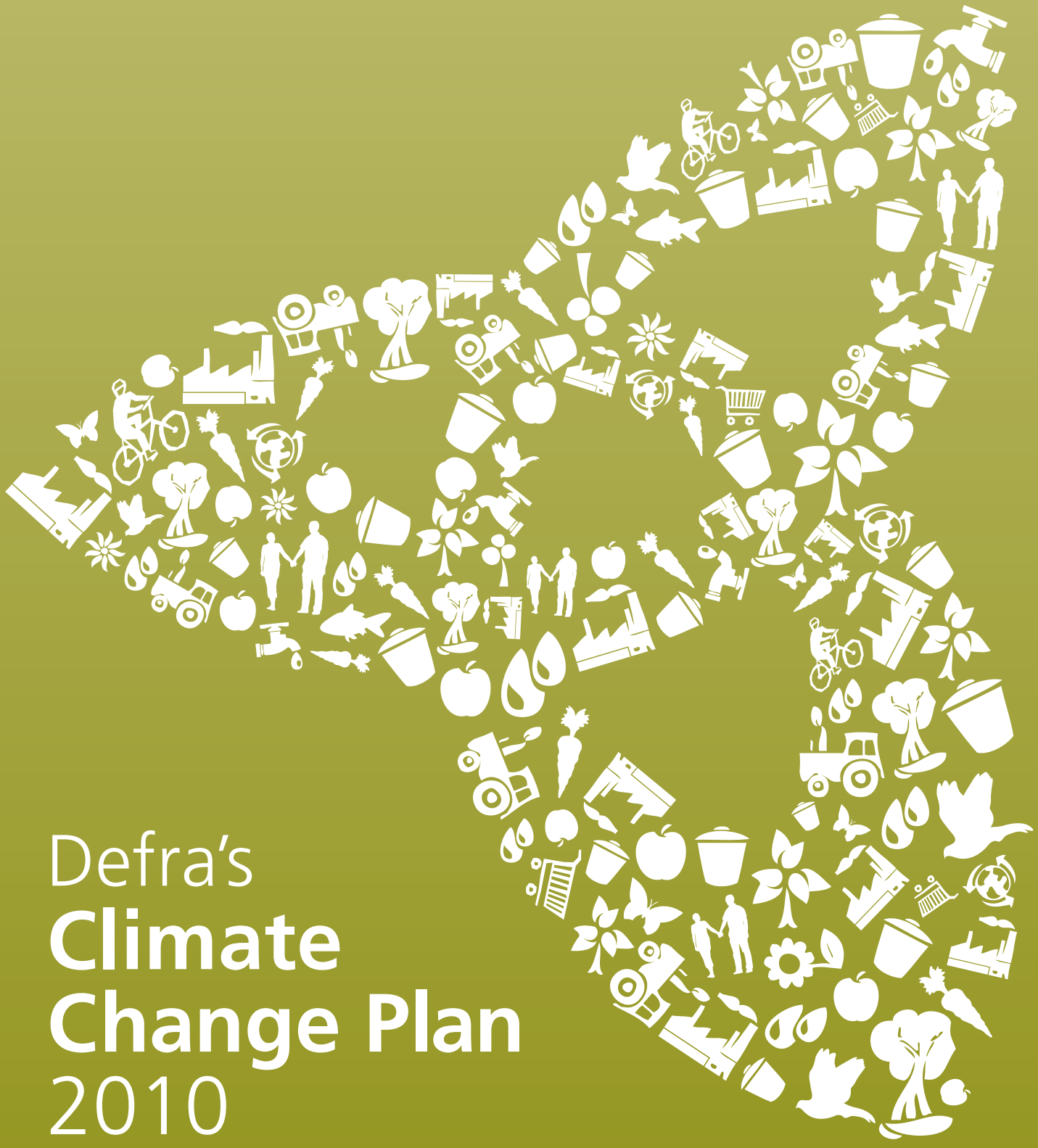


Defra's **Climate Change Plan** 2010

defra
Department for Environment
Food and Rural Affairs

Contents

Ministerial Foreword

The Earth's climate is constantly changing. Human activity over the past 250 years – the burning of fossil fuels, land use change, and agriculture – has altered global average temperatures by increasing the concentration of greenhouse gases such as CO_2, methane and nitrous oxide.

Atmospheric concentrations of CO_2 and methane have more than doubled since the industrial revolution and the acidity of the oceans has gone up by 30%. Arctic sea ice cover has decreased by over 30% since the 1970s; sea levels around the UK have increased by 10cm during the 20th Century; and in 160 years of records, the 10 hottest years have all been since 1997.

So what should we do? While we don't know the exact nature of future change, it is only responsible for us to do our best to prepare both by reducing the level of greenhouse gas emissions, and by planning for the different climate that will result from our past emissions.

