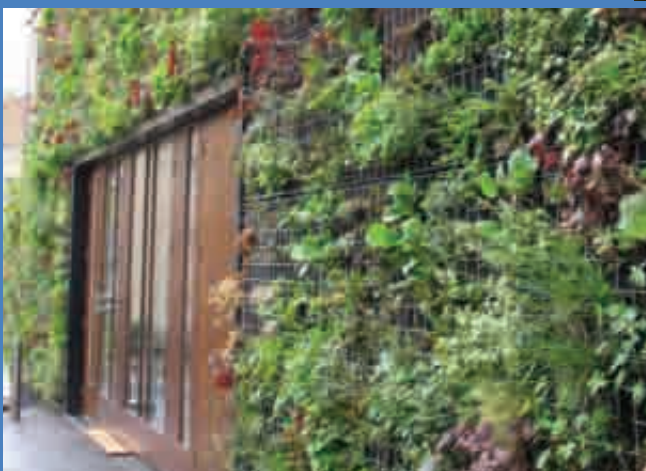


Adapting to climate change

UK Climate Projections

June 2009



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Foreword by
Hilary Benn





It is now clear from scientific evidence that global warming since the mid 20th century is largely due to human activity. That's why the world, including the UK, needs to act now to limit future climate change and to prepare for the change that we cannot avoid.

In the UK, we can be proud of what we have done so far. Under our Climate Change Act we have set statutory targets to reduce our emissions by a third by 2020 and by at least 80% by 2050. We are now the first country in the world to have set ourselves a greenhouse gas 'budget', and we are pushing for a new international agreement to cut emissions globally. Making this happen will be the responsibility of all of us in the decades ahead. But at the same time we need to adapt to the climate change that is already inevitable as a result of past emissions.

The UK Climate Projections 2009 (UKCP09) are an important step forward in improving understanding of our complex climate. There are assumptions and uncertainties in any work of this kind, but these Projections represent strong and credible climate science. They begin to quantify the uncertainties we face and so will help us to understand the risks that lie ahead.

The Projections show – through three different greenhouse gas emissions scenarios – how our future climate could change dramatically should the world fail to reduce its emissions. Although a difference in average temperatures of a few degrees may not sound significant, it is. Global average temperatures now are only 5°C higher than they were at the peak of the last ice age. If we follow a 'high emissions' path we could be heading for a global rise of over 5.5°C by 2100 compared with the pre-industrial period – that is, a larger change in temperature than between the last ice age and now. The Projections show that for the UK this could mean an average summer temperature rise of 5°C in the south west of England by the 2080s. Even under a 'low emissions' path southern England could see a rise of 3°C by the 2080s. In other words, although some global warming is now inevitable, it really matters whether or not the world achieves an international deal which cuts global emissions to keep global temperature increase below 2°C.

The UK Climate Projections show what the major changes to the UK's climate would most likely be in the absence of such action to cut global emissions. Broadly speaking, we can characterise these as warmer and wetter winters, hotter and drier summers, sea level rise, and more severe weather. Based on a 'medium emissions' pathway, which according to the Climate Change Committee is the one that the world is currently most closely following, we could see average summer temperature increases in the South East of England, of 3.9°C within our children's lifetimes (by the 2080s). At the same time we could see a 22% decrease in average summer rainfall in the South East and an increase of 16% in average winter rainfall in the North West by the 2080s, with increases in the amount of rain on the wettest days. These may turn out to be under-estimates: global emissions could be higher, with more severe consequences. Or alternatively through concerted international action we could put the world on a lower emissions pathway, resulting in less change.

The Projections make sobering reading. Although individual weather events cannot be directly attributed to climate change, we know what the impact of projected changes such as these could be because we have already experienced them. Coastal erosion has been a fact of life for centuries on the east coast of England. The August 2003 heat wave caused havoc across Europe and resulted in at least 2,000 premature deaths in the UK alone. Yet this occurred during a summer when average UK temperatures were only 2°C above the 1961-1990 average. The flooding in the summer of 2007 showed the devastating impact that can result from sudden heavy downpours; this caused the flooding of 55,000 properties and left 350,000 people without mains water. Flooding is just one of the consequences of climate change: others might include drought, overheating and effects on public health. We will be conducting shortly the first national Climate Change Risk Assessment to understand them more fully.

The Government has taken, and will continue to take, action to help protect the public from immediate risk. We have more than doubled spending on flood protection since 1997, developed a heat wave plan in the NHS and are helping communities affected by coastal erosion. The UK Climate Projections now provide additional evidence to help all of us take the necessary action now to plan for the long term.

The Projections show that although reducing greenhouse gas emissions is critical to avoid the most dangerous effects of climate change, past emissions mean that some changes are now inevitable whatever we do – with summers over 2°C hotter in southern England by the 2040s. It is therefore vital that we plan and prepare for these changes – whether it's in the design of school buildings or the protection of new power plants, maintaining the supply of drinking water, adjusting farming methods for drier summers, or understanding how our homes and businesses will have to adapt. Taking simple steps now will reduce the costs for all of us in the future. We set out in this document how we propose to help our society do this.

The Government's plan for tackling climate change has five elements:

- **Protecting the public from immediate risk** including through increased flood protection, coastal erosion management, efficient use of water and health contingency plans.
- **Preparing for the future** by, for instance, changing the way we build our houses and infrastructure and developing new ways to do business. This document sets out the science to help inform these decisions and explains what the Government is doing.
- **Securing a global deal in Copenhagen in December** to limit temperature increase to less than 2°C and avoid the most dangerous effects of climate change. Countries around the world need to cut emissions by 50% on 1990 levels by 2050.
- **Creating a low carbon UK.** We will not get global action unless countries like the UK provide a lead. We need to make fundamental changes to decarbonise the UK in a way which maximises business opportunities, treats people fairly and keeps energy supplies safe and secure.
- **Supporting individuals and businesses to play their part.** Government will work with all groups in society to support those already doing their bit and to encourage others to start.

These Climate Projections provide a crucial foundation for what we are doing. I hope you will find them helpful. They show us the sort of future that we in the UK will have to face up to – and the sort of future we must work hard to avoid. The same is true for every country in the world – from the poorest to the richest – and we can only make that change if we do it together.



A handwritten signature in white ink, appearing to read 'H Benn'.

Rt Hon Hilary Benn MP
Secretary of State for Environment, Food and Rural Affairs



Chapter 1 – Introduction

The Earth's climate is changing. Global temperatures are predicted to continue rising, bringing changes in weather patterns, rising sea levels and increased frequency and intensity of extreme weather for the UK. The extent of change will depend greatly on how successfully the world cuts its greenhouse gas emissions.

We need to understand how our climate might change so that we can prepare. Organisations need good evidence, which includes a measure of the uncertainties involved, to help them consider the risks that a changing climate might pose and plan what they should do to increase resilience and reduce those risks.

The UK Climate Projections 2009 have been developed to do this. The range of information presented is more complex than the last set, UKCIP02, and as such the results cannot easily be compared, but they are broadly consistent.

The United Nations Framework Convention on Climate Change (UNFCCC) negotiations at Copenhagen later this year will be vital in reaching an international agreement to limit global greenhouse gas emissions. The UK wants an agreement that limits global temperature increases to no more than 2°C above pre-industrial levels, beyond which the risks of dangerous climate change become much greater.

So we need to take action to reduce emissions and ensure that further climate change is avoided. According to the Climate Change Committee, global emissions need to peak by 2016 and then fall by 2050 to at least 50% below 1990 levels to give us the best chance of limiting temperature increases to 2°C.

This report explains the key findings and potential uses of the UK Climate Projections. The Government has also established the *Adapting to Climate Change Programme*. This report therefore provides an update on the Government's Adapting to Climate Change (ACC) Programme since this was last reported on in July 2008 in 'Adapting to Climate Change in England: a framework for action'.

In **Chapter 2** we explain what these Projections are. **Chapter 3** sets out some of the key findings for England and provides further information on some of the possible impacts.

We need to adapt in response to these changes and **Chapter 4** sets out what the Projections mean for organisations and individuals. It asks questions that we will need to consider now and in the years ahead and provides information on where to go for further advice.

The Projections underline the need for both adaptation and mitigation. We must continue to work for a global agreement on cutting emissions and the action we take now will have a lasting effect on our world. The Government has played a leading role internationally and we have passed the Climate Change Act and become the first country in the world to adopt statutory greenhouse gas budgets. **Chapter 5** sets out a summary of our work nationally and internationally on climate change mitigation.

Chapter 6 sets out how the Government and others are contributing to the Programme together with information about the work being done to adapt to climate change. There are similar initiatives underway in Scotland, Wales and Northern Ireland.



Mitigation and adaptation

Mitigation means taking action to tackle the causes of climate change, that is reducing concentrations of greenhouse gases in the atmosphere.

Adaptation means taking action to deal with the consequences of a changing climate, resulting from increased levels of greenhouse gases.

We will need to both adapt and mitigate in the years ahead.

Climate Change

The 2007 Fourth Assessment report from the IPCC (Intergovernmental Panel on Climate Change) said that it is **very likely** (over 90%) that man-made greenhouse gas emissions caused most of the observed increase in global average temperatures since the mid 20th century.

Chapter 2 – What are the UK Climate Projections?

The UK Climate Projections have been developed to help us understand our possible future climate. They take cutting edge climate science and provide the results in a form which can be used by a wide range of organisations that need to assess the level of risk they face.

This section provides an overview of:

- what climate models are;
- what is included in the UK Climate Projections;
- how uncertainty is dealt with in the modelling; and
- what emissions scenarios have been used in the Projections.

Climate models

Climate models are computer simulations of the way the Earth's climate works. Beginning with the laws of physics, they represent the characteristics of air, ocean water, ice, and crucially, heat around the Earth. They model chemical, biological and physical processes in the atmosphere, oceans and on land. Ever more sophisticated models and increasing computer power enable climate scientists to understand our climate better and study a range of possible future climates.

Model results are checked in part by simulating past and present climate observations and seeing how well they perform. All of the models used in UKCP09 are internationally recognised and peer reviewed.

These climate model results, together with observations of climate change, form the basis of the overwhelming consensus there now is in the scientific community and international bodies (including the Intergovernmental Panel on Climate Change – IPCC) that the world's climate is changing quickly and that this is mainly as a result of our actions.

The challenge now, and one which the UK Climate Projections will help us meet, is to use this enhanced sophistication and the variety of models to provide us with a more detailed picture of the nature and probability of various possible outcomes. This will inform practical decisions, helping our society to deal with the risks from climate change.

Contributors to UKCP09

The Projections have been funded by the UK Government, on behalf of the Scottish Government, Welsh Assembly and Department of the Environment Northern Ireland. UKCP09 has been produced by a consortium of organisations:

- The Met Office Hadley Centre
- UK Climate Impacts Programme
- British Atmospheric Data Centre
- Newcastle University
- University of East Anglia
- Environment Agency
- Proudman Oceanographic Laboratory
- Tyndall Centre
- Marine Climate Change Impacts Partnership

What is included in the UK Climate Projections?

This generation of climate change projections is built on recent advances in science and what we have learned from the many organisations already using climate change information to improve the way they manage their risks and longer term planning.

