riskmanagement/property/technical-guides/flood%20emergency%20response.pdf>
- Ranger and Surminski (2013) A preliminary assessment of the impact of climate change on non-life insurance demand in the BRICS economies.  
<http://www.sciencedirect.com/science/article/pii/S2212420912000404>
- Ridley, M. and Boland, D. (2015) Integrating water stress into corporate bond credit analysis: Benchmarking companies in three sectors. Commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ).  
<http://www.naturalcapitaldeclaration.org/bonds-water-scarcity/>
- Roelich, K. (2015) Financing Infrastructure and Built Environment Adaptation to Climate Change. University of Leeds report for ClimateXchange, Adaptation Scotland, EPSRC and the ARCC network. <http://adaptationscotland.org.uk/3/213/0/Financing-adaptation-of-infratructure.aspx>



- Sayers, P. B., Horritt, M. S., Penning-Rowsell, E. and McKenzie, A. (2015) Climate Change Risk Assessment 2017: Projections of Future Flood Risk in the UK. Report for the Adaptation Sub-Committee. <https://www.theccc.org.uk/publication/sayers-for-the-asc-projections-of-future-flood-risk-in-the-uk/>
- SCCIP (Scottish Climate Change Impacts Partnership) (2010) Adaptation to Climate Change – a Guide for Businesses in Scotland. <http://www.adaptationscotland.org.uk/Upload/Documents/AdaptingtoClimateChangeScreenFINAL2.pdf>
- Scotch Whisky Association (2015) Environmental Strategy Report 2015. <http://www.scotch-whisky.org.uk/news-publications/publications/documents/environmental-strategy-report-2015/#.V0QkPPkrJ1s>
- Scotch Whisky Research Institute (2011) Scotch Whisky Industry. Report for the Scotch Whisky Association. <http://www.adaptationscotland.org.uk/12/52/295/Scotch-Whisky-Industry.aspx>
- Scottish Government (2009) Scotland's Climate Change Adaptation Framework: Business and Industry Sector Action Plan. <http://www.gov.scot/Resource/Doc/175776/0114872.pdf>
- Scottish Government (2016) Managing Flood Risk and Drainage. <http://www.gov.scot/Topics/Built-Environment/planning/Policy/Subject-Policies/natural-resilient-place/Flood-Drainage>
- Scottish Water (2015a) Water Industry Commission Annual Return. <http://www.watercommission.co.uk/default.aspx?VirtualHandlerName=2014-15>
- Scottish Water (2015b) Public Water Supplies – Water Abstracted and Supplied: 2002/03-2014/15. Key Environmental Statistics 2015, Scottish Government.
- Seafish (2015) Climate Change Adaptation in UK Seafood: Understanding and Responding to Climate Change in the UK Wild Capture Seafood Industry. [http://www.seafish.org/media/1476673/climate\\_change\\_report\\_-\\_lr.pdf](http://www.seafish.org/media/1476673/climate_change_report_-_lr.pdf)
- SEPA (Scottish Environment Protection Agency) (2005) An economic analysis of water use in the Scotland river basin district. [https://www.sepa.org.uk/media/37271/economic-analysis\\_water-use\\_scotland.pdf](https://www.sepa.org.uk/media/37271/economic-analysis_water-use_scotland.pdf)
- SEPA (2015) The Impact of Climate Change on Water Scarcity. [http://www.sepa.org.uk/media/159070/climate\\_change\\_water\\_scarcity.pdf](http://www.sepa.org.uk/media/159070/climate_change_water_scarcity.pdf)
- SEPA (2016) Scotland's Flooding Future 2016-2021. <http://www.sepa.org.uk/media/163535/scotlands-flooding-future-infographic-hires.pdf>
- Side, J., Harris, R., Woolf, D., Bell, M. and Brooks, A. (2013) Impacts of climate change on built structures (offshore). MCCIP Science Review 2013, 295-301, doi:10.14465/2013. arc31.295-301.
- Silver, N., Cox, M. and Garrett, E. (2010) The Impact of Climate Change Overseas on the UK Financial Services Sector. Part of the UK Government's Foresight Project on the International Dimensions of Climate Change. <http://webarchive.nationalarchives.gov.uk/20121212135622/http://www.bis.gov.uk/assets/foresight/docs/international-dimensions/11-1024-impact-climate-change-overseas-on-uk-financial-services.pdf>
- Standard & Poor's Ratings Direct (2014a) Climate Change: Preparing for the Long-Term (22 May 2014). [http://fsi.gov.au/files/2014/09/Standard\\_Poors\\_Attachment\\_J.pdf](http://fsi.gov.au/files/2014/09/Standard_Poors_Attachment_J.pdf)