Doing this is at the heart of Defra's role. As a Department, Defra is responsible for agriculture, forestry and land management. These sectors will be among the first to feel the effects of climate change, and they have a crucial role to play in reducing the country's greenhouse gas emissions. We also need to keep our natural environment healthy and resilient, so that we and the economy can continue to benefit from what it gives us.

Defra is already preparing for the impact of climate change. Defra has invested more in new and improved flood defences: so providing better protection for hundreds of thousands of homes.

Defra is also working to reduce emissions; greenhouse gas emissions from the waste sector alone have fallen by 57% since 1990.

So we are making progress, but there is much more to do.

This Plan sets out how Defra will continue to deal with the challenges and opportunities of climate change. This includes adaptation – working in Whitehall, with partners in Natural England, the Forestry Commission and the Environment Agency, and through a range of policies and practical steps. It explains what Defra is doing to support the country's transition to a low-carbon economy, develop stronger scientific evidence, and develop better skills.

Responding to climate change requires leadership and action by us all, and this Plan will help move us forward.

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

Defra's Climate Change Plan

Introduction

The challenge

Climate change is a huge challenge. Our climate is already changing, in the UK and around the World. The last ten years were the hottest decade ever recorded. As well as reducing our greenhouse gas emissions to *mitigate* future climate change, we will have to *adapt* to the climate change that is now in train. Even if global greenhouse gas emissions stopped completely tomorrow, the global temperature rise would still reach an estimated 1.4°C (over pre-industrial levels) by 2100 because of our past and present emissions. The global consequences for water, ecosystems, food supply, coastal regions, and public health will become more severe if emissions continue and temperatures keep rising.

Adaptation and mitigation

Adaptation means learning to live with some climate change. It means protecting ourselves against negative impacts, and taking advantage of more positive aspects of climate change for some sectors – for example, agriculture.

Mitigation means minimising the extent of future climate change, by reducing the amount of greenhouse gases being emitted, and by maximising our ability to remove CO_2 from the atmosphere – for example, through growth of forests.

Climate change is one of a range of global pressures that our generation will need to respond to if we want to secure and enhance our prosperity and quality of life. These include rising populations, the depletion of natural resources, and the degradation of our environment. We should not underestimate the scale of the challenge this poses to all parts of society – individuals, communities, businesses and Government. For example, the agriculture and land use sector is already responsible for roughly a third of the World's emissions, and global emissions must be reduced by at least half by 2050 if we are to have even a 50% chance of keeping temperature rise to 2°C. The sector needs to reduce emissions urgently and do so whilst at the same time safeguarding the environment (which underpins our capacity to adapt) and satisfying rising demands for food and bioenergy.

The Natural Environment

Natural systems support our way of life in ways that are not always visible but are valuable to us all. This might take the form of financial value or of other less tangible benefits, for example to our health and well-being. We are already eroding the "infrastructure" of these systems; pressures which are forecast to intensify with climate change.

- the value to flood risk management of wetlands has been estimated at £1,279 per hectare per year.
- pollination supports food production in the UK to the value of £1bn per year.
- soil erosion in England alone is estimated to cost the agriculture sector around £45m a year.
- properly managed, urban green spaces can help us manage surface water flooding, filter pollution and cool the city air by up to 2°C.
- in 2002, water customers paid over £90m to remove nitrates and pesticides from drinking water sources.
- increasing physical activity through universal access to quality green spaces could save the NHS around £2.1bn every year.
- air pollution reduces the average life expectancy of people living in the UK by 6 months, at an annual cost of £15 billion (in the range £8-17 billion).

In planning our response to the social and economic challenges posed by climate change we need to understand and capitalise on the crucial role played by the natural environment. Defra is committed to securing a diverse, healthy and resilient natural environment, which provides the basis for everyone's well-being, health and prosperity now and in the future; and where the value of the services provided by the natural environment are reflected in decision-making.

We can overcome these challenges, but it will involve changes in the way we live and the choices we make. Change is inevitable. The choice we face is whether to ignore it and carry on as we have been or to plan ahead and manage the risks. If we bury our heads in the sand we won't avoid change, but we will miss the opportunity to protect and sustain the things we value most.

Meeting the challenge

Reducing our emissions, and learning to live with climate change, both involve making choices about how to change. We know we must do both, and research has shown that making these choices together brings greater benefits than making them separately[1]. Often, the actions needed to adapt will be independent from those needed to mitigate. But sometimes the changes needed to adapt and mitigate will support each other, and sometimes they will come into conflict. It will be important to recognise the "win-wins", and recognise and manage the tensions.

Some choices need to be made now. We need to cut emissions urgently, and we are building some infrastructure now which will still be around when the climate has changed significantly. Trees take a long time to reach maturity, so if we want more woodlands we need to act soon. Other choices won't need to be made until later – for example, decisions about which crops to plant can be changed from season to season. But it's important to know that these decision points are coming, so we aren't caught by surprise. All of us in Government, business and civil society will need to build greater flexibility into our decision-making processes to enable us to respond to the changing context around us.

