UK Climate Risk Independent Assessment (CCRA3)

Technical Report

Introduction

Lead Authors: Richard A. Betts, Kathryn Brown
Contributing Authors: Fai Fung, Jason A. Lowe

This chapter should be cited as:

Table of Contents

Key Messages .............................................................................................................................................. 2

1. Context .................................................................................................................................................. 3
   1.1 Human-caused climate change and the need for mitigation and adaptation .............................. 3
   1.2 The Climate Change Act and National Adaptation Programme ................................................ 4
   1.3 The Climate Change Risk Assessment (CCRA) process and structure .................................... 5
   1.4 Purpose of the CCRA .................................................................................................................... 7
   1.5 Changes in the evidence and socioeconomic context since the 2nd UK Climate Change Risk Assessment ........................................................................................................................................ 9

2. The CCRA3 approach to assessing climate change risks and opportunities for the UK ........... 10
   2.1 Definition of risk and opportunity ................................................................................................. 10
   2.2 Risks and opportunities considered in CCRA3 ........................................................................... 11
   2.3 CCRA3 Urgency Scoring approach compared to CCRA2 .......................................................... 13
   2.4 Framing the current and future climate context for CCRA3 ....................................................... 14
   2.5 Current and future socioeconomic context for CCRA3 .............................................................. 20
   2.6 UK and international perspectives ................................................................................................. 20

3. Sources of evidence for CCRA3 .......................................................................................................... 21
   3.1 Evidence from the literature .......................................................................................................... 21
   3.2 New research for CCRA3 .............................................................................................................. 21
   3.3 Using the latest UK Climate Projections ....................................................................................... 21

4. Overview of the Technical Report chapters ..................................................................................... 22

5. References ............................................................................................................................................ 24

Annex 1. RCP emissions scenarios and projections consistent with current policies and ambitions ........................................................................................................................................ 28
Key Messages and outline

This is the introduction to the Technical Report of 3rd UK Climate Change Risk Assessment (CCRA3). It sets the context for CCRA3 and provides some key background information.

- With current commitments and ambition on emissions, global warming could reach between approximately 2°C and 4°C by the end of this century, or potentially even higher.

- Even if the international community meets the goals of the Paris Agreement, further climate change will occur and hence will require adaptation.

- This CCRA3 Technical Report assesses the urgency of adapting to UK climate risks and opportunities, considering both the current climate and projected future climates consistent with two future pathways:
  
  (i) stabilising 2°C by the end of the century, representing achievement of the Paris Agreement goals;
  (ii) 4°C global warming at the end of the century the current trajectory, consistent with the current limited global ambition for reducing emissions

- This includes risks and opportunities arising from climate change within the UK and from the impacts of climate change elsewhere in the world.

- 61 risks are assessed, grouped into 5 categories:
  - Natural Environment and Assets
  - Infrastructure
  - Health, Communities and the Built Environment
  - Business and Industry
  - International Dimensions

- The extent to which current UK adaptation plans will manage these risks is also assessed, and the benefits of additional action on adaptation within the next 5 years. The risk are scored according to the urgency of additional adaptation action.

As context, section 1 gives the terms of the CCRA in the Climate Change Act (2008) and Climate Change (Scotland) Act 2009, and its purpose in informing the UK and devolved national adaptation programmes. It explains the aim of providing advice on the relative urgency of new government action on adaptation in different risk areas. The CCRA does not recommend specific actions that should be taken, as that is out of scope. Section 1 also outlines the structure of the CCRA3 process and where the Technical Report is placed within this. This section also summarises how the evidence and context has changed since the 2nd UK Climate Change Risk Assessment (CCRA2).

As background specific to CCRA3, section 2 provides the definition of risk used in this assessment. It gives a brief overview of similarities and differences in the approach of CCRA3 compared to CCRA2.
Section 2 also describes how CCRA3 frames the view of future climate change to give a clear and consistent assessment of future risks within the numerous and highly complex set of possible climate futures. This includes the consideration of potential outcomes either with or without further action on mitigation in the context of the Paris Agreement and the UK, Scottish and Welsh targets for reaching Net Zero emissions (hereafter referred to as “Net Zero”). It also introduces key aspects of the socioeconomic context, again including Net Zero, the UK’s exit from the European Union, and also the emergence of potential implications of the Covid-19 pandemic.

Section 3 outlines the sources of evidence for CCRA3, including how existing academic literature and non-academic reports are brought into the process and how these are supplemented by new analysis carried out specifically for CCRA3. The method for considering the new UK Climate Projections alongside evidence based on previous projections is introduced.

Section 4 provides an overview of the technical chapters, giving a brief summary of the scope and listing the specific risks that are examined.

1. Context

1.1 Human-caused climate change and the need for mitigation and adaptation

It is beyond doubt that the global climate is changing due to human alterations of the composition of the atmosphere and the character of the land surface. The global average surface temperature has risen by over 1°C compared to conditions before the industrial revolution (Chapter 1: Slingo, 2020). This is bringing unfamiliar local weather patterns, making some types of extreme weather events more likely, and causing an accelerated rise in sea levels. These changes are altering the stability of ecosystems and habitats, and increasing weather-related risks to people, both around the world and in the United Kingdom.

Although the Paris Agreement commits the nations of the world to limit global warming to well below 2°C above pre-industrial levels and pursue efforts to limit warming to 1.5°C, projections consistent with policies currently in place worldwide imply warming of between approximately 2°C and 5°C by the end of this century (Figure 1) depending on the rate of greenhouse gas emissions and the response of the climate system to these emissions. This will further increase the shifts in weather patterns and extremes, further increasing risks to people and biodiversity, with higher warming leading to greater risks.

Limiting warming to lower levels may still be achievable if global emissions are rapidly reduced to net zero or net negative, but even if global warming is successfully limited to between 1.5 and 2°C, weather patterns will still be different to those in recent decades, and sea levels will continue to rise to some extent. Adaptation to at least this minimum level of change is therefore needed, and also needs to be assessed for larger changes since the actual future level of warming and associated climate hazards cannot be known. Both mitigation and adaptation are therefore required to minimise risks from human-caused climate change.
Figure 1 Observed and projected global mean surface air temperature changes relative to 1850-1900, illustrating a range of future projections consistent with current worldwide policies relating to greenhouse gas emissions. Observations from 1860 to 2020 are from HadCRUT5 (Morice et al., 2020), showing the central estimate (black) and uncertainty (grey). Future changes from 2021 to 2100 (gold) are from the UKCP18 global probabilistic projections (Murphy et al., 2018), showing the range between the 5th percentile with the RCP4.5 emissions scenario and the 95th percentile with the RCP6.0 emissions scenario. Although the 95th percentile of RCP4.5 temporarily exceeds that of RCP6.0 by up to approximately 0.15°C around 2050, this is not shown here. See Section 2.3.3 for discussion of RCP4.5 and RCP6.0 as consistent with current policies.