The UKCP09 Projections go well beyond the previous projections made in 2002, by accounting for uncertainties in future changes in a systematic manner. This is achieved using a methodology designed to sample major known uncertainties in relevant physical, chemical and biological processes. The results are based on projections of hundreds of different variants of the Met Office Hadley Centre climate model, combined with results from twelve of the world's other leading climate models, and information from past climate observations. This new and comprehensive approach allows us to provide probabilities for different climate outcomes, based on the strength of evidence provided by current knowledge, climate modelling capability and using expert judgement. The Projections provide data on both the actual and observed UK climate, and provide projections of climate to the end of this century covering:

Land:

- Probabilistic projections for temperature, precipitation, air pressure, cloud and humidity and other variables by region and 25km grid squares and for monthly, seasonal and annual values.

Results are provided for the three different emissions scenarios – high, medium and low.

Climate is generally defined as an average of what happens to weather over a 30 year period and we follow this approach in these Projections. These Projections of future climate change therefore present information for seven overlapping 30-year time slices, starting with 2010 to 2039. The middle decade of each time slice is used as short hand (for example, 2020s for the first time period).

Coastal and marine:

- Probabilistic projections for temperature, precipitation, air pressure and for cloud over the sea.
- Projections for sea level rise, storm surge, sea surface and sub-surface temperature, salinity, currents, and waves.

Some of the marine projections can only be provided for the medium emissions scenario.

For a variety of different reasons it is more challenging to provide probabilistic projections of future changes to wind speed, soil moisture and snow. Whilst the project explored these issues the results are not yet sufficiently robust. This is explained further in the *UK Climate Projections Science Report: Climate Change Projections* available through the Projections website at <http://ukcp09.defra.gov.uk> The technical guidance signposts other existing climate modelling results that can be used for those wanting to consider these variables.

Peer Review

A scientific peer review of the Projections was undertaken, involving twelve independent reviewers specifically chosen to cover a wide range of views on climate modelling.

They concluded that the methodologies used to create the Projections are credible, and the work is to a very high standard but that the work is complex and needs guidance to support use of the data.

For more information on the peer review findings, visit the Adaptation pages on Defra's website www.defra.gov.uk/adaptation

Chapter 2 – What are the UK Climate Projections?

What does probability mean in the UK Climate Projections?

It is very important to understand what probability means in UKCP09. The probability range is the way in which the project has systematically sought to understand and quantify a variety of uncertainties which are inherent in seeking to model something as complex as the world's climate. The interpretation of probability generally falls into two broad categories. The first type of probability relates to the expected frequency of occurrence of some outcome, over a large number of independent trials carried out under the same conditions: for example the chance of getting a five (or any other number) when rolling a dice is 1 in 6, that is, a probability of about 17%.

This is not the meaning of the probabilities supplied in UKCP09, as there can only be one pathway of future climate. In UKCP09, we use the second type (called Bayesian probability) where probability is a measure of the degree to which a particular level of future climate change is consistent with the evidence. In UKCP09, this information comes from observations and outputs from a number of climate models, all with their associated uncertainties. The methodology which allows us to generate probabilities is based on large numbers (ensembles) of climate model simulations, but adjusted according to how well different simulations fit historical climate observations in order to make them relevant to the real world. The user can give more consideration to climate change outcomes that are more consistent with the evidence, as measured by the probabilities. One important consequence of the definition of probability used in UKCP09 is that the probabilistic projections are themselves uncertain, because they are dependent on the information used and the method used to create the Projections.

The background to the development of the Projections, including the methodologies used, limitations and caveats and user guidance are provided through the UK Climate Projections website at <http://ukcp09.defra.gov.uk>. It is essential to understand the information in the accompanying technical site before the Projections are used for decision making or research (see chapter 4).

Only a very small selection of the findings from the Projections are presented in chapter 3 of this report; a very wide range of in-depth results can be found on the website.

Dealing with uncertainties

There is inevitably some scientific uncertainty associated with projecting future climate. This uncertainty arises for a number of reasons. For example, we have to estimate future emissions of greenhouse gases to model the temperature response; there is natural inter-annual variability in global mean temperature; different climate models have used different estimates for climate feedbacks (for example, the effect of clouds); and climate models could never be complete representations of our hugely complex climate system.

However, our understanding of climate change is based around three things: what we have observed (now and from records of the past climate); what we know from fundamental laws of physics; and climate models which bring together our scientific understanding and observations.

As scientists do more work and increase our knowledge of the climate system, this uncertainty will reduce. However, we can turn the notion of scientific uncertainty around and express it in terms of probabilities or likelihood (ie, the strength of evidence for climate changing in the future). If we do this, we can say that the large body of evidence for climate change is unequivocal, as the overwhelming majority of scientists agree.

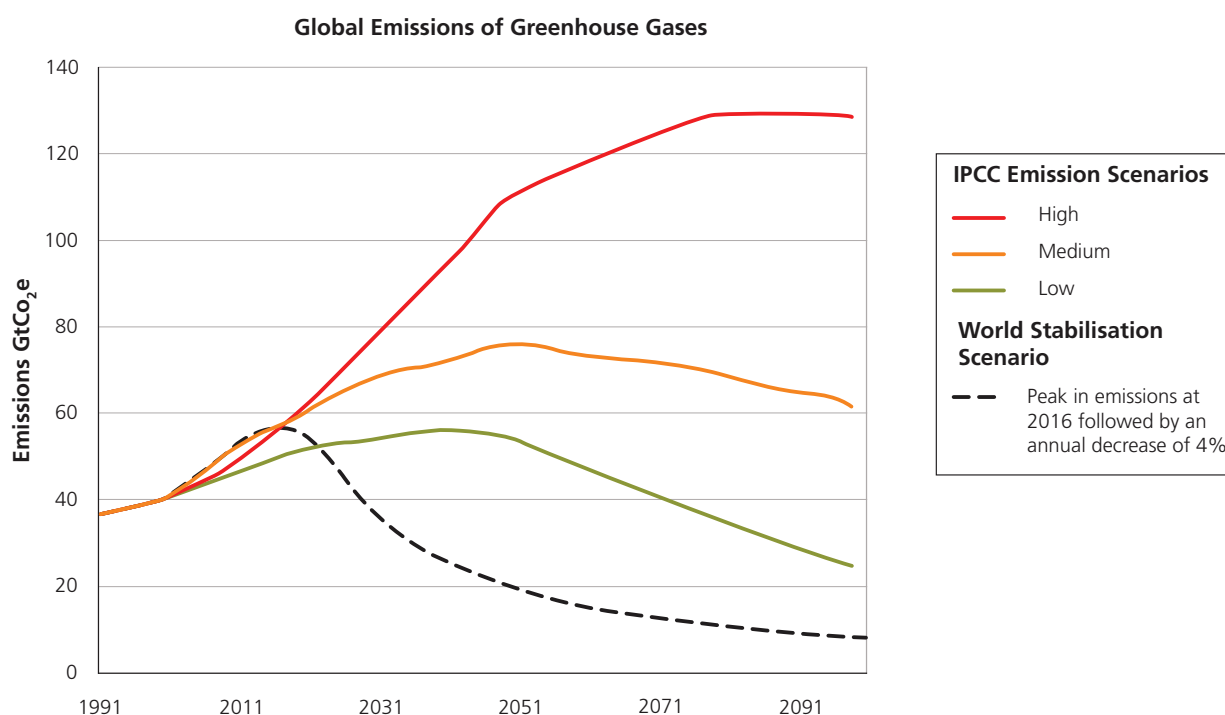
What are the UK Climate Projections? – Chapter 2

Emissions scenarios

The Projections provide data for three different future scenarios of greenhouse gases. They have been chosen from a collection of scenarios in the Special Report on Emissions Scenarios (SRES) developed by the IPCC. The three scenarios chosen for the UK Climate Projections represent a broad range of possible futures.

These emission scenarios are based on different pathways showing how a range of factors, such as population, economic growth and energy usage, might change over time. They were developed to help understand how these various factors interact and might increase or decrease greenhouse gases, but it should be noted that they do not include international policies to reduce greenhouse gas emissions. For example, the medium emissions storyline describes a future world of very rapid economic growth, a growing population peaking in 2050 at nearly 9 billion and continued use of fossil fuels, but with substitution of renewable energy sources for some fossil fuel use. Rapid introduction of new and efficient technologies driven by market forces is assumed. The high scenario is based on heavier reliance on fossil fuels, whereas the low scenario assumes a strong move away from fossil fuels.

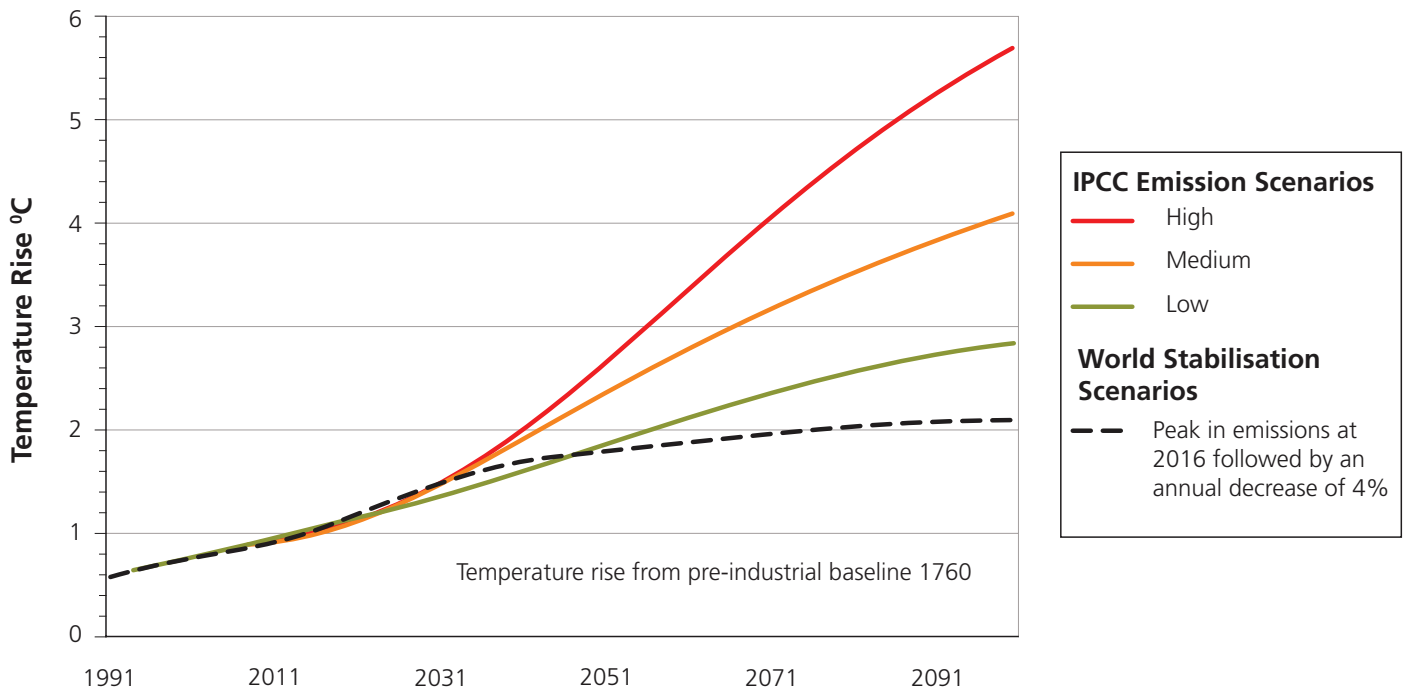
The three emissions scenarios are shown on the graph below, set alongside the emissions pathway needed to achieve the EU's goal to limit global warming to 2°C. They show changes in global greenhouse gas emissions. The first graph shows how greenhouse gas emissions have changed since 1991, how the different scenarios diverge in the future and how they relate to our aims for global negotiations to cut emissions (the dashed line). The second graph (on page 7) shows the increase in global temperature for the different scenarios using a pre-industrial baseline of 1760.