There are great uncertainties. We know climate change is happening, and we know we are causing it. But we don't know exactly how sensitive our climate is: how much the World will warm, and what the other effects will be, for example on weather patterns and the acidity of the oceans. We know livestock and fertilisers create greenhouse gas emissions, but don't know precisely how much. We know natural ecosystems are fundamental to our economic and social well-being, but we can't yet value that contribution precisely.

Forestry: a "win-win" option

Trees and woodlands can help us mitigate and adapt at the same time. Trees take carbon out of the atmosphere as they grow, and can lessen the impacts of climate change by providing shade, absorbing flood waters, improving water quality, and fighting soil erosion.

The Read Report, published in November 2009, presents an authoritative assessment of the contribution that UK woodlands can make. Its five recommendations are:

- a clear need for more woodland.
- the status quo is not an option: we need to adapt now.
- UK woodlands are a resource to be managed wisely – they are a large store of carbon, vulnerable to pest and disease outbreaks and the effects of climate change.
- the harvesting and use of wood from UK woodlands increases forestry's potential contribution to mitigation.
- trees and woodlands can help society to adapt.

Defra is committed to creating more woodlands in England, and to maximising their contribution to adaptation. Pages 39 to 42 and 101 to 103 set out the actions Defra is taking.

1 OECD (2009) Economic Aspects of Adaptation to Climate Change: Integrated Assessment Modelling of Adaptation Costs and Benefits. Available at: http://puck.sourceoecd.org/vl=1186975/cl=17/nw=1/rpsv/workingpapers/19970900/wp_5ksm3715ql23.htm

It's important to address these uncertainties, and Defra is playing its part. For example, Defra is funding research into the impacts of climate change, better measurement of greenhouse gas emissions, and valuation of ecosystem services.

But we can't wait for all these answers before we have to make some choices, and we do know enough to start taking positive action now. To find the right actions to take now, and to start taking them, Defra's strategy is guided by three principles:

1. Sustainable Development: Looking at the whole picture

Natural and man-made systems are often large, complicated, and highly interconnected – for example global ecosystems, or supply chains stretching across the World. Developing our understanding of the bigger picture is central to Defra's approach.

When looking at how to protect or improve these systems, we cannot consider only a single part of the equation. We must keep in mind the range of economic, social, and environmental objectives which will ensure we can develop sustainably.

Defra's approach is to:

- use the best evidence we can get to understand the bigger picture.
- consider all our objectives together.
- find ways to act which maximise positive impacts and minimise negative ones.

Reducing greenhouse gas emissions sustainably

Tackling climate change is crucial to protecting our natural environment. Action on climate change also provides a major opportunity to improve the environment more widely, making our cities healthier and quieter, cutting our resource use and significantly reducing damage to the natural environment. Wherever feasible, the Government will make the most of measures which bring such wider benefits. However, in some cases trade-offs will have to be made. That may mean, for example, taking higher-cost measures on climate change to avoid creating problems for air quality. At the same time, the pressing need to tackle climate change may mean some environmental impacts cannot reasonably be avoided. In those cases, steps will be taken to minimise the effects.

Putting this approach into practice means, for example, increasing the use of bioenergy, but in a way which does not cause significant environmental or social damage at home or abroad, including to food security. To achieve this, the Government:

- has established a reporting system on the sustainability of biofuels.
- is pursuing an ambitious research strategy to inform policy.
- is supporting the development of sustainable advanced (or next generation) biofuel technologies.
- is negotiating in the European Union for robust sustainability standards.
- is working through the Global Bioenergy Partnership for sustainability criteria and indicators.

It also means ensuring that a large increase in low carbon energy infrastructure can be delivered, while minimising its effects on the local environment. To achieve this, Defra, the Department of Energy and Climate Change (DECC), and the Department for Communities and Local Government (CLG) are:

- working with Natural England (NE), the Environment Agency (EA) and other bodies to ensure statutory obligations are met and adverse environmental impacts are minimised, while ensuring more consistent, evidence based, and timely consenting decisions on renewable energy projects.
- continuing to apply higher planning tests in National Parks and Areas of Outstanding Natural Beauty.

Adapting to climate change sustainably

Defra's *Adapting to Climate Change in England: a Framework for Action*[2] explains how Defra's approach to adaptation is governed by the five principles of sustainable development:

Living within environmental limits:
- to ensure any actions taken consider natural resources, biodiversity and whole ecosystems, and improve or enhance them wherever possible.
- adaptation measures must not be carbon or energy intensive, but rely on more low-carbon, energy efficient and resource efficient technologies.

Ensuring a strong, healthy and just society:
- place the wellbeing and health of people at the centre of adapting to climate change.
- make sure that adaptation measures do not disproportionately affect any particular group.

Achieving a sustainable economy:
- give businesses and organisations the information they need to adapt effectively, maximising opportunities and reducing threats.