1.2 The Climate Change Act and National Adaptation Programme

The UK Climate Change Act (2008) and Climate Change (Scotland) Act 2009 set out a statutory five-yearly cycle of UK climate change risk assessments, followed by national adaptation programmes for England, Northern Ireland, Scotland and Wales. Each cycle leads into the next so that learning, experience and adaptation action can feed through and result in progress in adapting to climate change in the UK over time. Figure 2 shows this cycle.

The Climate Change Act also set up the Climate Change Committee and its Adaptation Committee. The Adaptation Committee has two statutory roles under the UK Act; to provide advice to the UK Government and devolved administrations on climate change risks and opportunities, and to assess progress in adapting to climate change in England. Under the Climate Change (Scotland) Act, it can also assess progress of the Scottish Climate Change Adaptation Programme. This is also shown in Figure 2.
The UK Climate Change Act (2008) and Climate Change (Scotland) Act 2009 set up a process of continuous, five-yearly UK Climate Change Risk Assessments, followed by a set of national adaptation programmes which are devolved. The Acts also require the Climate Change Committee to provide advice on the Risk Assessment and to report on progress on adaptation in England and Scotland, shown on the left (the Scotland Act requires ‘the relevant body’ to report on progress, allowing Scottish Government to choose who it asks to report). A range of other policies and programmes feed into the cycle of Risk Assessments and Adaptation Programmes, shown on the right.

**Figure 2** The UK’s Statutory Adaptation Cycle. The UK Climate Change Act (2008) and Climate Change (Scotland) Act 2009 set up a process of continuous, five-yearly UK Climate Change Risk Assessments, followed by a set of national adaptation programmes which are devolved. The Acts also require the Climate Change Committee to provide advice on the Risk Assessment and to report on progress on adaptation in England and Scotland, shown on the left (the Scotland Act requires ‘the relevant body’ to report on progress, allowing Scottish Government to choose who it asks to report). A range of other policies and programmes feed into the cycle of Risk Assessments and Adaptation Programmes, shown on the right.

### 1.3 The Climate Change Risk Assessment (CCRA) process and structure

The first CCRA was published by the Department for Environment, Food and Rural Affairs (Defra) in 2012, and the second in 2017. For the third assessment, CCRA3, as it did for CCRA2 in 2016, Defra has asked the Adaptation Committee to prepare an Independent Assessment as a component of its statutory advice on the CCRA (see Figure 2), synthesising the latest evidence on the risks and opportunities to the UK from climate change.

This Technical Report is part of the set of reports that together make up the Independent Assessment to fulfil that request (Figure 3). It collates together the latest evidence and provides urgency scores for each risk or opportunity considered, implementing the method set out in chapter 2. In addition to the Technical Report, the Independent Assessment also consists of a number of supporting research reports, summary documents (by UK country and sector) and an Advice Report that forms the Committee’s statutory advice to government. The information flow between these documents is shown in Figure 3, and the purpose of each is shown in Table 1.
### Table 1. Purpose of documents of the CCRA3 Independent Assessment

<table>
<thead>
<tr>
<th>Document</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advice Report</td>
<td>Summarises and interprets the evidence provided in the technical chapters. Also provides the Adaptation Committee’s statutory advice to Government on the risks and opportunities to the UK from climate change. Authored by the CCC.</td>
</tr>
<tr>
<td>Technical Report</td>
<td>Provides the detailed analysis that underpins the assessment of risks or opportunities, and the resulting urgency scores. Alongside this introduction, there are seven technical chapters. Evidence is drawn from the literature and new research. Authored by a consortium of experts led by the University of Exeter in partnership with the Met Office, working to the CCC.</td>
</tr>
<tr>
<td>Summaries</td>
<td>Two types: National Summaries that summarise the most relevant aspects of the risk assessment for each UK country (England, Northern Ireland, Scotland and Wales), and a set of seventeen factsheets that summarise the risks and opportunities for a range of topics relevant to different government bodies. Authored by a consortium of experts led by Sustainability West Midlands working to the CCC.</td>
</tr>
<tr>
<td>Supporting reports</td>
<td>Provides supporting evidence to inform the technical chapters, supplementing the existing literature and filling key evidence gaps from CCRA2 or updating analysis with new information. Authored by consultants working to the CCC and by researchers in other programmes.</td>
</tr>
</tbody>
</table>
The CCRA3 Technical Report was commissioned by the CCC but produced through a large consortium of experts coordinated by the University of Exeter in partnership with the Met Office. Authors are listed at the beginning of each Technical Report chapter.

The governance for the Independent Assessment included a Customer Group (UK Government and devolved administration funders) to provide feedback to the CCC on progress and comment on whether the outputs were fit for purpose and met the aims of the Customer Requirement, which was provided to the CCC in 2018. The Customer Group was supported by a Project Board made up of government departments and agencies from across the UK. The CCC was also supported by an expert advisory panel of independent experts who commented on the priorities and analytical approach of the assessment early on in the process.

The production of the Independent Assessment has undergone an extensive stakeholder engagement and review process. Over 450 people from 130 organisations have been involved in developing the set of reports in the assessment. The Method (Chapter 2: Watkiss and Betts, 2021) was developed by the CCC in consultation with the academic community and other stakeholders. The list of risks assessed was initially developed by the CCC and government stakeholders, and further evolved through collaboration between the Technical Report authors, the CCC and stakeholders. The CCC organised stakeholder meetings for government officials and other interested groups in London, Belfast, Edinburgh, and Cardiff throughout 2019 and into 2020. These meetings focussed on collating available evidence and policy updates. Two drafts of the technical chapters were reviewed by three different review groups; a technical peer review panel; a government review group, and a group of external reviewers who responded to an open call, in order to provide independent comments. In total, over 5,000 review comments were received on the technical chapters and the responses to each comment were collated and are available upon request. The final CCRA3 Technical Report is an independent report based on evidence from the literature and new research, having been scrutinised through the review process. Where expert interpretation has been necessary due to incomplete or conflicting evidence, this represents the views and judgement of the authors of the respective Technical Report chapters and has been identified as such.

The primary intended audience for the Independent Assessment is the departments of the UK Government, departments of the devolved administrations, and their respective Arm’s Length Bodies. The Government also asked that the report is written with a secondary audience in mind of organisations making significant policy or investment decisions. These key stakeholders have been involved throughout the process, in particular through the scoping the CCRA3 Technical Report and providing input relating to adaptation issues within their remit. It should be noted however that the individual chapters of the CCRA3 Technical Report are the product of their respective authors only (listed at the front of each chapter). The accompanying Advice Report represents the Climate Change Committee’s interpretation of the evidence set out in the Technical Report, including their official advice as required under the UK Climate Change Act (2008).