Our aim is to reduce the risk of dangerous climate change, but also to be ready to deal with a worse case than we hope will come to pass. The Projections provide a range of emissions scenarios, to enable organisations to plan prudently for a wide range of eventualities. The graph below shows how different emissions scenarios would affect global temperature rise by 2100 from a baseline of pre-industrial levels (1760). For the next two to three decades there is little difference between the scenarios in terms of how they impact on global temperatures. After this point the impact of different emissions levels becomes significant, leading to a very wide difference between low and high greenhouse gas emission scenarios by the 2080s.

Chapter 2 – What are the UK Climate Projections?

Global Mean Temperatures



Currently, global greenhouse gas emissions are increasing. If we continue on this path it will put us on a trajectory to the medium, or even high, emission scenario. This would have very serious consequences and we therefore need to continue to work urgently to achieve large cuts in global emissions.

Confidence in climate projections

There is a 'cascade of confidence' in climate models and the UK Climate Projections are no exception.

We have very high confidence in the occurrence of global warming due to emissions of greenhouse gases caused by humans. We have moderate confidence in aspects of continental-scale climate change projections. Climate change information at the 25km scale is indicative to the extent that it reflects the large-scale changes modified by local conditions. This produces a range of examples of local climates consistent with current larger-scale model projections.

Confidence in climate change information also depends strongly on the variable under discussion. For example, we have more confidence in projections of mean temperature than we do in those of mean rainfall, and changes in averages are more robust than changes in extreme values.

The probabilities provided in the Projections quantify the degree of confidence in projections of each variable, accounting for uncertainties in both large scale and regional processes as represented in the current generation of climate models. However, the probabilities cannot represent all uncertainties. Users should understand that future improvements in global climate modelling may alter the projections, as uncertainty is gradually reduced.¹

¹ The probabilities relate to each scenario, but the emissions scenarios themselves were not given any probability by the IPCC.



Chapter 3 – What are the key findings?

The key findings from the Projections highlight the main types of changes we might see for the UK. A subset of the key findings from the UK Climate Projections website is presented here.

We know we cannot predict the future with certainty. This latest science gives us the best information to date with which to understand and deal with the uncertainty.

The Projections described in this report present data for the UK but they are inextricably linked to bigger changes worldwide. What this means in practice is that different countries will experience climate change differently.

Further work is being undertaken by the UK Government on a national Climate Change Risk Assessment, which will help us understand further what impacts we will have to deal with.

This chapter provides an overview of:

- how the UK climate is already changing;
- some key findings from the Projections, illustrating the type of information provided through the Projections;
- some examples of our current vulnerability;
- some of the consequences of, and opportunities associated with, projected changes in climate; and
- the regional variation in the climate changes and impacts across the UK.

Observed trends

The temperature in Central England has already risen by about 1°C since the 1970s, with 2006 being the warmest year in the 348 year record we have. The sea surface temperature around the UK coast has risen by 0.7°C in the last 30 years.

Over the last 250 years, there has also been a slight trend for increased rainfall in winter and decreased rainfall in summer, a trend which is in line with the expected changes.

In addition, all regions of the UK have experienced an increase in the amount of winter rain that falls in heavy downpours.

Sea levels around the UK have risen by about 1mm/a year over the 20th century, although recent rates are slightly higher than this.

Key Findings

The Projections show how serious the changes for the UK could be if the world continues to follow the medium emissions scenario or, even worse, follows a high emissions scenario. The Committee on Climate Change used the medium scenario in its analysis published in December 2008 because it was consistent with current levels of global emissions, as well as forecasts of future emissions by other independent forecasters, for example, the International Energy Agency. Data and trends are therefore presented here using that scenario, with these figures put into context by comparison with the high and low scenarios for 2080 on page 16. Results are given for:

- the central estimate (see Glossary for details);
- the most likely range (between the 10% and 90% probability levels – in brackets where given);
- the periods 2010-2039 (2020s), 2030-2059 (2040s) and 2070-2099 (2080s).

All changes are measured relative to a 1961-1990 baseline². This means that we have already experienced some of the climate change shown in the findings in this chapter.

All key findings quoted here represent results averaged over administrative regions (shown below). The maps provided alongside show results graphically for the UK based on individual 25km grid squares, illustrating how climate change will vary across the country. As explained in the previous chapter, as spatial scale gets smaller, results tend to have a greater range and larger uncertainty.

The Projections in Wales, Scotland and Northern Ireland

Adaptation policy is a devolved matter. As such, each country develops its own policies and reports to its own ministers to respond to the challenges presented by a changing climate.

The Projections have been successfully developed in partnership with all administrations in the UK. There is variation in the projected climate outcomes between different locations. The key findings for Scotland, Wales and Northern Ireland are presented on their websites. Links to each are provided below.

Department of the Environment Northern Ireland:

http://www.doeni.gov.uk/index/protect_the_environment/climate_change/

Scottish Government: www.scotland.gov.uk/changingclimate

Welsh Assembly: www.wales.gov.uk/climatechange

Map of the UKCP09 administrative regions:



In this chapter we set out just a few of the key findings from the Projections to show some of the most significant implications and give an idea of the type and breadth of information available.

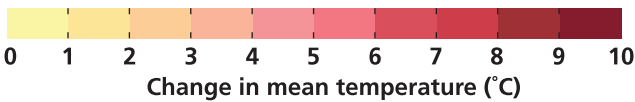
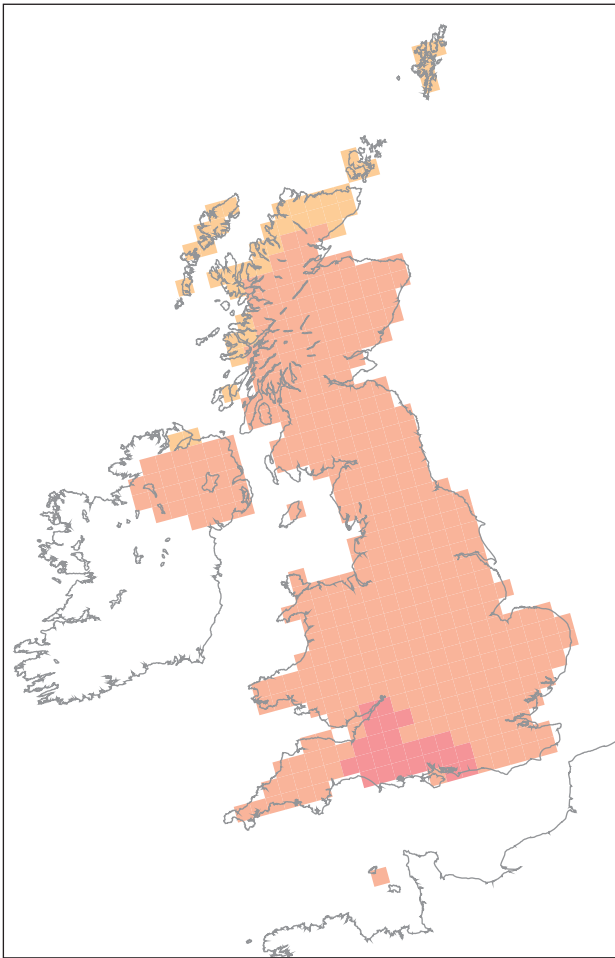
Examples of how the climate is likely to change through the century have been given for the South East, South West and North West regions for illustration. Full regional results can be found on the projections website at <http://ukcp09.defra.gov.uk>.

Administrative regions over which changes are averaged in the regional key findings.

² The baseline has been created from a modelled average, see Climate Change Projections Report at <http://ukclimateprojections.defra.gov.uk/content/view/full/824/517/>

Chapter 3 – What are the key findings?

Summer temperature: all areas of the UK will get warmer, more so in summer than in winter.



Across the UK, central estimates of the average regional summer (June, July, August) temperature rise in the 2080s are between 3 and 4°C.

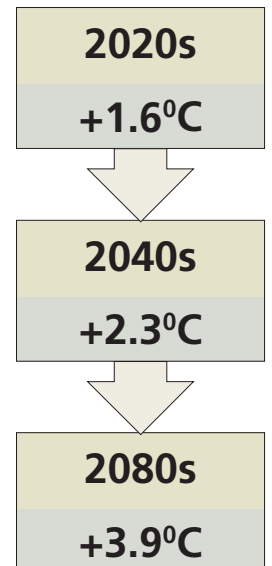
Central estimates of temperature change in °C from the 1961-1990 baseline for 25km grid squares, (2080s, for the medium emissions scenario).

South East of England:

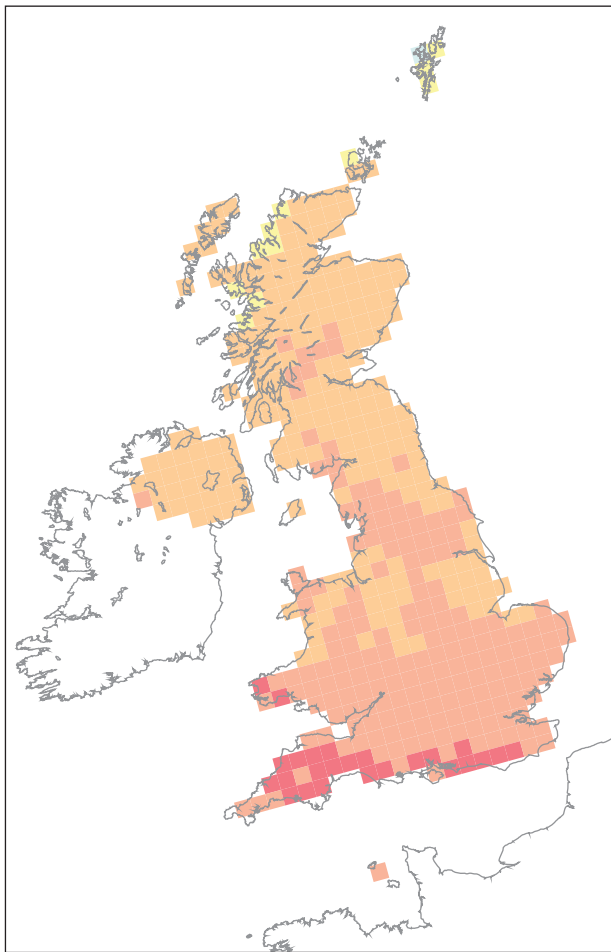
Central estimates of average summer temperature increase through time, for a medium emissions scenario, for the South East of England in the 2020s, 2040s and 2080s.

Projections of central estimates of average summer temperature change in the South East get larger over time. Projected increases in average summer temperatures are 1.6°C (0.6-2.7°C) during the 2020s, 2.3°C (1.0-4.0°C) by the 2040s and 3.9°C (2.0-6.4°C) by the 2080s.