Promoting good governance:
- including empowering communities to influence adaptation and take appropriate action for themselves.

Using sound science responsibly:
- to allow for flexibility and reflect the inherent uncertainty in planning for future climate change – scenarios are not predictions, and they will be affected by other uncertain events.

2. Working in partnership

Meeting these challenges will need everyone to play their part. If everyone can see the bigger picture, they can work out how to make a difference. And people understand their own situation better than anyone else – for example, there is no "one size fits all" answer to adaptation because it depends on where you are and what you're doing. So one aspect of Defra's work is enabling everyone to understand the picture and their part in it, and supporting individuals, communities, and businesses to take action themselves.

Working in partnership: Red Rose Forest

Urban trees – Salford Triangle
© Red Rose Forest and Dave Borrows

Red Rose Forest is an environmental and regeneration initiative for Greater Manchester and Salford, developed by a partnership including: Natural England, the Forestry Commission, the metropolitan boroughs of Bolton, Bury, Trafford and Wigan and the cities of Manchester and Salford, as well as United Utilities, a water company.

The Red Rose Forest Partnership run a Green Streets project which works with local people on activities like planting street trees, providing hanging baskets and planters, and creating communal green alleyways and living green walls. The project brings together residents, businesses and the public sector to promote the value of "green infrastructure" as a way of tackling a range of social, health and economic issues.

By giving local people the opportunity to get involved in the design of their scheme and helping residents to lead the consultation process, the project supports local communities to develop a new sense of ownership, and confidence that they can change their neighbourhoods for the better. The project addresses many of the environmental issues associated with climate change such as the heat island effect and air pollution, as well as providing a range of benefits to health and well being.

2 Available at: http://www.defra.gov.uk/environment/climate/programme/

Defra leads the Government's work towards a sustainable, secure, and healthy food supply. This includes making the food chain more resilient to climate change, and recognising that the ecosystem services provided by agricultural land are likely to be increasingly important to help cushion society from the effects of climate change. At the same time, emissions must be reduced – the greenhouse gas footprint of the UK food chain was 160 $MtCO_2e$ in 2006, about 22% of the emissions associated with all UK economic activity. This diagram shows the actions the Government is taking at each point in the food chain.

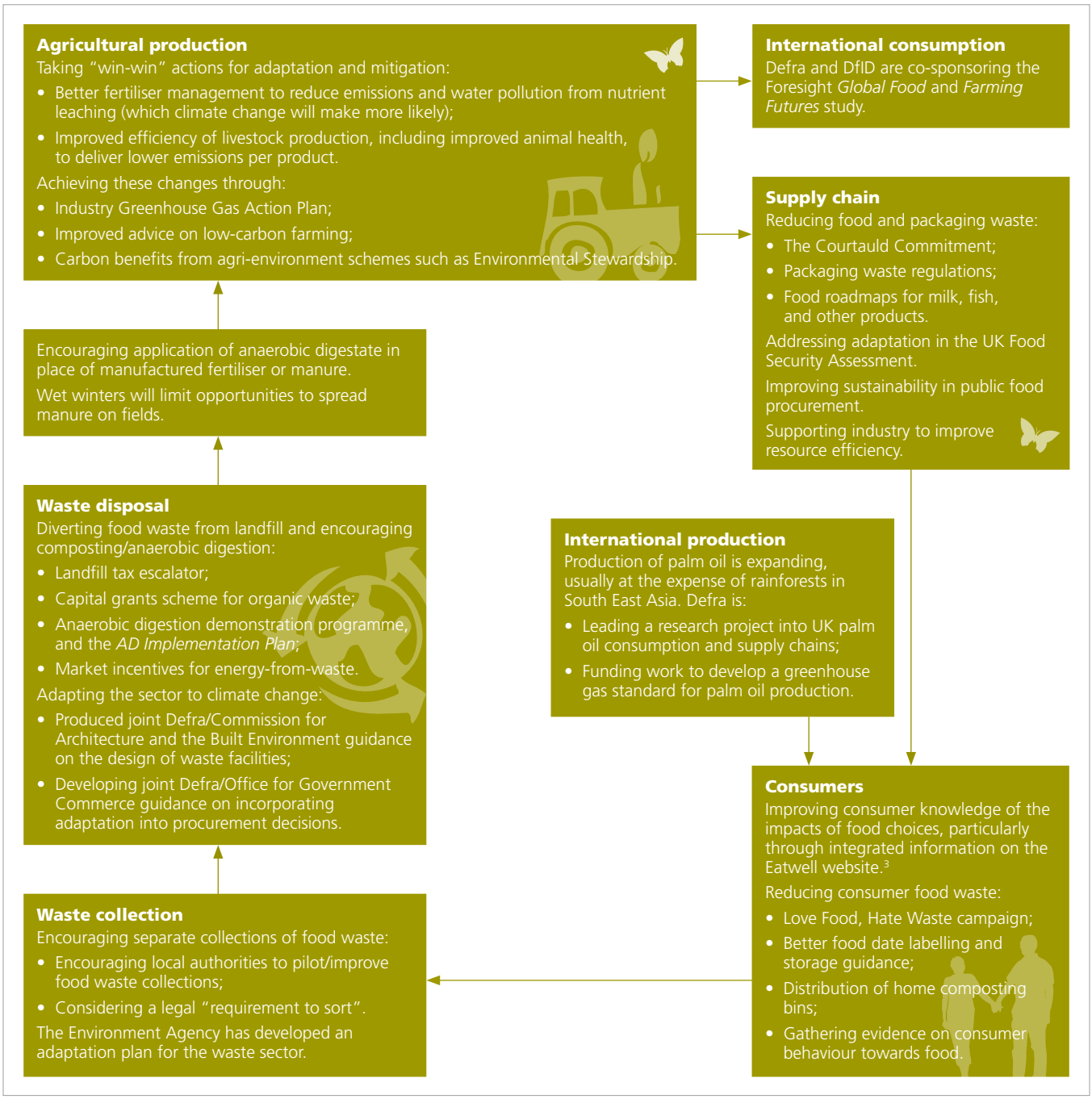
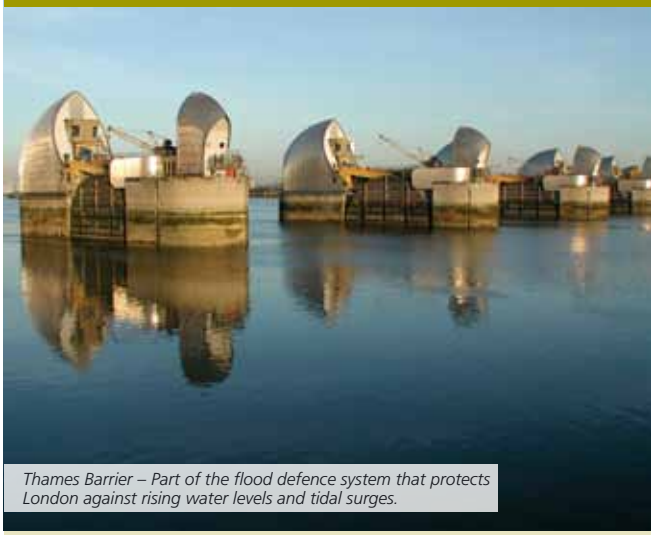