1.4 Purpose of the CCRA

The aim of the CCRA3 Independent Assessment is to address the following question, as it was for the previous CCRA:

Introduction
“Based on our 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 adaptation programmes of the devolved administrations?”

As for CCRA2, the analysis set out in this report seeks to characterise each risk or opportunity by scoring the degree of urgency it poses in the next five years – more urgent risks and opportunities being classified as either ‘more action needed’ or ‘further investigation’ (Figure 4). For the former, the Urgency Score implies that additional adaptation is needed urgently, either over and above what is already happening, or in some cases adaptation needs to start in cases where there is currently nothing happening. Further investigation denotes risks or opportunities where not enough evidence is available to make a robust judgement on what further action is needed. Less urgent risks and opportunities are not scored as ‘do nothing’ but rather as either sustaining current action if the amount of action is in line with the magnitude of the risk or opportunity, or as a ‘watching brief’ where further action is not currently justified, but monitoring the situation is.

![Figure 4 Urgency Scores for climate change risks and opportunities used in the CCRA3 method. Further details are provided in Chapter 2 (Watkiss and Betts, 2021).](image)

It is important to note that this report focusses on current and future risks and not the specific adaptation actions that are needed to reduce risk in the future. The report identifies specific areas where further action is felt to be needed, based on the available evidence. It does not take the further step of recommending what specific actions should be taken, though it does discuss the benefits of taking further action, and this by necessity includes commentary on specific actions. The task for the UK Government and devolved administrations, following this assessment, is weighing up the costs and benefits of different options and setting objectives and actions in the next national adaptation programmes.

1.5 Evolution of the evidence and context since the 2nd UK Climate Change Risk Assessment

Scientific evidence for ongoing climate change and the role of human influence has continued to accumulate and further strengthen since CCRA2. This is partly because climate change itself is continuing, and partly because observational datasets and techniques for analysis and modelling continue to improve. Methods for quantifying the influence of climate change on the likelihood and severity of extreme weather events have been developed further and applied more widely (Swain et al., 2020; Herring et al., 2021). The assessment of the potential for unprecedented events even under the current climate is a particular area of substantial progress since CCRA2 (e.g., Thompson et al., 2017). Furthermore, the new generation of climate models, with updated representations of scientific understanding and higher spatial and temporal resolution, has improved skill in simulating some regional climate processes, and these form a key part of the new UK Climate Projections (Lowe et al., 2018). Analysis and understanding of socioeconomic components of climate risk has also evolved, and more integrated approaches to risk assessment are becoming more widely employed.

A number of national climate risk assessments have been published in various countries, as described in Chapter 2 (Watkiss and Betts, 2021), with new approaches to the communication of climate risk being developed and implemented (Sustainability West Midlands, 2020).

The political and societal context has also evolved significantly since CCRA2 was published in 2017. Following the publication of the IPCC Special Report on Global Warming at 1.5°C (IPCC, 2018), numerous countries are preparing more ambitious climate mitigation commitments than previously adopted following the publication of the IPCC Special Report on Global Warming at 1.5°C. This includes the UK’s ambition and statutory target to achieve Net Zero greenhouse gas emissions by 2050, with separate accompanying targets for Net Zero by 2045 in Scotland, 2050 in Wales, and a target still to be confirmed for Northern Ireland. Worldwide this is a rapidly-changing situation, with new announcements of country targets being made in advance of COP26. Alongside this, public concern over climate change has become much more prominent, with growing calls for stronger action accompanied by campaigns taking various forms including pressure group activity, school strikes and civil disobedience. Citizens Assembly approaches are being implemented as a means of facilitating and publicising structured public discussion on climate change, with the Climate Assembly UK being one example (Climate Assembly UK, 2020).

Other potentially important changes in the socioeconomic context include the UK’s exit from the European Union, and the shifts this will create in environmental policy, trade, and potentially, cooperation on issues such as monitoring and shared research programmes.

Moreover, and significantly, the world has been dealing with the effects of the SARS-CoV-2 (Covid) pandemic, which at the time of writing remains severe and ongoing. The long-term effects of the pandemic are difficult to predict, and there are potentially profound effects on human vulnerability to climate change through increasing inequality, reduced resources and capacity to cope with other shocks. The experience of the pandemic could also lead to a change in how governments view and plan for risk, but it remains too early to tell at the time of writing.
2. The CCRA3 approach to assessing climate change risks and opportunities for the UK

2.1 Definition of risk and opportunity

This Report uses the same definition of risk as was presented in the CCRA2 Evidence Report; ‘the potential for consequences where something of value is at stake and where the outcome is uncertain’. When used in its general sense, the word ‘risk’ is taken to include both negative and positive consequences, and so includes opportunities. However, the CCRA3 method differentiates between assessing negative risks and positive opportunities, and these are reported separately throughout the technical chapters and in the synthesis report as far as possible. The risk descriptors (see Section 4 below) are marked up as risks, opportunities, or both in some cases where there are a range of effects on a given receptor.

Risk assessments often use measures of probability and consequence to characterise the risk, and attempts are made to define these quantities as accurately as possible. Some risk assessments consider the potential for a specific event to happen, as is done in the UK National Risk Assessment which is led by the Cabinet Office. Other studies, particularly climate change risk assessments often look at the potential change (e.g., mean or variability) in a variable such as temperature or rainfall.

In all cases, climate change risk assessments must cope with a large amount of uncertainty. Although all of the risks discussed in this report have some implicit likelihood associated with them, it cannot be quantified precisely. In some cases, we have collected information on probabilities attributed to changes in variables or events, based on an understanding of how the physics of the climate system may change in the future. Climate simulations such as those presented in the 2018 UK Climate Projections (UKCP18: Lowe et al., 2018) and other sets of projections give a current best estimate of which changes in the UK and global climate are more or less likely than others for any given emissions scenario, but these probabilities do not include all sources of uncertainty, and only represent changes in the climate such as temperature and sea level, rather than impacts such as flooding. Rather than provide an estimate of likelihood for individual risks, the authors estimate the magnitude of the impact specified in the name of the risk descriptor, for specific time periods in specific climate futures - the 2050s and 2080s on pathways to approximately 4°C and 2°C global warming in the late 21st Century. These are considered to broadly represent lower and upper rates of climate change consistent with either current policies relating to greenhouse gas emissions or the successful achievement of international climate policy ambitions - the rationale for each is described in Section 2.3 below. The definition of magnitude is outlined in Chapter 2 (Watkiss and Betts, 2021).