The temperature increases provided in the diagram are central estimates of the summer average change for 30 year time periods centred on the decade shown.

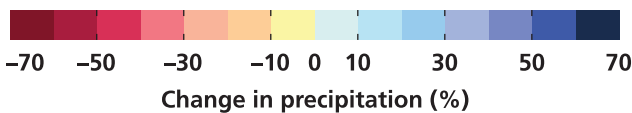


Summer precipitation: summer precipitation tends to decrease across the UK.



Across the UK, central estimates of regional average summer precipitation change are projected to be between -17% to -23% in the 2080s.

Central estimate of % change in summer precipitation from the 1961-1990 baseline across 25km squares (2080s, for the medium emissions scenario).



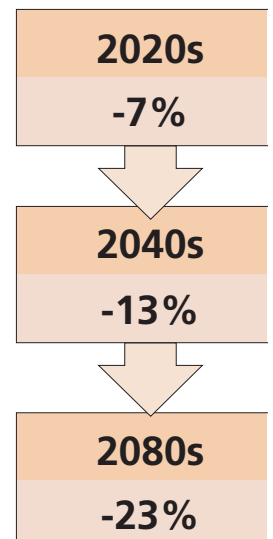
South West of England:

Central estimate of summer rainfall through time, for a medium emission scenario, for the South West of England in the 2020s, 2040s and 2080s.

Across the UK, central estimates of regional average summer precipitation change in the 2080s are -17% to -23%.

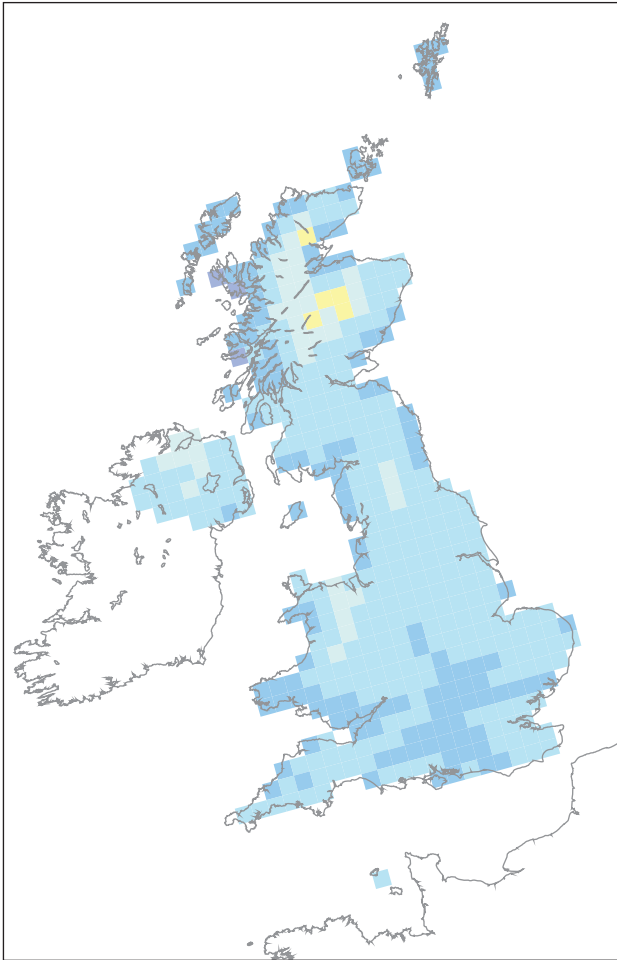
Projections of central estimates of average summer precipitation change in the South West get larger over time. Projected changes in average summer precipitation are -7% (-26 to +14%) during the 2020s, -13% (-35% to +11%) by the 2040s and -23% (-49% to +6%) by the 2080s.

The diagram shows central estimates of summer precipitation change at the 25km spatial resolution for the 2080s.



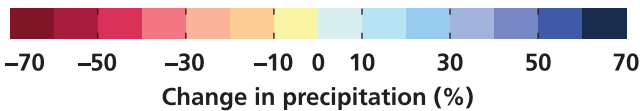
Chapter 3 – What are the key findings?

Winter precipitation: winter precipitation tends to increase across the UK.



Across the UK, central estimates of regional average winter precipitation change are projected to be in the region of +14% (NE) to +23% (SW), in the 2080s.

Central estimate of % change in winter precipitation from the 1961-90 baseline across 25km squares (2080s, for the medium emissions scenario).

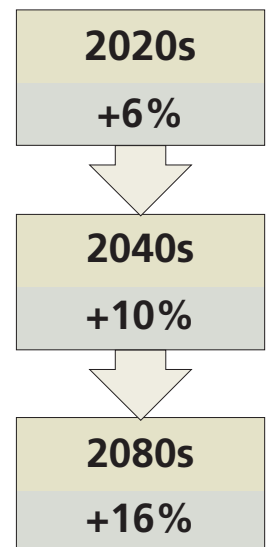


North West of England:

Central estimates of average winter rainfall through time, for a medium emissions scenario for the North West of England for the 2020s, 2040s and 2080s.

Projections of mean winter precipitation change in the North West get larger over time with projected increases in average winter precipitation of +6% (-1% to +14%) during the 2020s, +10% (+1% to +21%) by the 2040s and +16% (+3% to +35%) by the 2080s.

The precipitation changes provided in the diagram are central estimates of winter averages for 30 year time periods centred on the decade shown.

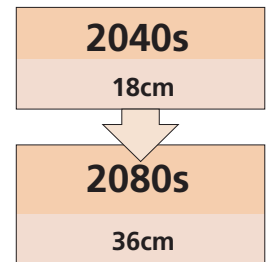


Sea level rise and storm surge:

Central estimates of sea level rise in London through time, for a medium emissions scenario in the 2040s and 2080s.

The central estimates for sea level rise (taking into account land movement) show that sea level is projected to rise by 18cm in London by 2040 and 36cm by 2080.

Sea level rise is calculated in a different way to the probabilistic projections; the results shown are for individual years and the central estimate represents the point at which half of the models used simulate a greater increase and half simulate a smaller increase.



We have also modelled a worst case that give rises of up to 1.9 metres by 2100 (high++ scenario). The high++ is for 2095 for the UK, and is a highly unlikely, extreme scenario for the purposes of contingency planning, for example future Thames Barrier requirements. It should be noted that recent observations and model projections do not suggest this extreme scenario will occur.

The projected future trends in storm surge are less than 9cm above current average storm surge levels, by 2100, not including sea level rise, everywhere around the UK, and in many places this is within what might be expected through existing natural variation. More information on storm surge can be found on the website (<http://ukclimateprojections.defra.gov.uk>).

Comparisons of UKCP09 with UKCIP02

The results of this new set of Projections are broadly consistent with the previous set, UKCIP02. But there is a lot more information in UKCP09 and wider ranges in the new set of Projections. The reasons for the differences between the two sets of projections lie in the different model results and methodologies which were used to derive them. UKCP09 includes:

- the effects of land and ocean carbon cycle feedbacks;
- uncertainty due to natural variability;
- modelling uncertainty: UKCIP02 was derived using a variant of one (Met Office) model, whereas UKCP09 is derived from ensembles of variants of Met Office models together with information from other international climate models; and
- uncertainties associated with the statistical processing required to convert results from model ensembles into probabilistic projections, none of which were able to be included in UKCIP02 projections.

A more detailed analysis of the comparison between UKCIP02 and UKCP09 is available in the *UK Climate Projections Science Report: Climate Change Projections* available through the website. (<http://ukclimateprojections.defra.gov.uk>)

The effect of different emissions scenarios

Inertia of the climate system means that global temperature changes lag behind the emission of greenhouse gases. We are already committed to another 0.6°C rise in average global temperatures and will have to adapt to this unavoidable warming. It also means that actions to cut emissions started now will not slow the rise of global temperature until at least 2040.

Emissions over the next few decades, which will affect the degree of climate change in the latter half of the century, will be largely determined by what we do internationally. This will have a huge impact on what level of climate change future generations will have to live with. By urgently and rapidly reducing emissions, by for example reaching a peak in global emissions in 2016 and achieving a 4% decrease per

Chapter 3 – What are the key findings?

year thereafter, a global temperature rise to 1.8°C by 2050 is expected, but this would then stabilise at about 2°C by 2100, avoiding many of the more severe impacts of climate change.

We have set out here the changes for the UK. The rest of Europe will also experience climate changes to a greater or lesser extent. The climate of the UK differs from that of Southern Europe, for example, because our position in the North Atlantic brings different weather to our shores than that experienced further south. The global climate models show clearly that the North Atlantic circulation, known as the Gulf Stream, will continue to protect us from some of the more severe changes that will be seen by our neighbours over the coming decades.

Impacts and Vulnerability

We know that our current climate has impacts on our economy, health and environment, and that the changing climate of the UK will pose increased risk in future due to higher temperatures, rising sea levels and a greater frequency of extreme events such as heatwaves, flooding and drought.

The Projections do not directly outline the impacts of climate change (such as flooding and droughts) as these will vary according to local conditions and vulnerability. The Projections do however provide evidence for organisations to begin to explore and plan for likely changes in climate. Like previous climate change scenarios, the Projections will be used in impact models to obtain information about events such as floods and droughts.

However, even before this additional work is done, we can make assumptions about what these impacts will be based upon previous experience and observed trends.

- There were about 35,000 premature deaths across Northern Europe in the intense heatwave in 2003 (IPCC WGII AR4, 2007) with around 2000 premature deaths in the UK. The heatwave in 2003 occurred during a summer in which average summer temperatures were 2°C above the 1961-1990 average in the UK. However it was the high daily maximum temperatures, combined with a lack of effective plans to deal with these that created casualties. As average temperatures increase, so do the number of hot days, and this relationship is not necessarily linear. A study undertaken by the Met Office suggests that such heatwaves are expected to become more frequent in coming decades, as summers as warm as this will be 'normal' by the 2040s.
- In its 2004 report, 'A Changing Climate for Insurance', the Association of British Insurers notes that claims from storm and flood damages in the UK doubled to over £6 billion over the period 1998-2003 with the prospect of a further tripling by 2050.
- In the 2007 floods, 10,000 motorists were trapped in vehicles on the M5 and surrounding roads.

Looking ahead, the impacts of the changing climate will depend significantly on how well central Government, local councils, businesses, voluntary organisations and individuals plan for and adapt to these changes. The effects on our health during a heatwave can be reduced through effective planning by the NHS and social services, and by individuals knowing what to do. Similarly, the effects of flooding can be reduced by investment in flood defences and sensible long-term planning. The rest of this document outlines some of the actions already in hand to plan for a changing climate and what more we need to do.

Marine impacts of climate change

Climate change impacts on the marine environment are considered by the UK Marine Climate Change Impacts Partnership (MCCIP), a partnership of Government Departments and their Agencies, nature conservation organisations, scientists and green NGOs.

For information on the potential impacts of climate change on coastal economies and people, ocean acidification, non native species and seabirds visit MCCIP's website: <http://www.mccip.org.uk>

What happens if greenhouse gas emissions are higher or lower?