Figure 1: *Looking at the whole picture: the food chain*

3 Available at: www.eatwell.gov.uk

Staying flexible: the Thames Estuary 2100 project



Thames Barrier – Part of the flood defence system that protects London against rising water levels and tidal surges.

Thames Estuary 2100 (TE2100) is an Environment Agency project to develop a tidal flood risk management plan for the Thames Estuary to the end of this century. Using the latest climate change scenarios and models, and taking account of future sea level rise, the final plan will recommend what flood risk management measures will be required in the Estuary, where they will be needed, and when they will need to be in place.

The final plan will be flexible to ensure that it can be adapted if sea levels rise faster, or storm surges become more intense than anticipated. Preliminary findings show that the Thames Barrier, with some adaptation, will continue to provide protection through to the end of the century. However, by 2070 there may be a need to improve many of the flood defence walls and embankments, and create new inter-tidal habitats to offset the impact of rising sea levels before 2030.

3. Dealing with uncertainty by staying flexible

Taking action doesn't have to mean closing off options. Because of all the uncertainties, we shouldn't gamble on any one future coming to pass.

Keeping our options open can simply mean not taking decisions now if we can take them later, when we will have more information at our disposal. But sometimes it's important to take a decision now – putting it off will just mean the problem gets worse or the decision is taken for us. When a decision has to be taken now, it can be better to choose a path forward which leaves some room for manoeuvre later. As well as acting where necessary, a crucial part of Defra's strategy is deploying analysis to reduce uncertainty for the future.

Working through the EU and internationally

Climate change is a global problem, and the UK plays a leading role in the EU and internationally. The focus of this Climate Change Plan is on Defra's work to reduce emissions and adapt to climate change within the UK. But Defra also looks at the whole international picture, and works with partners across the World (including through the UN and the EU), to deliver environmental objectives at home and overseas.

Copenhagen and the road ahead

The talks at Copenhagen did not deliver everything the UK would have liked, but there was significant progress. Key developing countries such as Brazil and Indonesia put forward emissions reduction targets for the first time. Countries agreed to "fast start" finance of up to 30 billion US dollars to 2012, and to set up a High Level Panel on Finance to work towards a fund worth 100 billion US dollars per year by 2020.
Six countries (the UK, Australia, France, Japan, the US, and Norway) announced that their "fast start" contribution would include 3.5 billion US dollars for REDD (Reduced Emissions through Deforestation and Forest Degradation). The Prime Minister set out the need for 25 billion US dollars by 2015 to secure a 25% reduction in the rate of deforestation.