As well as estimating the magnitude of specific impacts within the range of 2°C to 4°C global warming late this century, the assessment also considers low likelihood, high impact events that sit outside of the assessment of magnitude. The approach to this is described below and set out in more detail in Chapter 2.

As a risk assessment, the focus of CCRA3 is not necessarily on the most likely outcomes, but on outcomes that are likely enough to warrant consideration. The judgement of this depends on the
magnitude of the potential impact – an event which would have extremely severe consequences may warrant consideration in the risk assessment even if it has a very low likelihood of occurring.

2.2 Risks and opportunities considered in CCRA3

CCRA3 assesses a set of 61 specific risks and opportunities to the UK from climate change (Table 2). As was the case for CCRA2, the list of risks and opportunities (Table 2) was decided on through an extensive process of consultation between the Government Customer, the CCC and the authors of the technical chapters. Taking the list from CCRA2 as a starting point, the CCRA Customer Group and Project Board suggested various modifications to make the list more policy relevant. The list was refined over a 9 month period with input from the CCC’s Adaptation Committee and the chapter authors, and was refined further after the first order draft chapters were produced to limit duplication of analysis across different risks and to fill a few gaps identified by the authors. The focus of the list is to create a set of risks and opportunities that have direct relevance to different government bodies.

<table>
<thead>
<tr>
<th>Table 2 Risks and opportunities assessed in the CCRA3 Technical Report</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Environment and Assets</strong></td>
</tr>
<tr>
<td>N1 Risks to terrestrial species and habitats from changing climatic conditions and extreme events, including temperature change, water scarcity, wildfire, flooding, wind, and altered hydrology (including water scarcity, flooding and saline intrusion).</td>
</tr>
<tr>
<td>N2 Risks to terrestrial species and habitats from pests, pathogens and invasive species</td>
</tr>
<tr>
<td>N3 Opportunities from new species colonisations in terrestrial habitats</td>
</tr>
<tr>
<td>N4 Risk to soils from changing climatic conditions, including seasonal aridity and wetness.</td>
</tr>
<tr>
<td>N5 Risks and opportunities for natural carbon stores, carbon sequestration from changing climatic conditions, including temperature change and water scarcity</td>
</tr>
<tr>
<td>N6 Risks to and opportunities for agricultural and forestry productivity from extreme events and changing climatic conditions (including temperature change, water scarcity, wildfire, flooding, coastal erosion, wind and saline intrusion).</td>
</tr>
<tr>
<td>N7 Risks to agriculture from pests, pathogens and invasive species</td>
</tr>
<tr>
<td>N8 Risks to forestry from pests, pathogens and invasive species</td>
</tr>
<tr>
<td>N9 Opportunities for agricultural and forestry productivity from new/alternative species becoming suitable.</td>
</tr>
<tr>
<td>N10 Risks to aquifers and agricultural land from sea level rise, saltwater intrusion</td>
</tr>
<tr>
<td>N11 Risks to freshwater species and habitats from changing climatic conditions and extreme events, including higher water temperatures, flooding, water scarcity and phenological shifts.</td>
</tr>
<tr>
<td>N12 Risks to freshwater species and habitats from pests, pathogens and invasive species</td>
</tr>
<tr>
<td>N13 Opportunities to freshwater species and habitats from new species colonisations</td>
</tr>
<tr>
<td>N14 Risks to marine species, habitats and fisheries from changing climatic conditions, including ocean acidification and higher water temperatures.</td>
</tr>
<tr>
<td>N15 Opportunities to marine species, habitats and fisheries from changing climatic conditions</td>
</tr>
<tr>
<td>N16 Risks to marine species and habitats from pests, pathogens and invasive species</td>
</tr>
<tr>
<td>N17 Risks and opportunities to coastal species and habitats due to coastal flooding, erosion and climate factors.</td>
</tr>
<tr>
<td>N18 Risks and opportunities from climate change to landscape character</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
</tr>
<tr>
<td>I1 Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures</td>
</tr>
<tr>
<td>I2</td>
</tr>
<tr>
<td>I3</td>
</tr>
<tr>
<td>I4</td>
</tr>
<tr>
<td>I5</td>
</tr>
<tr>
<td>I6</td>
</tr>
<tr>
<td>I7</td>
</tr>
<tr>
<td>I8</td>
</tr>
<tr>
<td>I9</td>
</tr>
<tr>
<td>I10</td>
</tr>
<tr>
<td>I11</td>
</tr>
<tr>
<td>I12</td>
</tr>
<tr>
<td>I13</td>
</tr>
</tbody>
</table>

**Health, Communities and the Built Environment**

| H1 | Risks to health and wellbeing from high temperatures |
| H2 | Opportunities for health and wellbeing from higher temperatures |
| H3 | Risks to people, communities and buildings from flooding |
| H4 | Risks to the viability of coastal communities from sea level rise |
| H5 | Risks to building fabric |
| H6 | Risks and opportunities from summer and winter household energy demand |
| H7 | Risks to health and wellbeing from changes in air quality |
| H8 | Risks to health from vector-borne disease |
| H9 | Risks to food safety and food security |
| H10 | Risks to water quality and household water supplies |
| H11 | Risks to cultural heritage |
| H12 | Risks to health and social care delivery |
| H13 | Risks to education and prison services |

**Business and industry**

| B1 | Risks to businesses from flooding |
| B2 | Risks to businesses and infrastructure from coastal change from erosion, flooding and extreme weather events |
| B3 | Risks to business from water scarcity |
| B4 | Risks to finance, investment and insurance including access to capital for businesses |
| B5 | Risks to business from reduced employee productivity due to infrastructure disruption and higher temperatures in working environments |
| B6 | Risks to business from disruption to supply chains and distribution networks |
| B7 | Opportunities for business from changes in demand for goods and services |

**International Dimensions**

| ID1 | Risks to UK food availability, safety, and quality from climate change overseas |
| ID2 | Opportunities for UK food availability and exports from climate impacts overseas |
| ID3 | Risks and opportunities to the UK from climate-related international human mobility |
| ID4 | Risks to the UK from international violent conflict resulting from climate change overseas |
| ID5 | Risks to international law and governance from climate change that will impact the UK |
| ID6 | Opportunities from climate change (including Arctic ice melt) on international trade routes |
| ID7 | Risks associated with international trade routes |
| ID8 | Risk to the UK finance sector from climate change overseas |
| ID9 | Risk to UK public health from climate change overseas |
| ID10 | Systemic risk arising from the amplification of named risks cascading across sectors and borders |
2.3 CCRA3 Urgency Scoring approach compared to CCRA2

The CCRA3 Technical Report assesses the urgency of adaptation to the risks and opportunities in Table 2 with a 3-step Urgency Scoring approach (Figure 5). This follows a broadly similar approach to CCRA2.