This chapter has focussed on Projection results for the IPCC 'medium emissions' scenario. As explained above, analysis by the Committee on Climate Change suggests that this scenario is broadly consistent with current levels of global emissions. This could lead to significant changes to the UK climate with impacts on our health, infrastructure and environment (see page 20). The medium emissions scenario is by no means inevitable. International efforts to shift to a lower carbon path – as the Government is working for – could reduce global emissions significantly. But for planning purposes, we have used a range of IPCC scenarios and further details for the 'low' and 'high' emissions scenarios are set out below for comparison:

- Summer average temperatures in the South East (2080s):
 - For the high emissions scenario, projected increases of 4.9°C (2.6 – 8.1°C).
 - For the low emissions scenario, projected increases of 3.0°C (1.4 – 5.1°C)

The difference for the central estimate in the South East is therefore almost 2°C between the high and low scenarios. This difference carries with it significant additional risks to our society and for our natural and built environment.

- Summer average rainfall in the South West (2080s):
 - For the high emissions scenario, projected decreases of -29% (-57% to +4%).
 - For the low emissions scenario, projected decreases of -15% (-39% to +13%)

- Winter average rainfall in the North West (2080s):
 - For the high emissions scenario, projected increases of +26% (+9% to +50%)
 - For the low emissions scenario, projected increases of +15% (+4% to +30%)

Again, the differences for both summer decreases and winter increases in rainfall carry with them significant risk implications for flood management and water stress.

- For sea level rise for London (2080) relative to a 1980 to 1999 baseline the changes with a high emission scenario are projected to be 43cm (19cm to 68cm range) but for low emissions are projected to be 31cm (16cm to 45cm).

Taken together, these figures show that for the 2080s the level of emissions to which the world commits now will make a huge difference to our future. The international agreement for which the Government is working – limiting average global temperature rises to 2°C – would see emissions even lower than in the 'low' scenario, so the likely changes would be correspondingly less. The importance of an international agreement to reduce emissions cannot therefore be underestimated.

For the 2040s, however, the differences between the emissions scenarios are very small – less than half a degree for summer temperature and very little difference in rainfall. This reflects the time lag between emissions and climate change: past emissions mean that climatic changes for the next three decades cannot now be avoided. However, as the figures in this chapter show, our climate in the 2040s is likely to be very different from today, with rises projected in average summer temperatures in all English regions of at least 2°C (0.8°C to 4.2°C across the range of probabilities). For all regions the central estimate shows a decrease in summer precipitation and an increase in winter precipitation by the 2040s. That is why we will need to adapt to climate change even as we seek to change its future course. Both strategies – mitigation and adaptation – are urgently required.

Managing the risks of climate change: Gloucestershire County Council

On 20th July 2007 Gloucestershire received one and a half times the average monthly rainfall for the whole of July in one day.

As a result, Gloucestershire County Council suffered £50 million worth of damage which included a £25 million repair bill for highways, £2.4 million for 20 schools, £2 million for community buildings, and £206,000 to dispose of extra waste generated by the floods.

This prompted a programme to improve the resilience of the Council and the wider area. In 2007 the Council adopted a Climate Change Action Plan which includes actions to reduce the impacts of flooding and heatwaves as well as building an assessment of future risks into its planning processes.

What's changed?



- Gloucestershire County Council will have invested £9 million in flood resilience by the end of 2009.
- The Council has contributed £0.8 million to district council land drainage projects on ordinary watercourses and £0.6 million to Environment Agency flood alleviation projects. Flood resilience measures are estimated to have improved the resilience of 1500 homes.
- The Council has been actively raising public awareness of flood resilience to promote flood defence products to householders, and providing practical help and advice to other authorities.
- The Council is working with NHS Gloucestershire (the Primary Care Trust) in implementing Heatwave planning.
- An assessment of climate change risks across the Council's assets is underway.
- A key focus of the County Council's work has been to embed climate change within its risk management approach, and to use risk management as the Council's strategic approach.

Anglian Water adaptation strategy

In 2005, climate change was recognised by Anglian Water as a significant risk to their services. Adaptation was essential to protect customers, services, sites, infrastructure, employees and the environment from the associated risks. Thus, in addition to a challenging carbon reduction programme, they have developed the Anglian Water Adaptation Strategy.

What did they find?

- Operating in the driest region of the country with one of the longest coastlines and low-lying land, the effects of climate change particularly affect the company. Investigations showed that critical infrastructure will be increasingly vulnerable to rising sea levels, more intense storms and flooding.
- Substantial planned housing growth in the next 25 years will add further pressure to the region's water resources, water quality and biodiversity.

What is being done?



- The impacts of climate change, sea level rise and more frequent and intense storm events have been assessed to identify what adaptation is required to ensure that Anglian Water can continue to deliver their services.
- Anglian Water has proposed a £36.8 million investment in flood protection at 27 water sites, 46 wastewater sites and 81 pumping stations, and £58 million on improving the resilience of the water supply system over the next five years.
- Work has also been done to understand the implications of more intense storm events on sewer design. In Great Yarmouth the company has used its knowledge of changes in rainfall intensity over recent years to increase the design capacity of its proposed sewer improvements in the town.
- Anglian Water has engaged with other regional stakeholders in the development of Local Climate Impact Profiles and the review of shoreline management plans.



Likely impacts of these changes?

Buildings

Offices are more likely to overheat as a result of warmer summer temperatures. Methods of passive cooling, such as the use of blinds and external shading, will be needed so as not to:

- Increase the reliance on air conditioning, which will increase energy consumption.
- Premises may be exposed to increased risk of flooding due to higher winter rainfall levels and an increased frequency of extreme weather.
- There will be increased risk of subsidence – the summer of 2003 saw claims of £400 million for subsidence.

Economy and society

Businesses will have to think about how these changes affect them and the people they serve or sell to.

- Climate change may affect food supply chains, for example, where our food comes from.
- There may be opportunities for new markets and new jobs; for example in tourism or from making new products to help us cope with these changes.

Agriculture

There will be:

- Risks to agriculture from changes to the growing season, droughts and floods, increased heat stress in livestock, more storm damage and increased risks from pests and diseases.
- Agriculture may, however, also see increased yields in some crops with higher temperatures, and the opportunity to grow new crops.

The natural environment

- A new University of East Anglia study estimates that fish stocks will migrate north by 40km every decade for next 50 years.
- Fire risks on heathlands could increase as a result of higher summer temperatures and lower rainfall.
- Spring is already happening earlier in the year. Some key trees are leafing and some butterflies arriving 10 days earlier than was the case 30 years ago due to increases in temperature in March and April.

Wildfire risk management: Peak District National Park

A major moorland fire in the Bleaklow area of the Peak District National Park in August 1997, which burned for over two weeks, led to the formation of the Peak District Fire Operations Group (FOG). It brought together six different fire authorities, three water companies, the National Trust, private estates and the National Park Ranger Service and as a result has helped to significantly reduce the impact of wildfires on important peatland habitats.

FOG is working together to improve the preparation, planning and training of staff in advance of the fire season to help reduce the risk of wildfires, which is expected to increase in future with hotter, drier summers.

Outcomes: what is being done?

A fire plan is in place for all areas of Moorland in the National Park, which provides information on the following to help ensure rapid and effective response to wildfires:

- available equipment
- contact numbers and land ownership details
- potential water sources
- access routes and rendezvous points
- vegetation type and ecological status
- hazards such as overhead electric cables
- The Moors for the Future Partnership (www.moorsforthefuture.org.uk) in collaboration with the University of Manchester has produced a fire risk plan which identifies locations on the moors where a fire is likely to break out (although it doesn't provide information on likely timing) which can be closely observed.



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- All partners use compatible material, for example the same fittings for pumps and hoses which has facilitated the use of collapsible portable dams which can easily be transported to remote areas of moorland to help extinguish fires.
- Regular and appropriate training is provided, including simulated emergencies and new equipment exercises to help ensure the retention of skills that may be lost during periods where fires are less common, such as a wet summer.

Transport infrastructure

- Road surfaces will need to be more heat resilient to cope with higher projected summer temperatures.
- Alternative routes may need to be found or existing routes protected for road and rail infrastructure; for example sea defences may need to be provided to prevent routes from being damaged by coastal erosion.
- Climate change is likely to affect UK ports in particular with extreme weather or rising sea levels resulting in flooding and possibly disrupting operations. In addition, ports on the east coast may face an increased risk from storm surges. To reduce these risks port operators may need to, for example, change the height and configuration of harbour walls and their drainage.

Regional impacts

There will be significant regional variation in the impacts experienced due to variation in:

- the type and severity of climate change experienced across the country.
- local conditions including for example the resilience of the natural environment and infrastructure, (e.g. power or food supply), to climate and extreme weather such as storms and existing vulnerability to flooding and coastal erosion.

For example, urban areas in the south are likely to need to plan for increased heatwaves, while the areas in the north could see further opportunities for tourism.

Further details on what the Government is doing, and has done, in response to these issues can be found in Chapter 6. In the following chapter we set out how you can access and make the most out of the Projections. More information on impacts in each region can be found on the Defra's adaptation website www.defra.gov.uk/adaptation.



Chapter 4 – How can the UK Climate Projections be used?

This chapter explains how the UK Climate Projections can be used and what support is available to help get the best out of them. There is a range of evidence available to help organisations assess the risk of climate change and deal with the potential impacts. For example the Environment Agency have produced guidance on flood risk and coastal defence and the Engineering and Physical Services Research Council have funded research to look at the adaptation of buildings to help ensure they are resilient to a changing climate.

Detailed guidance on the use of the Projections can be found on the UKCP09 website <http://ukcp09.defra.gov.uk> alongside information on how to access further training in using them.

What is available from UKCP09

- A summary of the **key findings** – illustrative findings taken from the large available range to demonstrate the trends in future climate. Some key findings for UK are covered in Chapter 3 of this report.
- **Pre-prepared maps and graphs** of the climate changes we are likely to see over the 21st century, to provide “at a glance” results.
- **Scientific reports** which describe the science behind the UK Climate Projections, including a detailed description of the methodology and a briefing report for those who need an overview of the science and a report outlining how the climate has changed.
- **Customisable output** for the greatest level of detail to help planning, policy-making and technical research. This is a web-based user interface that enables the user to pick any specific projections they want to obtain. Information on training in the use of this tool is available through the website.
- **Online user guidance** on how the information provided can best be used. This includes a number of worked examples and frequently asked questions. It will continue to be updated following the launch of the Projections, with for example case studies showing how the real data has been used.

For further information see the UKCP09 website <http://ukcp09.defra.gov.uk>.

Who are the Projections for?

The Projections will be of potential interest to anyone who is affected by, or wants information on, climate change in the UK.

The following checklist provides a good starting point for organisations to think about whether they need to make changes to how they operate in order to withstand future shocks and grasp opportunities. If any of these are relevant then they will want to consider the Projections as a potential tool to help them plan a strategy for adapting to a changing climate.

- Is your organisation **affected by the weather and climate** in terms of changes in the average climate (hotter drier summers, warmer wetter winters) as well as extremes such as floods or droughts? This might include possible disruption to movement of people or goods, or the reliability of equipment at higher temperatures.
- Does your organisation take **decisions or make investments which have long life times?** These might include construction work, investing in high value equipment with a long life span or deciding where to locate services.
- Does your organisation make **significant investment or have high values at stake**, such as protection of life or natural environment?
- Does your organisation provide or support (critical) **national infrastructure** such as power supply?