The talks in Mexico this year will be very important for Defra's international environmental objectives. Working closely with DECC, Defra's international work focuses on forestry, agriculture, fluorinated gases, consumption and production, and the marine environment.

Sustainable international development

Defra supports the Department for International Development (DfiD) in achieving the Millennium Development Goals (MDG). Defra leads on MDG 7 (environmental sustainability) – which includes targets on protecting the environment, reducing biodiversity loss, and reducing greenhouse gas emissions – and contributes to MDG 1 (food security).

One of Defra's objectives is to support the major emerging economies of Brazil, China, India, South Africa, and Mexico to develop sustainably. Defra's Sustainable Development Dialogues with these countries include projects, many of which deliver climate change objectives. For example:

- working with the Ministry of Environment and Forests in India on natural resource management.
- working with Brazilian industry to reduce their emissions.
- promoting co-operation between the UK and China through the Sustainable Agriculture Innovation Network.
- assisting South Africa to enhance environmental protection through the "Green Scorpions" project.
- helping Mexico to develop a sustainable urban plan for the State of Nuevo Leon.

Forestry

The REDD negotiations are particularly important for Defra. They will determine global action on forestry for the next decade, including whether deforestation will be slowed or halted, and how forests will be managed, including to protect biodiversity. They also link directly to efforts to tackle illegal logging and the trade in other unsustainably produced commodities such as palm oil.

Agriculture

To support the global agricultural sector in facing the challenge to reduce emissions and adapt to climate change sustainably, Defra is:

- leading for the UK on working with international partners (including France, Germany, the US, and New Zealand) to secure United Nations Framework Convention on Climate Change (UNFCCC) agreement to a work programme on agriculture.
- supporting the Global Research Alliance on agricultural emissions, launched by New Zealand at Copenhagen.
- taking forward commitments made at the L'Aquila Summit and the World Summit on Food Security to support countries in developing their own strategies, including through the sustainable use of genetic resources for food and agriculture.
- increasing investment in research and development, including through the Consultative Group on International Agricultural Research, and a new innovation platform bringing together the Government, business, and researchers to stimulate new technologies to increase production efficiency while decreasing environmental impacts.

Fluorinated gases (F-gases)

Defra has been working with DECC to push for an international agreement to progressively reduce the production and consumption of hydrofluorocarbons (HFCs). The UK will also play an active role in discussions relating to the EU Review of F-gas regulations over the next 18 months.

Consumption and production

As well as actively negotiating Europe-wide minimum energy efficiency standards for energy-using products, Defra works internationally within the G8, the G20, United Nations Environment Programme (UNEP), and the International Energy Agency (IEA) on a number of projects to raise the importance of product standards. Defra's aim is to share knowledge, best practice, and market information about product performance to achieve a greater degree of harmonisation of standards globally in order to generate a stronger push for market transformation towards more efficient and sustainable products.

White sandy beach and sea – West Cornwall coast.

The marine environment

The UK is taking a lead role in developing carbon capture and storage, and the North Sea provides significant capacity to store carbon dioxide beneath the seabed. Defra has been working with international partners under the OSPAR Convention and the London Protocol on marine pollution to ensure that the legal framework is in place for this important technology, providing a future for the North Sea industry while protecting the marine environment.

Adaptation in the EU

The 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 including the setting up of an EU Clearing House Mechanism and an Impacts and Adaptation Steering Group for sharing information on climate change impacts, vulnerabilities and best practice.

The impacts of climate change will vary across Europe, so adaptation will need to be carried out nationally or regionally. But there is a role for the EU to support and complement the work of member states. For example, the future climate must be taken into account in the EU's own policies and programmes, research and evidence should be shared across the EU, and member states should work together to support adaptation outside Europe.

Addressing climate change through the EU Common Agricultural Policy

The next round of reform of the Common Agricultural Policy (CAP) is due to be completed by 2013. Protection and enhancement of the rural environment should have a central, rather than a peripheral role under a future CAP. In ensuring that the CAP is used in future to deliver public goods of European relevance, the Government will work to ensure that the strategic importance of climate change is adequately reflected in rural development and agri-environment policy.

Currently, Pillar 1 consists of expensive and untargeted subsidies. Pillar 1 needs to phased out through a carefully managed transition.

Pillar 2 currently provides funding to improve the competitiveness of agriculture and forestry, protect and enhance the natural environment, encourage the cultivation of energy crops, and support wider rural development. The UK has alreadydemonstrated that schemes funded through Pillar 2 rural development programmes, such as agri-environment schemes, can play a positive role in climate change mitigation and adaptation. For example, under Environmental Stewardship, part of the Rural Development Programme for England (RDPE), a number of land management options are available that can contribute to climate change mitigation by either reducing greenhouse gas emissions or increasing carbon storage. This is alongside a number of existing and newly developed options that could contribute towards a more resilient natural environment.