**Figure 5** CCRA3 urgency scoring framework. See Chapter 2 (Watkiss and Betts, 2021) for further details.

Step 1 assesses the current and future magnitude of risk, and step 2 assesses the extent to which the risk will be addressed by current adaptation or adaptation already planned. Step 3 assesses the benefits of additional action within the next 5 years. The approach has been further developed to bring in further information within these steps, such as the potential for lock-in of inappropriate or maladaptive responses, the potential to exceed critical thresholds that impact on the effectiveness of adaptation, and interactions between individual risks. For each risk, these 3 main steps and additional sub-steps determine the urgency score (Figure 5).

For risks and opportunities within the UK, the risk magnitude and adequacy of current adaptation were assessed for each of the 4 UK nations wherever possible. Where there was not sufficient evidence to distinguish between the nations, the same risk magnitude and adaptation scores were assigned to all. The overall urgency score was provided for all nations. International risks and opportunities were assessed at the level of the UK as a whole.
As with CCRA2, much of the evidence for the risk assessment is drawn from the existing literature. However, more substantive bespoke research has been possible in CCRA3 compared to CCRA2, enabling some key knowledge gaps to be addressed, including socioeconomic scenarios, interacting risks, thresholds in the natural environment, and human behaviour (see Chapter 2, Watkiss and Betts 2021, section 2.2.4).

A further difference in approach is necessitated by the publication of new climate projections, UKCP18. Although the assessment of several risks benefitted from new analysis using UKCP18, much of the existing evidence on future UK risks is based on earlier projections such as UKCP09, so the approach needed to take account of this. This is described further in Section 3.3 below, and in Chapter 2.

2.4 Framing the current and future climate context for CCRA3

2.4.1 Overview

Assessing the urgency of adaptation requires information on climate and weather conditions that could occur under current and future conditions.

Assessment of the current risk magnitude take account of current weather and climate hazards and the exposure and vulnerability of people and the natural environment to these hazards. The overall risk may already have been present in a climate unperturbed by human influence, or may have increased in recent years due to changes in climate, socioeconomic factors, or non-climatic human influence on the environment (such as land use affecting habitats).

For the current climate, observed weather data clearly provides a major source of evidence for trends in average climate conditions, the magnitude of extreme weather conditions that can already occur, and whether these extremes are changing. Observed trends in data relating to ecosystems or people potentially provide evidence for whether impacts are occurring, and impacts of past extreme weather events also provide data on the magnitude of current risks. Event attribution techniques can be used to assess the change in likelihood of extreme weather events, not only for changes in temperature extremes but also now for extreme precipitation (Swain et al., 2020; Herring et al., 2021).

However, observed data may not capture the full range of possibilities or give a true picture of the likelihood of particular events, even under the current climate. By definition, extreme events are rare and hence may not have yet occurred in particular locations, even if they are possible. Similarly, some events may have occurred occasionally, but are actually more likely than would be expected from past statistics. Recent advances in climate science have made it possible to assess the likelihood of rare or unprecedented events (Chapter 1: Slingo, 2021). This new capability, along with analysis of observed trends and event attribution, can in principle be used to inform an assessment of the current magnitude of risks, which may now be higher than that assumed purely on the basis of past experience.

For future climate, a very wide range of conditions are possible, depending on natural climate variability, the extent of human influence, and the response of the climate system to this influence. Future climate projections are often framed in terms of climate system responses to specific
scenarios of emissions or specific rates of build-up greenhouse gases in the atmosphere. However, CCRA3 takes a different approach. Since the focus of the CCRA is on informing adaptation, the assessment is framed in terms of risks associated with particular future pathways of future climate change which could come about through different combinations of circumstances, rather than focussing on the details of how these pathways may come about.

Specifically, the framing for future climate this century is in terms of two main outcomes for detailed analysis, plus a third set of outcomes providing wider context for the risk assessment:

(i) An approximate minimum level of global warming that can be expected if humans take action to reduce their influence on climate. This provides information on the minimum level of change for which further adaptation will be necessary.

(ii) An approximate maximum rate of global warming consistent with a continuation of current human influence, accounting for uncertainties in anthropogenic greenhouse gas emissions and the climate system response. This quantifies the risks that we wish to avoid or reduce through mitigation, or for which adaptation may be needed if no mitigation action occurs. A maximum rate of warming is considered, rather than a central estimate, since this is a risk assessment rather than a prediction of “most likely” futures

(iii) Higher rates of warming above those currently considered consistent with the current trajectory, and low-likelihood, high-impact events such as climate system tipping points. Again, this is necessary in a risk assessment since the future cannot be predicted with high confidence.

The first outcome is represented by a pathway in which warming is limited to approximately 1.5°C to 2.5°C global warming, and the second by a pathway in which warming reaches approximately 4°C global warming between 2080 and 2100 (Figure 6). Both of these are used for detailed analysis in the assessment, and the rationale for each is described below. The use of approximate rather than precise definitions of global warming levels allows a number of relevant projections to be included in the evidence base for each, including the 5th Coupled Model Intercomparison Project (CMIP5) models and the previous set of UK projections, UKCP09, amongst others, some using RCP scenarios and others using different scenarios. Further details of the sets of projections and scenarios aligned to both the 2°C and 4°C warming pathways are provided in Chapter 2 (Watkiss and Betts, 2021).

The third group of outcomes recognises the possibility of even higher rates of warming, as part of a wider approach of considering low-likelihood, high-impact outcomes to allow for informed decision-making in cases when such outcomes may be important. Such a very high scenario is distinct from the scenario of approximately 4°C global warming at the end of century. The rationale for the distinction between these scenarios and the upper bound of the higher ‘main analysis’ scenario is provided below.

Information on low-likelihood, high-impact events is also considered. Some of these, such as tipping points or strong feedbacks involving the carbon cycle, may themselves lead to faster rates of warming or sea level rise. Others may change the climate outcome to one of an entirely different

---

1 The new CMIP6 climate models are driven by the Shared Socioeconomic Pathway (SSP) scenarios rather than the RCPs. However, since the CCRA3 assessment is framed in terms of pathways to global warming levels rather than emissions scenarios, the use of the RCPs does not affect the relevance or timeliness of the analysis.
nature to that in the main projections. These are not used directly for assessing the magnitude of risks or for scoring the urgency of adaptation, but are presented as wider context so that they can be considered if any adaptation decisions are very sensitive to low-likelihood, high-impact outcomes.