Chapter 4 – How can the UK Climate Projections be used?

- Is your organisation taking decisions with significant **impacts**, for example a decision made now to enter a contract or use a particular standard of technology that cannot be changed for over a decade?

Working through the above list of questions, it is clear that most organisations will need to consider these issues at some level, since nearly all make spending decisions, have premises and use transport. Those involved in planning at various levels as well as local authorities will have a particular need to look at the range of services for which they are responsible and consider their role as leaders of communities. Those providing support in emergencies and for vulnerable groups also need to consider how a changing climate affects existing risks.

In addition to this, the Projections will be of significant use to scientists and engineers working to understand in more detail what the changing climate will mean, for example for changes in human and animal disease patterns, or how we design better buildings which will keep us cool in the summer.

Adapting doesn't necessarily mean spending large sums now; it's planning for what changes need to be made and when, based on the risk of impacts. It may be about capital spend, but it is just as likely to be about changing systems, behaviours and the way we operate, as illustrated in the case studies throughout this document. We want adaptation to be sustainable, so the impacts on our planet, and on mitigation, are not adverse. We need to build this into our normal decision making, so we take the right decisions at the right time.

Guidance on the use of the Projections

Of course, the Projections are only one tool of many and will not be suitable for every application. Users need to understand these limitations, and also need to make sure that they understand how best to use the Projections.

The UK Climate Projections website (<http://ukcp09.defra.gov.uk>) contains links to an accompanying technical site where extensive guidance is provided for those planning to use the Projections for decision making or research. Users should read and understand this guidance before using the Projections. We are also mindful that as dealing with the risks from a changing climate are increasingly built into the legal and contractual frameworks of public bodies and their delivery partners, we need to ensure appropriate use of the Projections across particular sectors. The Government is for example providing specific guidance to all local planning authorities on how to use and interpret the new Projections, alongside other relevant information on risks.

Over time the Government will provide further advice and good practice guidance on how to get the most from the Projections. This will be based in part on feedback from users and scientists, which can be provided through the website.

Support for organisations in using the Projections and adapting to climate change

General support

The UK Climate Impacts Programme (UKCIP), based at Oxford University, provides support to organisations across the UK to help them understand the risks of climate change and how to adapt. The Programme is funded by Defra on behalf of the UK Government, Scottish Government, Welsh Assembly and Department of the Environment Northern Ireland. Since its inception in 1997 it has brought together research and good practice to develop a range of tools and support materials including:

- **Adaptation wizard:** this is an internet-based tool to help organisations determine their vulnerability to climate change, to identify risks and develop a strategy for dealing with them. It provides links through to the rest of the UKCIP toolkit with advice on which tool is most appropriate.

- **Business assessment tool (BACLIAT):** this provides a simple checklist to help businesses assess the potential impacts of climate change on logistics, finance, markets, process, people and premises and to explore management implications.
- **Local climate impacts profile (LCLIP):** this uses readily available information about how current weather affects the work of a local authority to help understand the risks and get the issue of climate change on the agenda locally.
- **Risk Framework:** this provides a step-by-step decision-making framework to help organisations judge the significance of climate change risks compared to the other risks they face.

Training in using the Projections

We want to make sure organisations make the best use of the new product and so will be offering:

- The Projections in Practice programme – this is a major series of training sessions, seminars and briefing sessions for key decision making bodies. It will be delivered in partnership across the UK, by Defra, Department for the Environment Northern Ireland, Scottish Government and the Welsh Assembly, with UKCIP. There will be a range of events at national and regional level, some covering particular sectors or policy areas (such as local government, or insurance) plus computer-based classroom sessions. The training is free of charge and you can find out how to sign up on UKCIP's website (www.ukcip.org.uk/pip).
- Two e-learning modules – these are developed to provide out-reach for those unable to attend the classroom training sessions and further support for those who require it. They are also available through UKCIP's website www.ukcip.org.uk.



Chapter 5 – What is the Government doing to cut emissions?

The UK has made big cuts in the greenhouse gases it emits, reducing emissions by more than 18% since 1990.

But the Projections in this document, based on three plausible unmitigated scenarios of future global emissions of greenhouse gases, show that unless we take further action then climate change will pose a threat to our way of life, endangering our environment, our economy, and our security. So we are determined to reduce our emissions of greenhouse gases further still, and press other countries to do the same.

To avoid dangerous levels of climate change global greenhouse gases must start to fall within the next decade and then be at least 50% below 1990 levels by 2050. The sooner we take action to achieve this, the greater the chance we will have of succeeding and the cheaper it will be. So we will continue to push hard on the issue internationally, within Europe, and at home.

Action abroad

The UK cannot tackle climate change alone: the UK accounts for just 2% of global greenhouse gas emissions. To avoid the impacts of climate change becoming too severe to handle, we need to reduce greenhouse gas concentrations in the atmosphere to a level which avoids “dangerous climate change”.

What we define as “dangerous climate change” has to be a societal decision. The EU has set a target to limit global mean surface temperature rise to 2°C above the pre-industrial level. It is based on the knowledge that temperature increases of more than 2°C will result in very costly adaptation measures, huge impacts on water availability, food security and ecosystems and unacceptably high risks of irreversible events (such as the melting of the Greenland ice sheet). This is a very challenging goal and to achieve it we need to get on a trajectory where global emissions must start to fall in the next decade and be at least 50% below 1990 by 2050.

A key part of our effort internationally is our work to prepare the ground for a global, comprehensive and long-term framework for addressing climate change under the UN Climate Change Convention. We will shortly publish the UK’s priorities for achieving a deal at Copenhagen this December, to put the world on track to reduce the risks of dangerous climate change. Achieving such a deal this year will not be easy, yet the projections show how important it is that we succeed in this. Closer to home, we have been working through the EU to develop an ambitious, common European position for international negotiations, and to agree Europe-wide targets on climate change, energy efficiency and renewable power. Like the UK, the EU as a whole is on track to meet its commitment under the Kyoto protocol.

Action at home

The Department of Energy and Climate Change (DECC) was created in October 2008. We face unprecedented challenges to our environment, our economy and the future security of our energy supplies – and the decisions we make now will affect the planet and our way of life for generations to come. DECC exists to tackle these challenges. The new Department is responsible for the UK’s strategy for tackling climate change, for reducing UK emissions in line with domestic targets and EU and international commitments and making the transition to a low carbon UK economy.

We have also committed to decarbonising our energy supplies. We are committed to generating 15% of our energy from renewable sources by 2020, a programme of new nuclear power stations and we have said no to new coal plants without Carbon Capture and Storage from day one.

The Government is working with business to put the UK at the heart of the global growth in low carbon goods and services.

Climate Change Act 2008

The UK's 2008 Climate Change Act introduced a world first: a long-term framework for reducing greenhouse gas emissions that is legally binding on Government, and is a centrepiece of our strategy to develop and deliver a low carbon future.

The Act sets a target to reduce UK greenhouse gas emissions by at least 80% by 2050, and puts us on the path to that target by creating a system of binding carbon budgets to cover five-year periods, set up to fifteen years ahead. The first three of these carbon budgets, covering the periods 2008-2012, 2013-17 and 2018-2022, were announced in April 2009 in line with advice from the independent Committee on Climate Change, which the Act created to advise Government. The Committee recommended that the UK should achieve a reduction in emissions of all greenhouse gases of 34% relative to 1990 in the third period (2018-2022), and of 42% once a global deal to reduce emissions is achieved. The Government will tighten the carbon budgets in the light of a global deal.

Carbon budgets

We will set out our full domestic strategy in an Energy and Climate Change White Paper in July. The White Paper will describe our policies and proposals for meeting the carbon budgets established by the Climate Change Act and show how these fit in to a wider integrated strategy on climate change and energy.

A great deal has already been achieved on energy efficiency, on generating power with less carbon dioxide, and on reducing emissions from transport; however, the Government accepts that the latest science argues for going further and faster in these and other areas, and we will show how we propose to do this while maintaining a secure energy supply, seizing opportunities for new green jobs, and helping the most vulnerable meet their needs for heat and power.

How you can help

Government action is crucial, but can only ever be one part of the solution. The scale of the problem presents a challenge to individuals, families, communities and businesses to do their bit to reduce emissions – and save money on bills at the same time.

Government is helping people take action. The most recent Budget provided a further £365 million of funding for improving insulation for homes in the social sector, constructing new homes with higher energy efficiency, and providing loans for small and medium businesses and public sector organisations.

Further to this, all homes in Britain will have smart meters installed by 2020. This will help people see what energy they are using and how to save money on their bills. It will mean an end to staying in and waiting for a meter reading, no more estimated bills and will lead to quicker, smoother switching between suppliers and cheaper, easier prepayment.

Energy suppliers promote energy saving measures under the CERT programme. Typically these measures will include cavity wall and loft insulation. Last September the Government announced its intention to expand the scheme as part of a £1 billion package of help to tackle rising energy prices.

We want more households, communities and businesses to move from being passive users of energy to active producers – reducing their carbon impact which will help them play a role in the fight against climate change. The Government will be introducing cash incentives for people who generate their own electricity from renewables or heat from low carbon sources.

Grants are available from the Low Carbon Buildings Programme to help with the upfront costs of installing equipment like wind turbines or solar panels. More information can be found at www.lowcarbonbuildings.org.uk

People on certain benefits may also be eligible for assistance under the Government's Warm Front scheme, which provides heating and insulation measures for householders in England. Warm Front has helped nearly two million homes since it was introduced, making homes warmer and more energy efficient and providing savings of up to £300 per year on energy bills. Households connected to the gas grid are eligible for grants of up to £3500, while those off the gas grid can apply for funding of up to £6000.

The **'Act on CO₂' campaign** offers information to help people save money, save energy and reduce CO₂ emissions in their daily lives. Advice includes the different fuel costs and CO₂ emissions of new cars, how to save CO₂ and money around the home, and how efficient appliances can cut down electricity bills. More information is available from <http://campaigns.direct.gov.uk/actonco2/home.html> or from the advice line on 0800 512 012 for free energy saving advice. You can work out your carbon footprint using the Act on CO₂ calculator which will provide you with a personalised action plan and tips on how to save energy.

The **Carbon Trust** helps large, medium and small businesses by working with them to reduce their carbon emissions. Their help includes interest-free loans for energy-saving projects, surveys to help find energy saving opportunities, and advice and information. They also help businesses develop commercial low carbon technologies for the future. More information from <http://www.carbontrust.co.uk> or from an advisor on 0800 085 2005.



Chapter 6 – What is the Government doing to adapt to a changing climate?

The daily pattern of weather in the UK is a familiar and constant part of everyday conversations. For the most part we can readily deal with these changes, from planning our social life through to the design of our houses and our infrastructure.

Extremes of weather, however, have more serious consequences for our society, our economy, and our health.

To deal with this, we put in place things like flood defences, we grit roads in winter and we plan to deal with emergencies. At a more personal level, we accept that sometimes the weather will simply mean we cannot do something we wanted to. In this way, we adapt to the weather we experience.

The Projections show, however, that the natural variation in the climate from season to season, and year to year, is likely to change, as the climate changes across the globe. A recent Farming Futures survey found that half of farmers asked said that they were already affected by climate change, and more expected to be affected in the next ten years.