The Government will work to strengthen the positive impact of these sorts of schemes, both domestically and across the rest of the EU.

Executive Summary

This document, Defra's Climate Change Plan, sets out the actions Defra is taking, in the policy areas where it has influence, to meet the challenges posed by climate change.

Adapting to a changing climate

Defra's overall purpose is to secure a healthy environment where we and future generations can prosper. Due to climate change, the speed and scale of future changes to our environment will present both threats and opportunities that we as a society will need to adapt to. At the same time, we rely on a healthy natural environment and the services it provides to support our economy and society in adapting. Defra is working to address these challenges, by coordinating a national programme of action to support all parts of society – individuals, businesses, Government and public authorities – to respond to the impacts of climate change.

In responding to the challenge of a changing climate, Defra has three clear priorities:

- securing the basics for human well-being.
- enhancing the resilience of ecosystems.
- building adaptive capacity.

Pages 20-87, which form Defra's Adaptation Plan, set out the actions Defra is taking to understand and deal with the risks and take up the opportunities of climate change. Key actions include:

- encouraging other Departments, public bodies and businesses to adapt to the effects of a changing climate through the Adapting to Climate Change Programme (ACC), which is run by Defra.
- reducing wastage through the Floods and Water Bill, which will allow water companies to control non-essential uses of water during droughts.
- investing in flood and coastal erosion risk management to help meet the challenge of higher winter rainfall, rising sea levels and more frequent storm surges.
- gathering evidence on how we can protect as well as benefit from the services provided by our natural environment to help respond to climate change, through major ongoing research initiatives such as the National Ecosystems Assessment.

- providing information to farmers and land managers about the threats and opportunities that climate change brings. The Farming Futures project provides a range of guidance and case studies on adaptation.
- encouraging greater use of green infrastructure to cool urban temperatures, reduce flood risk and connect wildlife habitats, including by supporting CLG to develop a new integrated natural environment Planning Policy Statement.

Pages 72 to 77 set out how Defra is working to improve its capacity to identify and manage climate change opportunities and risks. For example, by:

- embedding adaption in key business processes such as risk management, procurement, horizon scanning and investment appraisal.
- developing leadership, accountability and awareness of climate change adaptation at all levels across the Department.
- improving the way that climate risks are identified, managed and scrutinised in Defra.
- enhancing Defra's research base and the way that the Department manages evidence on climate change.

Reducing greenhouse gas emissions

The Climate Change Act 2008 set in law a long-term target to reduce the UK's emissions to 80% below 1990 levels by 2050, and established the system of UK carbon budgets. The first three UK carbon budgets, capping UK emissions until 2022, were set at Budget 2009.

In July 2009, the Government published the *UK Low Carbon Transition Plan*[4], which explained how the Government plans to meet the first three UK carbon budgets. The Transition Plan introduced the system of Departmental carbon budgets, giving each Department its own carbon budget – a share of the UK carbon budget – based on the level of influence it has over the different emissions-producing sectors of the economy. It also announced that every Department would publish a *Carbon Reduction Delivery Plan* setting out how its carbon budget will be met.

Defra has direct influence over emissions from several sources, including agriculture, land use, waste, fluorinated gases, and industrial chemical processes such as acid manufacture. Together, these sources total roughly 15% of the UK's greenhouse gas emissions. Defra also develops policies which cut emissions across virtually every sector of the economy. These policies, including Defra's work on the food chain, the water system, and sustainable patterns of consumption and production, play a vital role in meeting emissions targets by making our economy more sustainable and less resource-intensive.