- Standard & Poor's Ratings Direct (2014b) Dealing with Disaster: How Companies are Starting to Assess Their Climate Event Risks. 21 May 2014.  
<http://www.insurancejournal.com/news/international/2014/05/22/329797.htm>
- Standard & Poors Ratings Direct (2014c) Are Insurers Prepared for the Extreme Weather Climate Change May Bring? 19 May 2014. <http://www.actuarialpost.co.uk/article/are-insurers-prepared-for-climate-change-risk-6257.htm>
- Standard & Poor's Ratings Direct (2015) Storm Alert: Natural Disasters can Damage Sovereign Creditworthiness (10 September 2015).  
[https://www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1449131&SctArtId=339895&from=CM&nsi\\_code=LIME&sourceObjectId=9327571&sourceRevId=1&fee\\_ind=N&exp\\_date=20250909-22:42:56](https://www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1449131&SctArtId=339895&from=CM&nsi_code=LIME&sourceObjectId=9327571&sourceRevId=1&fee_ind=N&exp_date=20250909-22:42:56).
- Stenek, V., Amado, J-C. and Greenall, D. (2013) Enabling Environment for Private Sector Adaptation: An Index Assessment Framework.  
<http://www.ifc.org/wps/wcm/connect/6060670042bd92b6b297be0dc33b630b/Enabling+Environment+for+Private+Sector+Adaptation+-+Stenek,+Amado,+Greenall.pdf?MOD=AJPERES>
- Stott, P., Stone, D. and Allen, M. (2004) Human contribution to the European heatwave of 2003. *Nature*, 432, 610-614.
- Sur, S. (2012) Asking the right questions: basic concepts of risk management for developing adaptation and mitigation strategies. In: *Managing Climate Change Business Risks and Consequences* (Stoner, J. A. F. and Wankel, C. eds.). Palgrave Macmillan, New York, pp. 17-48.
- Surminski, S. (2014) The role of insurance in reducing direct risk: The case of flood insurance. *International Review of Environmental and Resource Economics*, 7, 3–4, 241-278.  
<http://www.nowpublishers.com/article/Details/IRERE-0062>
- Surminski, S. and Eldridge, J. (2015) Flood insurance in England: An assessment of the current and newly proposed insurance scheme in the context of rising flood risk. *Journal of Flood Risk Management*. <http://onlinelibrary.wiley.com/doi/10.1111/jfr3.12127/abstract>
- Surminski, S., Bouwer, L. and Linnerooth-Bayer, J. (2016) How insurance can support climate resilience. *Nature Climate Change*, 6, 333-334.  
<http://www.nature.com/nclimate/journal/v6/n4/full/nclimate2979.html>
- Swiss Re (2012) Flood – an underestimated risk: Inspect, inform, insure.  
<http://media.swissre.com/documents/Flood.pdf>
- TCFD (Task-force on Climate-related Financial Disclosures) (2016) Phase I report of the Task-force on Climate-related Financial Disclosures. <https://www.fsb-tcfd.org/phase1reportdocument/>
- The Economist (2011) Broken links: The disruption to manufacturers worldwide from Japan's disasters will force a rethink of how they manage production.  
<http://www.economist.com/node/18486015>
- UKCIP (2005). Beating the Heat: Keeping UK Buildings Cool in a Changing Climate.  
[http://www.ukcip.org.uk/wordpress/wp-content/PDFs/Beating\\_heat.pdf](http://www.ukcip.org.uk/wordpress/wp-content/PDFs/Beating_heat.pdf)
- UKCIP (2010). A Changing Climate for Business. [http://www.ukcip.org.uk/wordpress/wp-content/PDFs/UKCIP\\_Business.pdf](http://www.ukcip.org.uk/wordpress/wp-content/PDFs/UKCIP_Business.pdf)