This chapter sets out what the Government is already doing to adapt our society to the changes we are likely to see and what more will need to be done as our understanding and the evidence grows. The UK is fortunate in having a relatively temperate climate and our capacity to deal with climate change, if we plan ahead, is good. We will be able to learn from other parts of the world which already have a warmer climate or different rainfall patterns. It is not just the future climate that is the challenge, it is making the transition from the society we have built around our current climate that needs planning.

We also have to recognise that what happens in the rest of the world will have a direct effect on the UK – whether it is through trade, food security, political stability or tourism. Therefore we need to think about the international effects of climate change as well.

Working in partnership in the EU

The UK Government welcomed the EU White Paper on adaptation, published in April 2009, and is working closely with the EU Commission and other member states to take forward the proposals.

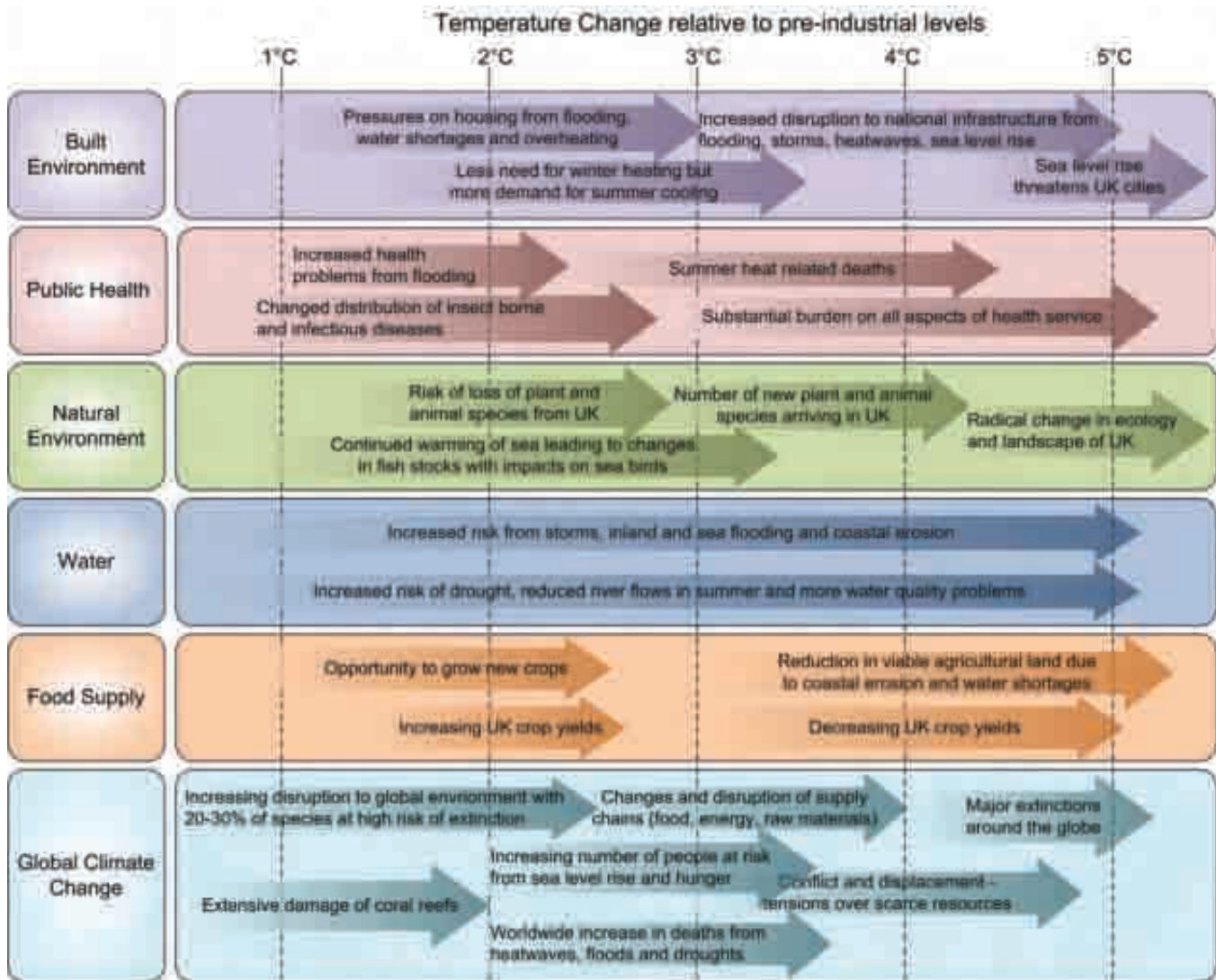
The impact of climate change will vary across Europe, and adaptation will therefore generally need to be carried out nationally or regionally. However, there is a role for the EU to play in supporting and complementing the work of member states. For example, the EU will need to make sure that the future climate is taken into account in its own policies and programmes, that member states develop and share evidence and research, and that we work together to support adaptation outside Europe.

Further information about what the EU is doing can be found at: http://ec.europa.eu/environment/climat/adaptation/index_en.htm.

The chart below looks at the changes the UK and the wider world might experience as global temperatures rise. Whilst the changes in the UK as a result of higher temperatures would be significant for the countryside as we know it now, and for society, the impacts globally could be much bigger. Temperature increases of 3°C could see flooding of low-lying areas, further extreme pressures on the availability of water in Africa, significant risks to rainforests and the loss of Arctic permafrost.

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The consequences of climate change on the UK, and globally.



Consequences are indicative
 Sources: IPCC (2007) Climate Change 2007: Working Group II Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Vol. II, Part 1, 22-61; Cambridge University Press.
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 MCCIP (2009) Make Climate Change Economics (Linkages Report Card 2009) 6th Edition. Baines, J.N.; Bunting, P. S. and Frost, M.T.; Summary Report. MCCIP, London.
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Rising to the challenge

To deal with the risks and understand the opportunities, Government will:

- raise awareness of the potential impact of climate change so that all of us can begin to think about how we need to respond;
- prioritise decisions that have long-term effects, for example, investment in new transport, water, energy and communications infrastructure that will have a long life span;
- take action early where the benefits clearly outweigh the costs. Some changes which can be made within the space of one or two years – such as changing crops or providing shade in playgrounds need not be done now. However, designing new buildings or refurbishing old ones to make them climate resilient is likely to be more cost-effective than making changes later;

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- ensure a fair deal for communities and in particular the vulnerable, by helping people now, as well as in the future; for example, older people and children are more vulnerable to heatwaves, so heatwave plans include easy to follow advice that people can use to keep cool at home and set out what support is available to them; and
- protect our natural environment to support biodiversity and allow people to enjoy our countryside; this is being done, for example, through our management of forests and wetlands.

Priorities for action

Last year the Government launched a website providing information on adapting to climate change and showing what each of the main Government departments is doing.

All Government departments will be producing Adaptation Plans by spring 2010. These will focus on the activities likely to be significantly affected by climate change and which will therefore require action (such as major construction projects). Departments will also be working on their plans for reducing greenhouse gases and will need to develop their adaptation plans alongside these. Departmental Adaptation Plans will also contribute to the development of the Government's first National Adaptation Programme, due to be put to Parliament in 2012. This will be monitored by the Adaptation Sub-Committee of the Climate Change Committee.

The priorities are to take the right long-term decisions including on investment and to protect public health and critical national infrastructure. Examples of work underway are set out below.

Flood risk and coastal erosion

More winter rainfall, rising sea levels and more frequent storm surges will increase flood risk. We have:

- more than doubled spending on flood and coastal erosion risk management in cash terms since 1997, reaching a total of £2.15 billion over the three years of this Spending Review;
- commissioned the Environment Agency to develop a long-term investment strategy looking at flood and coastal erosion risk management over the next 25 years;
- completed 67 flood defence schemes since summer 2007 so protecting 43,000 homes;
- announced a £5 million grant scheme for household-level flood protection measures and announced in March 2009 the provision of £1 million towards three land management demonstration projects and will be consulting on providing support for communities and individuals at risk from coastal change;
- just launched a new coastal change policy consultation and associated coastal pathfinder programme to explore how coastal communities can successfully adapt to the impacts of coastal change, and Government's role in supporting this; and
- Published the Thames Estuary 2100 Project (Environment Agency) for consultation; this aims to develop a tidal flood risk management plan for the Thames Estuary through to the end of this century based on the latest climate change projections and potential future sea level rise.

Business

Business will need to adapt both to the risks and opportunities. We have:

- provided free Floodline Warnings to business; this is a direct service providing flood warnings by telephone, mobile, email, SMS text message, fax or pager; and
- provided advice on Business Link about how climate change may affect businesses, and what practical steps businesses can take, as well as what specific industries can do.

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Blackpool Seafront Regeneration

Aim:

- To improve Blackpool's coastal defences to protect businesses and homes while creating an attractive public space



What is being done:

- Led by ReBlackpool, Blackpool's Urban Regeneration Company, this sea defence scheme takes into account both climate change and integrated regeneration. This innovative coastal protection scheme prevents coastal erosion and mitigates flood risk for 1,500 business and homes whilst not cutting a seaside resort off from the sea.
- The width of promenade will be increased to create an additional 5 hectares of open space for the public with six new headlands with new attractions and public art.
- Also included is enhanced access and usage for both the beach and promenade.

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Energy

The summer 2007 floods highlighted the urgency and importance of protecting vital energy supplies. The utility companies have:

- carried out a major review of substation resilience to flooding and development of investment plans for the economic regulator (Ofgem) to consider during the companies' current price review; and
- purchased relocateable flood defence barriers, improved business continuity planning and constructed new substations designed to sit above the level of potential flood waters.

Droughts and water supply

A combination of higher summer temperatures and reduced summer rainfall could see significant increases in the risk of droughts. We have:

- launched a consultation on a Floods and Water Bill which will allow water companies to control more non-essential uses of water during droughts; and
- published a water strategy for England, *Future Water*; which sets out the Government's long-term plans for water including how the sector should adapt to a changing climate through increased metering and a much greater emphasis on water efficiency.

Environment Agency: Planning for future flood risk

Defra and the Environment Agency, working with the Centre for Ecology and Hydrology, are looking at the relationship between catchment characteristics and climate change impacts on peak flows for 155 river catchments.

The UK Climate Projections will help Defra and the Environment Agency to identify which river catchments are most vulnerable to the future river flooding we anticipate from a changing climate, allowing us to make decisions about where additional work will be required. And, for all flood management schemes, we will be able to make much better decisions about the design of river defences and the need to improve flood resilience for those most at risk.

Transport

Transport will be affected in a number of ways. We have:

- introduced new road surface specifications, similar to those applied in the south of France, and introduced improved drainage standards for new works and renewals; this will improve drainage allowing for increases in rainfall intensity of 20% – 30%, and will mean a road network that is more resilient in the face of climate change; and
- decided that, to ensure more resilient new – and existing – nationally significant infrastructure, a two-year cross-departmental project, under the Adapting to Climate Change Programme should be set up (from April 2009), focusing on transport, water and energy sectors.

Public health

Government has a responsibility to protect public health and promote wellbeing – particularly for the vulnerable in our society. The health effects of heat will become more important over the coming years. We have:

- published the *Health Effects of Climate Change in the UK, 2008* and the National Heatwave Plan; and

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- started running a Heat-Health watch system from 1 June to 15 September each year; This monitors heatwave threshold day and night temperatures and helps alert people to the health problems associated with high temperatures during the summer months.