**Figure 6.** Pathways of future global warming for framing the CCRA3 assessment. Lower pathway (blue): groups of projections approaching stabilisation of global warming at approximately 2°C around 2100, illustrated with components of the UKCP18 probabilistic global projections with the RCP2.6 emissions scenario, with percentiles reaching warming of 1.5°C to 2.5°C in 2100. Higher pathway (orange): groups of projections reaching global warming of 4°C at the end of the 21st Century (2080-2100), illustrated by the UKCP18 probabilistic global projections with the RCP6.0 emissions scenario 50th to 95th percentile changes. Note that neither of these pathways is intended to represent the full range of possible rates of warming from a specific emissions scenario; instead, they represent two groupings of global warming pathways around rates considered relevant to the risk assessment. For further details including comparison with the full RCP6.0 and RCP2.6 probabilistic projections, see Chapter 2 (Watkins and Betts, 2021), Boxes 2.5 and 2.8.

### 2.4.2 Lower pathway: approximately 2°C global warming in the late 21st Century

The lower scenario represents an approximate minimum level of future climate change to which adaptation will be necessary, defined as a stabilisation of global warming at 2°C above 1850-1900 levels by 2100 with a tolerance of ±0.5°C (Figure 6). This therefore includes outcomes which meet the aims of the Paris Agreement by limiting warming to between 1.5°C and 2°C, and also allows for consideration of studies with “temperature overshoot” scenarios reaching up to 2.5°C warming. This range encompasses a large proportion of the UKCP18 global probabilistic projections with the RCP2.6 emissions scenario and CMIP5 projections with the RCP2.6 concentration pathway.²

---

² The RCPs (Representative Concentration Pathways) are used in two ways: (i) emissions scenarios, when Earth System Models calculate the change in CO₂ concentrations, accounting for climate-carbon cycle feedbacks, as
This broad definition with a tolerance of ±0.5°C should not be taken to imply that the difference between 1.5°C and 2°C global warming is considered negligible. The IPCC (2018) clearly demonstrated that at the global scale, projected global impacts are generally larger at 2°C warming compared to 1.5°C. It is simply that a greater level of precision is not justified in the context of the 4 broad categories of urgency score used to frame the outputs of the CCRA3 Technical Report (Figure 4). Since climate change uncertainties are more substantial at smaller scales (see Chapter 1: Slingo, 2021), many of the possible UK-scale risks associated with over 2°C global warming could also apply at 1.5°C warming. Hence, a wide definition of the scenario ensures that all studies with relevant information for a minimum level of UK climate risk can be considered.

**2.4.3 Higher scenario: approximately 4°C global warming at the end of the 21st Century**

The higher scenario represents a rate of global warming that could occur if action to mitigate climate change fails to go beyond current pledges. This is not necessarily the most likely rate of warming – rather, it is a level of warming considered sufficiently likely to warrant consideration in the context of a risk assessment. This likelihood is judged on the basis of two factors:

i) Future global emissions in the absence of stronger action on climate change mitigation.

ii) The response of the climate system to those future emissions.

Both of these contributions to future warming are subject to substantial uncertainties.

Quantifying future emissions in the absence of stronger climate mitigation action is challenging and subject to high uncertainty, and is also subject to ongoing change in context. Although estimates of such emissions are routinely made (United Nations Environment Programme, 2020; Climate Action Tracker, 2021), these are intended to provide a systematic means of comparing the implications of new international commitments as a tool for monitoring progress on mitigation policy rather than providing information for risk assessments. For a risk assessment such as CCRA3, a more comprehensive assessment of the range of potential outcomes is required.

Predictions of political, economic, technological and societal futures are inherently deeply uncertain, and risk assessments need to consider the implications of this uncertainty. Moreover, with new national commitments on emissions being accounced regularly, central estimates of future emissions trajectories require regular updates.

---

in UKCP18, and (ii) concentration pathways, as input to atmosphere-ocean models which do not make carbon cycle calculations, as in the CMIP5 models. This distinction is important as it can affect the projected rates of CO₂ rise (Booth et al., 2017) and consequent rate of global warming (Hausfather and Betts, 2020). The same names are commonly applied to both uses. To distinguish between these two uses, the CCRA3 Technical Report adds “emissions scenario” and “concentrations pathway” after the RCP name.

3 For example, the Climate Action Tracker (2021) uses a simple climate model and presents uncertainties in future global warming between the 16th and 84th percentiles of the probability distribution. CCRA3 uses the UK Climate Projections which are based on a number of climate models constrained against observed climate change, and considers the 5th to 95th percentile uncertainty range.
If emissions remain at current levels\(^4\) from 2021 until 2100, cumulative CO\(_2\) emissions would be approximately 3400 Gigatonnes (GtCO\(_2\)). If pre-2020 Nationally Determined Contributions (NDC) commitments are implemented by 2030 and then decarbonisation continues at the same rate, cumulative emissions would reduce to approximately 2900 Gigatonnes (Vivid Economics and UCL, 2020). However, while the near-term trajectory of global fossil fuel emissions can be projected with some degree of confidence, uncertainties are much higher for emissions trajectories beyond the next one to two decades (Rogeli et al., 2016). Considering currently implemented policies in 2016 (as opposed to NDCs, which are merely commitments), cumulative emissions from 2021 to 2100 range from approximately 2000 to 4900 GtCO\(_2\), with a median of approximately 3100 (Figure 7: Rogeli et al., 2016). Therefore, rather than basing the risk assessment on a single best estimate of future emissions, a range of potential emissions needs to be considered.

The UKCP18 climate projections are driven by emissions scenarios associated with the Representative Concentration Pathways (RCPs). Of these, the cumulative emissions associated with RCP4.5 and RCP6.0 are within the range consistent with current policies (Figure 7). The RCP8.5 emissions scenario is above the upper end of the current policies range (Hausfather and Peters, 2020) and RCP2.6 is below the lower end.

\(^4\)Total anthropogenic emissions of 43 GtCO\(_2\) per year in 2019, including fossil fuel use, land use change and cement production. While emissions were lower in 2020, they have returned to approximately 2019 levels in early 2021.

\(^5\)Projected cumulative emissions for 2011-2100 (Rogeli et al., 2016), minus historical cumulative emissions 2012-2020 (Friedlingstein et al., 2020)
For a risk assessment, it is not necessary to capture the full range of possibilities consistent with current trajectories: the focus is naturally on the higher end of the full set of possibilities. To provide such a focus while allowing a usefully large set of relevant literature to be considered, the CCRA3 higher warming pathway is defined as the range between the 50th and 95th percentiles in the UKCP18 projections driven by RCP6.0 emissions. The 50th percentile of the global annual temperature anomaly exceeds 3.5°C global warming by 2100 of the century, and the 95th percentile reaches 4°C global warming in 2080 and nearly 5°C in 2100 (Figure 6). Emissions trajectories in the upper part of the range consistent with current policies therefore bring a substantial likelihood of global warming exceeding 4°C within this century – nevertheless, it is not the most likely outcome, especially since emissions lower than RCP6.0 are also consistent with current policies. The 50th to 95th percentile range with RCP6.0 emissions includes projections used in a wide pool of literature with impacts projections applicable to a scenario of approximately 4°C warming in the late century, including studies that used previous generations of scenarios such as those from the IPCC Special Report on Emissions Scenarios (SRES: Nakićenović, et al., 2000).