- UKCIP (2014a) BACLIAT Vulnerability Assessment. <http://www.ukcip.org.uk/wizard/future-climate-vulnerability/bacliat/>
- UKCIP (2014b) Engaging with Climate Services Providers. <http://www.ukcip.org.uk/projects/engaging-with-climate-services-providers/>
- UKMMAS (UK Marine Monitoring and Assessment Strategy) (2010) Charting Progress 2 Feeder Report: Productive Seas. <http://webarchive.nationalarchives.gov.uk/20141203181034/http://chartingprogress.defra.gov.uk/>
- Unilever (2013) Unilever Sustainable Living Plan Progress Report 2012. [https://www.unilever.com/Images/uslp-progress-report-2012-fi\\_tcm13-387367\\_tcm244-409862\\_en.pdf](https://www.unilever.com/Images/uslp-progress-report-2012-fi_tcm13-387367_tcm244-409862_en.pdf)
- UNISDR (United Nations Office for Disaster Risk Reduction) (2012) Concept note: Fourth session of the Global Platform for Disaster Risk Reduction. United Nations International Strategy for Disaster Reduction Secretariat, Geneva. <https://www.unisdr.org/we/inform/publications/23895>
- University of Leeds (2014) Estimating Global Value Chain Impacts Associated with UK Consumption Patterns. Report for the Adaptation Sub-Committee. <https://www.theccc.org.uk/publication/managing-climate-risks-to-well-being-and-the-economy-asc-progress-report-2014/>
- UN Global Compact and UN Environment Programme (2012) Business and Climate Change Adaptation: Towards Resilient Companies and Communities. [https://www.unglobalcompact.org/docs/issues\\_doc/Environment/climate/Business\\_and\\_Climate\\_Change\\_Adaptation.pdf](https://www.unglobalcompact.org/docs/issues_doc/Environment/climate/Business_and_Climate_Change_Adaptation.pdf)
- VisitEngland (2015) Domestic Seaside Tourism. [https://www.visitbritain.org/sites/default/files/vb-corporate/Documents-Library/documents/England-documents/seaside\\_0.pdf](https://www.visitbritain.org/sites/default/files/vb-corporate/Documents-Library/documents/England-documents/seaside_0.pdf)
- Wedawatta, G. and Ingirige, B. (2012) Resilience and adaptation of small and medium-sized enterprises to flood risk. *Disaster Prevention and Management*, 21, 4, 474-488, doi:10.1108/09653561211256170
- Wedawatta, G., Ingirige, B., Jones, K. and Proverbs, D. (2011) Extreme weather events and construction SMEs: Vulnerability, impacts and responses. *Structural Survey*, 29, 2, 106-119, doi: 10.1108/02630801111132795
- Welsh Government (2010) Climate Change Strategy for Wales. <http://gov.wales/docs/desh/publications/101006ccstratfinalen.pdf>
- Welsh Government (2015a) Climate Change Adaptation Business Tool. [https://businesswales.gov.wales/dmwales/sites/dmwales/files/documents/Tourism\\_Business\\_Resilience\\_Tool\\_Eng.pdf](https://businesswales.gov.wales/dmwales/sites/dmwales/files/documents/Tourism_Business_Resilience_Tool_Eng.pdf)
- Welsh Government (2015b) Sources of data and support. <http://thecccw.org.uk/wp-content/uploads/2015/02/WG-Business-SAP-workshop.pptx>
- Welsh Government (2015c) Private Sector Business Cases for Action on Climate Change. <http://thecccw.org.uk/wp-content/uploads/2015/02/WG-Bus-Case-for-action-on-CC-private-sector.pdf>

- Werrity, A., Houston, D., Ball, T., Tavendale, A. and Black, A. (2007) Exploring the Social Impacts of Flood Risk and Flooding in Scotland. Report for the Scottish Executive.  
<http://www.gov.scot/resource/doc/174676/0048938.pdf>
- West, J. M. and Brereton, D. (2013) Climate Change Adaptation in Industry and Business: A Framework for Best Practice in Financial Risk Assessment, Governance and Disclosure. National Climate Change Adaptation Research Facility, Gold Coast.  
[http://www98.griffith.edu.au/dspace/bitstream/handle/10072/54579/88671\\_1.pdf?sequence=1](http://www98.griffith.edu.au/dspace/bitstream/handle/10072/54579/88671_1.pdf?sequence=1)
- West Sands Partnership (2012) A Management Plan for the West Sands, St. Andrews: 2012-2025.  
<http://fifecoastandcountrysidetrust.co.uk/userfiles/file/WSMP%20Exec%20Summary.pdf>
- Winn, M., Kirchgeorg, M., Griffiths, A., Linnenluecke, M. K. and Günther, E. (2011) Impacts from climate change on organizations: A conceptual foundation. *Business Strategy and the Environment*, 20, 157-173. <http://onlinelibrary.wiley.com/doi/10.1002/bse.679/abstract>
- WRAP (2011) Freshwater Availability and Use in the United Kingdom.  
<http://www.wrap.org.uk/sites/files/wrap/PAD101-201%20-%20Manufacturing%20sector%20water%20report%20-%20FINAL%20APPROVED%20for%20publication%20-%202012,03,12.pdf>
- WRAP (2014) Federation House Commitment Progress Report 2014.  
<http://www.wrap.org.uk/content/food-and-drink-manufacturing-water-use-progress-reports>
- WRAP (2016) What is Courtauld 2025? <http://www.wrap.org.uk/content/what-courtauld-2025>
- WRc (2014) Research to Produce Indicators to Assess Current and Future Risk to the Chemicals, Paper and Mining and Quarrying Industries from Reduced Water Availability, and Potential for Uptake of Water Management Measures in these Industries. Report for the Adaptation Sub-Committee. <https://www.theccc.org.uk/publication/managing-climate-risks-to-well-being-and-the-economy-asc-progress-report-2014/>
- Wright, P. (2013) Impacts of climate change on ports and shipping. *MCCIP Science Review* 2013, 263-270, doi:10.14465/2013.arc28.263-270.
- Yildirim, K., Koyuncu, C. and Koyuncu, J. (2009) Does Temperature Affect Labor Productivity: Crosscountry Evidence. <http://www.usc.es/economet/journals1/aeid/aeid913.pdf>



**Committee on Climate Change**

7 Holbein Place  
London  
SW1W 8NR

[www.theccc.org.uk](http://www.theccc.org.uk)

 [@theCCCuk](https://twitter.com/theCCCuk)