Food security

A changing climate will affect how food is grown, irrigated and transported all over the world. We have:

- started to develop an assessment of the current state of food security, which will also look at likely trends in the next 5-10 year period; and
- established the Foresight Food and Farming Futures Project to look at how a global population of 9 billion people can be fed sustainably by 2050; this is due to report in late 2010 and although the focus is global, the implications for the UK will also be covered.

Agriculture and the natural environment

A thriving agricultural sector is vital to our economy, and effective management of our natural environment ensures we have a sustainable rural economy and countryside to work in and enjoy. We have:

- started providing information to farmers and land managers about the threats and opportunities that climate change brings; The Farming Futures project has produced a range of case studies and facts sheets, many of which address adaptation (www.farmingfutures.org.uk)
- raised awareness of disease threat. Defra monitors outbreaks of animal diseases internationally and is working with the Met Office to look at how the spread of blue tongue disease, for example, is affected by changing weather patterns;
- published “The Climate Change Adaptation Principles”. These will initially be used in the England Biodiversity Action Plan; We have also published practical guidance for conservation managers on how to manage sites in a changing climate (Hopkins et al 2007); and
- made resilience to climate change a central aim of the Government’s Strategy for England’s trees, woods and forests; Trees planted now may be growing for many decades, so it is vital that decisions now take account of what the future might be like.

Natural England: developing strategies to enable the natural environment to adapt

Natural England is working to assess the vulnerability of England’s natural environment to climate change, and to identify local management responses that will better enable the natural environment to adapt to changing climate conditions, and our enjoyment of it.

In March 2009, Natural England published climate change adaptation strategies for four English landscapes; the Norfolk Broads, Cumbria High Fells, Shropshire Hills and Dorset Downs. (The reports are available at: <http://www.naturalengland.org.uk/ourwork/climateandenergy/climatechange/adaptation/naturalengland.aspx>.)

Natural England is now working with local partners to implement the strategies and the project is being extended across England into five more study areas. The results will help inform the development of Natural England’s approach to adaptation at a landscape scale across England. The new climate projections will contribute to this, in particular by providing more detailed information about how changes in climate might vary among different regions, which will help to identify risks to which the natural environment in different parts of the country might be most vulnerable.

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Homes and buildings

We will need to ensure that our buildings are built and maintained to the right standard and that they are resilient to a changing climate. We have:

- built into the planning system clear expectations on adaptation: national policy statements on major infrastructure projects, regional strategies and local development documents must all take account of a changing climate;
- taken action on all the recommendations made in Sir Michael Pitt's Review of the 2007 floods, including assisting the development of surface water management plans in high priority areas and improving reservoir safety;
- introduced higher standards for building new social housing, requiring build to Level 3 of the Code for Sustainable Homes. This includes a water efficiency standard of 105 litres of water use per person per day; and
- made it a requirement on the builder to consider heat gains as well as heat losses in domestic buildings, and new minimum water efficiency standards for all new homes will come into force later this year.

Green Space Management in Islington

Islington Council's Greenspace service has started a number of adaptation measures within the borough's green spaces.

What is being done?

- Sustainable planting: the council is giving greater consideration to the use of sustainable drought tolerant planting. for example by:
 - using drought tolerant species and alternatives to grass (such as clover);
 - utilising parks and open spaces to develop sustainable urban drainage, reducing the amount of hard surfacing and allowing water to collect and drain naturally;
 - changing maintenance schemes in selected areas to allow grass to grow longer reducing carbon usage and increasing biodiversity; and
 - increasing the size of mulched areas to improve water retention of soils, particularly around trees increasing their ability to survive drought periods.

- Tree planting: the council has planted a number tree of species that grow naturally in climates similar to those predicted by climate models for the south east of England in 30-50 years. These species include Cork Oak, Chitalpa, Feijowa, Figs, Lagerstromia, Olives, Tamarix and Chinese date.



© Islington Council

- 'Greening the grey': the council is also putting £2million into a 'greening the grey' project. Working with partners and community groups, the council is developing projects producing green corridors including green walls, roofs and areas of new planting. Green roofs and other greening measures are adaptive responses to both increased temperatures and water run-off. As a result of this work 61.7% of all major applications for permanent new buildings approved between 1st March 2007 and the end of October 2008 in Islington had green roofs.

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Adapting to Climate Change Programme (ACC)

Under the Climate Change Act, the Government is required to produce a first statutory climate change Adaptation Programme by 2012. To lead and co-ordinate work in preparation for this, the Government has established the Adapting to Climate Change Programme, run by Defra, which is taking forward the following main areas of work:

Providing evidence

The UK Climate Projections give us better evidence on how the UK will be affected by a changing climate. The information in the Projections will feed into other models, for example those used by the Environment Agency to model floods.

Defra is also providing a challenge fund for work across Government to encourage use of the Projections and other climate information to inform policy and service delivery.

There is a wealth of information available, and it is important that this can be used effectively by public services and business. That is why:

- we are continuing to fund the UK Climate Impacts Programme (UKCIP) at Oxford University to act as a bridge between the research and user communities, and to turn scientific work into useful practical guides on how to adapt; and
- we are embarking on the first national Climate Change Risk Assessment as required by the Climate Change Act, which will be completed by 2012 on behalf of all the countries of the UK.

Raising awareness and building capacity

Many of the steps that organisations can take to adapt can be readily included in existing ways of managing risks or making long-term investments; but to be able to do this, they need to be aware of the problem. Defra funds the UKCIP to raise awareness, and to provide straightforward advice on how to deal with these challenges. We know that we often learn best from seeing how others have dealt with things. UKCIP provides case studies and examples of how businesses, local authorities and others are already getting on with adaptation.

The Adapting to Climate Change website (www.defra.gov.uk/adaptation) launched in 2008 is also helping people to find the information and advice they need. These include UKCIP tools, guidance on assessing risks, and what is happening locally and regionally.

Because of the importance of action locally and regionally, Defra has brought together a wide range of organisations in England through a Local and Regional Adaptation Partnership (LRAP) board.³ This is proving to be a good way of sharing best practice, developing guidance for local authorities and working on how to measure progress. In addition, at the regional level, Defra is supporting nine independent Regional Climate Change Partnerships which have carried out a range of awareness raising and research projects – further details at <http://www.defra.gov.uk/environment/climatechange/adapt/action/regions/index.htm>.

At a national level, we have also formed a Partnership Board to bring together public, private and third sector organisations. This covers local government, health, transport, business, energy and the environment and will help us think through practical ways to work together to make adaptation a natural part of everything we do.

³ Board members include representatives from the following organisations:

Defra, Communities and Local Government, Environment Agency, Government Offices, Natural England, UKCIP, IDeA, Nottingham Declaration Partnership, Local Government Information Unit, Local Government Association, Regional Climate Change Partnerships, Regional Improvement and Efficiency Programmes, Regional Development Agencies, Local Authorities and Local Strategic Partnerships.

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Measuring success and taking steps to ensure things get done

The Climate Change Act was the first piece of national legislation in the world to set out a framework in law for adapting to climate change. This includes:

- an Adaptation Reporting Power – this is a new power to require public bodies and regulated utility companies to set out the risks to their work from a changing climate and what they are doing to manage these risks. The Government is consulting on which of these organisations should be required to report as a priority.⁴
- a new expert scrutiny committee – the Adaptation Sub-Committee (ASC) of the Committee on Climate Change (CCC) to advise on the National Risk Assessment and the implementation of the Government's Adaptation Programme for England.

As well as using the law to support adaptation, we are also trying to build the need to respond to a changing climate in Government decision making:

The Local Government Performance Indicator on adaptation

All English local authorities now have to measure how well they are embedding adaptation in the full range of their work and across their wider communities. 56 out of 150 Local Strategic Partnerships have chosen adapting to climate change as a local priority.

The Green Book

Treasury guidelines on policy and investment appraisal (the Treasury "Green Book") outline how to identify and address the risks and opportunities from climate change to policies, programmes or projects right across government. (http://www.hm-treasury.gov.uk/data_greenbook_supguidance.htm)

The Government estate

Government needs to ensure its own estate is resilient to the current and future impacts of climate change. Defra is working with the Office of Government Commerce (OGC) and government departments to ensure all departments are increasing their estates' long-term resilience to the impacts of climate change.

Public procurement

The ACC Programme is working across Government to develop guidance for public procurement professionals on embedding adaptation in the goods and services they procure.

⁴ <http://www.defra.gov.uk/corporate/consult/climate-change-adapting/index.htm>



Adaptation: The process or outcome of a process that leads to a reduction in harm or risk of harm, or a realisation of benefits associated with climate variability and climate change.

Central estimate: The projected change that has an equal probability of the change being exceeded or not exceeded.

Climate change: Refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Climate model. A mathematical representation of the climate system based on the physical, chemical, and biological properties of its components, and how they interact .

Climate projections: The calculated response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, based on simulations by climate models. Climate projections critically depend on the emissions/ concentration/radiative forcing scenario used, and therefore on assumptions of future socio-economic and technological development.

Emissions scenario: A plausible future pathway of man-made emissions (e.g. greenhouse gases and other pollutants,) that can affect climate. These pathways are based on a coherent and internally consistent set of assumptions about determining factors (such as demographic and socio-economic development, technological change) and their key relationships.

Emissions trajectory – The projected trend in emissions using historic, recorded data on carbon dioxide emissions due to fossil fuels. This does not take into account any assumptions about changes in the future (for example, in behaviour or advances in technology) and is solely based on past emissions.

Greenhouse gas: A gas which absorbs and emits energy radiated by the Earth, trapping some of it and thus warming the climate.

Impacts: The effects of climate change on natural and human systems.

Potential impacts: all impacts that may occur given a projected change in climate, without considering adaptation.

IPCC: Intergovernmental Panel on Climate Change. An international forum of experts used by the United Nations to undertake periodical assessments addressing how climate will change, what its impacts may be and how we can respond. It was originally formed in 1988 and published its Fourth Assessment Report in 2007.

Kyoto Protocol: International legally-binding agreement adopted at Kyoto in 1997 under the UN Framework Convention on Climate Change to reduce the emissions of greenhouse gases.

Mean: shorthand for arithmetic mean, the sum of the values of all the members of a series of numbers, divided by the number of members.

Met Office Hadley Centre: The main Government-funded centre for climate change research and modelling. In UKCP09, the Met Office were responsible for the production of the probabilistic climate change projections, and management of the marine projections.

Mitigation: Action taken to reduce the impact of human activity on the climate system, primarily through reducing net greenhouse gas emissions for example carbon dioxide.

Risk: A combination of the probability of an event and its consequences, with several ways of combining these two factors being possible. There may be more than one event, consequences can range from positive to negative, and risk can be measured qualitatively or quantitatively.

UKCIP: The UK Climate Impacts Programme is responsible for promoting use of the UK Climate Projections, alongside other tools and guidance, to help organisations to prepare for the unavoidable impacts of climate change. UKCIP co-ordinated the stakeholder input into the development of the Projections. UKCIP is principally funded by Defra, and provides its services free of charge.

UKCP09: Short name for UK Climate Projections.

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Adapting to Climate Change

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