It is important to note that many impacts will continue to increase in magnitude after 2100, especially if warming is still ongoing at that time. Even if warming is limited to approximately 2°C, sea level rise is projected to continue due to ongoing melting of land ice and thermal expansion of ocean waters – with an extended RCP2.6 scenario, global sea level rise could reach over to 2m by 2300 (Palmer et al., 2018). Higher emissions scenarios are projected to lead to larger rises. The implications of these longer-term risks are not explored in CCRA3 because the aim is to assess the urgency of adaptation, but they provide additional context on the benefits of mitigation.

The timing of reaching a particular climate state is a crucial element for informing adaptation. The CCRA3 Technical Report assesses risks in the 2050s and 2080s on pathways to levels of global warming of 2°C and 4°C at the end of the century.

The above pathways to 2°C and 4°C global warming are broadly representative of climate futures with and without further international action on mitigation, so comparison of the assessed magnitudes of the risks on each of these pathways could be considered to be approximately indicative of the reduction in UK climate risks by meeting the Paris Agreement objectives as imprecisely defined above. However, it is emphasised that this is not the primary purpose of the CCRA3 method and should not be interpreted as a rigorous assessment of the benefits of mitigation.

2.4.4 Higher rates of global warming as part of the Low Likelihood High Impact assessment

In order to provide the widest possible context for assessment of adaptation urgency, the CCRA3 Technical Report also includes a general, less detailed consideration of low likelihood, high-impact outcomes, including rates of global warming faster than that reaching 4°C in 2080. Such rapid warming could arise if emissions grew along a pathway higher than those consistent with current policies, or from emissions consistent with current policies if feedbacks in the climate system are stronger than in the projections used here. The latter may require the passing of one or more tipping points in the climate system, most of which are considered to be of low likelihood but highly
consequential if they were to be passed. Chapter 1 (Slingo, 2021) describes some of these tipping points and their potential implications for climate change in the UK.

The above categories of Low Likelihood High Impact (LLHI) scenarios are not examined in detail for each risk but are addressed in a general way in each chapter. Chapter 2 provides further details, including definitions of which climate projections are included in the main analysis and which are LLHI high warming scenarios.

2.5 Current and future socioeconomic context for CCRA3

With risk consisting of hazard, vulnerability and exposure, the latter two components depend on socioeconomic factors and can also be modified by adaptation. CCRA3 uses information on current and planned levels of adaptation to assess whether there is shortfall and assesses the benefits of additional adaptation to assess the urgency of action.

The needs and capacity for adaptation can be strongly influenced by the socioeconomic context. Net Zero has the potential to influence the exposure and vulnerability components of many of the risks assessed in CCRA3, since all sectors of the economy will be involved in the transition to Net Zero. Although detailed, specific information on Net Zero socioeconomic pathways is not yet available, the Climate Change Committee’s assessment of potential Net Zero approaches (Climate Change Committee, 2019) provides broad information that is used in CCRA3 to make a first estimate of the implications for adaptation needs, potential and urgency.

During the course of conducting the CCRA3 assessment, socioeconomic conditions in the UK and around the world have suddenly been impacted by the Covid-19 pandemic. As well as potentially being influenced by the direct economic impact of the nationwide and near-global “lockdown” situations, the socioeconomic components of climate risks may also be influenced by measures and policies that may be designed to reinvigorate the economy. At the time of preparing the report, the implications of the pandemic for exposure, vulnerability and capacity for climate adaptation were only just beginning to emerge. They are included in the risk assessment to the extent that is possible, but this can only be regarded as preliminary.

2.6 UK and international perspectives

As well as assessing the risks and opportunities that climate change poses directly to the UK via potential impacts within its own geographical locality, CCRA3 follows CCRA2 in assessing the implications for the UK of current and potential climate change impacts elsewhere in the world. These international dimensions of climate change risk to the UK can include supply chains for food and other goods, migration and displacement, and security issues including the potential for conflict and humanitarian responsibilities. Both local and international risks and opportunities addressed in the assessment were selected through a process of consultation with stakeholders across various government departments.
3. Sources of evidence for CCRA3

3.1 Evidence from the literature

A major source of information for CCRA3 is the literature in both peer-reviewed academic journals and non-academic reports from relevant organisations. The latter are often particularly important as sources of evidence on current and planned adaptation, and these are considered in the assessment if they have been subject to independent review.

While much of this evidence was brought in to the CCRA3 process through the knowledge of the literature of the author teams, further evidence was obtained via three open calls for evidence and through the review process. When assessing the magnitude of future risks, studies in the literature used climate projections from a large number of models with a variety of different emissions or concentrations scenarios. Wherever possible, the assessment used studies with projections aligning to the CCRA3 lower and higher scenarios of approximately 2°C and 4°C global warming at the end of the 21st Century, as defined in Section 2.3. Where the only available studies used projections with warming rates outside of the specified ranges of these pathways, expert judgement was used to establish the implications for changes within those pathways.

3.2 New research for CCRA3

In addition, some research has been carried out specifically to feed into CCRA3, in order to address key knowledge gaps identified following CCRA2 and ensure that priority areas are informed by the most up-to-date evidence. Some of this was commissioned as part of the CCRA3 process, and some emerged from other research programmes such as the Met Office Hadley Centre Climate Programme and the Strategic Priorities Fund UK Climate Resilience programme of UKRI and the Met Office. Further details are provided in Chapter 2 (Watkiss and Betts, 2021).

3.3 Using the latest UK Climate Projections

An important issue for the CCRA process is ensuring that the risk assessment considers all relevant climate projections, including the most recent, state-of-the-art projections. The latest set of UK Climate Projections (UKCP18; Lowe et al., 2018) were published in 2018 with further components released in 2019 and 2020 and have been extensively used in the CCRA3 Technical Report and the research upon which it draws. UKCP18 global-scale probabilistic projections (Murphy et al., 2018) have been used for defining the higher and lower scenarios of warming for framing the assessment of future risk magnitudes, as described in Section 2.3. The UK-scale probabilistic land projections (Murphy et al., 2018), perturbed-parameter global and regional projections (Murphy et al., 2018) and marine projections (Palmer et al., 2018) underpinned the CCRA3 research carried out in support of the Technical Report (see Chapter 2; Watkiss and Betts, 2021), which directly informed the assessment of a number of risks. The high-resolution local projections (Kendon et al., 2019) provided further context through the provision of improved assessment of extreme weather events, against which the conclusions of other research could be compared.
Not all risks were directly informed by UKCP18 because it can take some time – many months, and often years – for new projections to be used in scientific studies and for the results to be published in the peer-reviewed literature. To check the robustness of conclusions based on older projections, key results from UKCP18 were compared with equivalent results from the previous projections from UKCP09 (Murphy et al., 2009) (Johns et al., 2021).

The main focus was on aspects of the projections that used emissions scenarios that represent trajectories to approximately 2°C or 4°C global warming in the late 21st Century, as described in Section 2.3. Although the scenario of 4°C warming by the end of the century has been defined on the basis of the RCP6.0 emissions scenario, the range of results for the probabilistic projections overlap to some extent between the RCP, so some percentiles of other scenarios can also fall within the definition of the pathway to 4°C warming by the end of the century. For example, as well as including a large proportion of UKCP18 projections with RCP6.0 emissions, the 4°C warming scenario also includes the upper end of projections RCP4.5 emissions that warmed relatively fast due to high climate sensitivity. It also included the lower end of projections with RP8.5 emissions that warmed relatively slowly due to low climate sensitivity (see for example Sayers et al., 2020 and Arnell et al., 2021).

In some cases, information relevant to 4°C global warming was only available from components of the UKCP18 that reached this level of warming faster than in the CCRA3 higher scenario, such as the majority of projections driven by the RCP8.5 emissions scenario. Where this involves quantities known to scale linearly with global warming levels, such as many aspects of extreme weather (Wartenberger et al., 2017), it can be appropriate to treat such changes as representative of the regional climate state reached at the same level of warming at a later time (Bärring and Strandberg, 2018). In these cases, the changes projected at 4°C global warming were therefore applied to a later date within the range of the CCRA3 higher scenario (see for example HR Wallingford, 2020). This method was not applied for quantities which are strongly dependent on the rate of warming rather than its instantaneous magnitude, such as sea level rise. Higher-warming RP8.5-based projections were also used to inform the general assessments of Low Likelihood High Impact scenarios described above.

4. Overview of the Technical Report chapters

Chapter 1 (Slingo, 2021) provides the climate science context for the risk assessment. It presents an update on observed climate change in the UK and across the world, including changes in the long-term climate state and extreme weather events and seasons. It provides a summary of the extent to which these changes are attributable to human-caused climate change and hence would be expected to increase further as human influence continues to grow. This is important information in the context of informing assessments of near-term risks. Since specific projections of the future consequences of current policies and global Paris-compliant policies are not available, Chapter 1 presents information available from the latest projections illustrating potential outcomes of these two categories of emissions futures. Chapter 1 also includes an overview of the implications for the standard projections of passing climate systems tipping points.
Chapter 2 (Watkiss and Betts, 2021) describes the methodology of the risk assessment and the steps taken by the authors in assessing the magnitude of risks, the effectiveness of current and planned adaptation and the benefits of additional action in the next 5 years, in order to assign the Urgency Score for each risk. Chapter 2 also summarises some of the key developments in evidence and understanding since CCRA2 was published, including lessons from other international risk, lessons learned from the CCRA2 process itself, and new understanding in climate science and adaptation, including improved evidence on vulnerability, exposure and adaptive capacity. It also includes a summary of the new or improved aspects of the CCRA3 method compared to CCRA2.

Chapters 3 to 7 present the assessment of risk and opportunity to the UK broadly categorised by general areas of policy or societal interest which illustrate how climate change is affecting all aspects of life in the nation. Natural Environment and Assets (Chapter 3: Berry and Brown, 2021) covers ecosystems, biodiversity, agriculture and the rural landscape, including the cultural landscape. Infrastructure (Chapter 4: Jaroszweiski, Wood and Chapman, 2021) represents the physical assets that humans have constructed to support a modern, functioning society by providing protection from the elements, supplies of energy and water, and to facilitate transportation. Human Health, Communities and the Built Environment (Chapter 5: Kovats and Brisley, 2021) includes well-being, culture and homes of people as individuals or groups. Business and Industry (Chapter 6: Surminski, 2021) represents the economic operation of the country, and International Dimensions (Chapter 7: Challinor and Benton, 2021) reflects the critical, close relationship between the UK and the rest of the world. All these aspects of UK life are sensitive to weather and climate and have evolved or been designed in the context of historical conditions.

Chapters 3 to 7 represent risk categories that are identical to those in CCRA2 so provide continuity. However, some chapter titles have been updated to better highlight key areas of focus.
5. References


Climate Action Tracker (2021) https://climateactiontracker.org/global/temperatures/ Accessed 17.05.21


Introduction


Annex 1. RCP emissions scenarios and projections consistent with current policies and ambitions.

Table A.1 Projections of cumulative emissions from 2021 to 2100 for pre-2020 NDC commitments, and current policies as of 2016 with uncertainties, compared with the RCPs. RCP data are from https://tntcat.iiasa.ac.at/RcpDb/dsd?Action=htmlpage&page=compare. Rogeli et al. (2016) (R16) provide ‘Current policies’ cumulative emissions for 2011 – 2100, from which cumulative emissions from 2021-2100 were derived by subtracting cumulative emissions from 2011-2020 (Friedlingstein et al., 2020)

<table>
<thead>
<tr>
<th>Emissions scenario / projection</th>
<th>Description</th>
<th>Reference</th>
<th>Cumulative emissions 2021 – 2100 (GtCO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP8.5</td>
<td>Standard emissions scenario associated with the RCP8.5 concentrations pathway.</td>
<td>van Vuuren et al., (2011)</td>
<td>6629</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>Standard emissions scenario associated with the RCP6.0 concentrations pathway.</td>
<td>van Vuuren et al., (2011)</td>
<td>3585</td>
</tr>
<tr>
<td>Constant emissions</td>
<td>Emissions remain at 2019 levels from 2021 to 2100.</td>
<td>Friedlingstein et al. (2020)</td>
<td>3446</td>
</tr>
<tr>
<td>Current Global Ambition CB6</td>
<td>Pre-2020 NDC commitments around the world in 2030 and continue to decarbonise at this same rate (changes in emissions intensity of GDP) after 2030. Prepared for the UK’s 6th Carbon Budget (CB6)</td>
<td>Vivid Economics and UCL (2020)</td>
<td>2855</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>Standard emissions scenario associated with the RCP4.5 concentrations pathway.</td>
<td>van Vuuren et al., (2011)</td>
<td>2423</td>
</tr>
<tr>
<td>RCP2.6</td>
<td>Standard emissions scenario associated with the RCP2.6 concentrations pathway.</td>
<td>van Vuuren et al., (2011)</td>
<td>853</td>
</tr>
</tbody>
</table>