4 Available at: http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

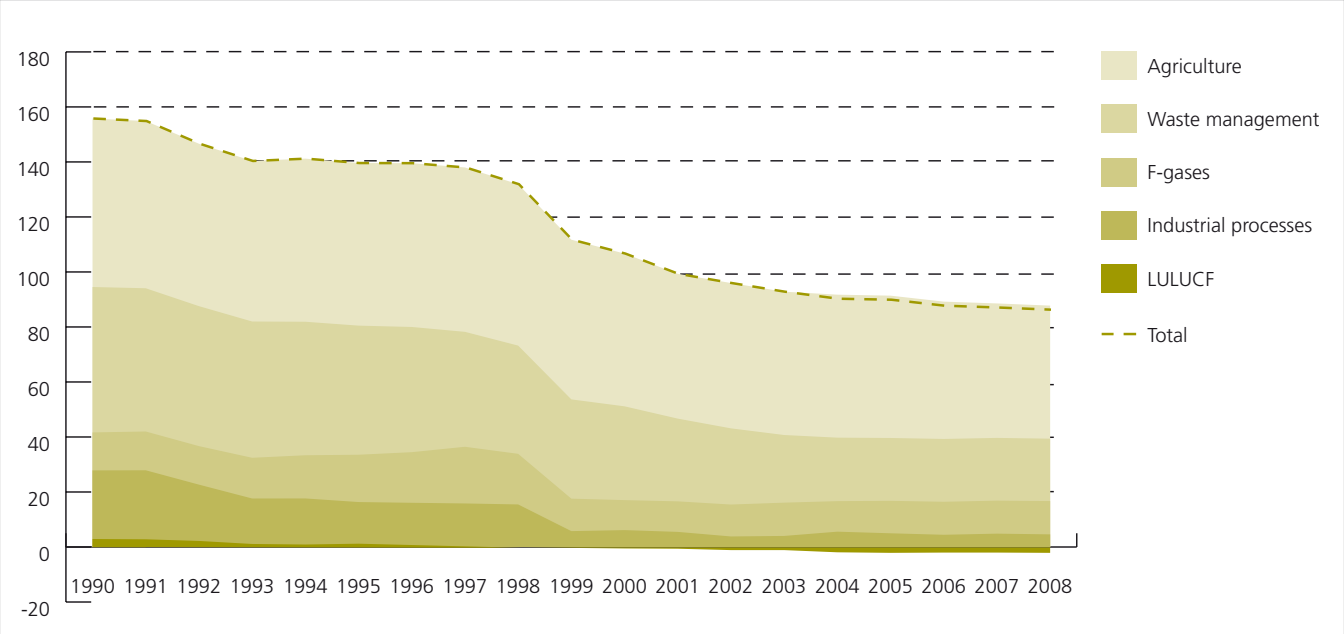


Figure 2: *Greenhouse gas emissions in Defra's key policy areas have fallen by around 46% since 1990.*

Pages 88 to 127 set out the actions Defra is taking to meet its carbon budget. The key actions include:

- **supporting the agricultural industry's first *Greenhouse Gas Action Plan*,** which aims to save English farmers money and reduce greenhouse gas emissions. Defra will have the Action Plan **independently assessed** to help ensure it is fit for purpose, and will **support its delivery** through a joint board, advice to farmers, and investment in improving evidence.
- **a new Peat Framework for Action**, which Defra will consult on later this year.
- **encouraging woodland creation**, through a number of measures, including establishing a Woodland Carbon Task Force and consulting on the potential for company greenhouse gas reporting guidance to encourage new investment.
- **extra emissions savings from products**, where Defra is negotiating in the EU for new energy efficiency standards which should double the savings already achieved.
- **further reducing emissions from waste**, through a comprehensive plan, including a recently-launched consultation on placing restrictions on certain wastes going to landfill.

Pages 128 to 157 form Defra's *Carbon Reduction Delivery Plan* and explain how Defra's carbon budget is constructed, how Defra works with others to reduce emissions, the indicators which will be used to track progress, and the milestones in the years ahead.

Native woodland planting at Giggleswick in the Yorkshire Dales National Park. With funding from the Forestry Commission, Yorkshire Dales Millennium Trust, Yorkshire Dales National Park Authority ©, Natural England, and private landowners 240 hectares of broadleaf woodland has been planted in the Yorkshire Dales National Park in the last 3 years, with a further 100 hectares approved for 2010

Defra's own estates and operations

Defra continues to strive to operate more sustainably – to make its own contribution to the national effort, to learn from its experiences, and to set an example for others.

To adapt Defra's estate, the Department is:

- **identifying risks to its existing buildings** – 172 sites across the Defra estate have already been surveyed to identify climate vulnerabilities and prioritise the work that is needed to address these risks.
- formally considering climate risks at the start of all new building and major refurbishment projects.
- making sure that key IT and communications systems are resilient to current and future climate risks.
- embedding adaptation in its procurement processes, especially for new construction projects.

Defra has reduced its estates' emissions by 18% since 2005, over-achieving its Sustainable Operations on the Government Estate (SOGE) targets. The Department is putting in place a number of measures (such as the installation of biomass boilers) which will deliver at least 12% further reductions in emissions over the next three years. This would mean the Department would meet its SOGE emissions reduction target for 2020 seven years early, in 2013.

Oil seed rape.

Defra's Lion House building, at Alnwick

Lion House, Alnwick

In 2008, Defra opened Lion House, a new, ultra-low emissions office building in Alnwick. The building achieved an Energy Performance Certificate (EPC) rating of A+ and has also won a number of prestigious awards which include being the first building in the UK to be awarded a BREEAM 'Outstanding' certificate.

Built to replace an office building that had become economically unviable, Lion House was designed to minimise emissions and maximise resource efficiency: a biomass boiler is capable of meeting 90% of heating demand; three 15kW wind turbines and a 120m² array of photovoltaic cells generate an estimated 75,000kWh of renewable electricity per year; and highly efficient insulation and lighting minimise energy and heat demand.

The new Lion House now produces only six tons of waste per month, 90% of which is recycled. This is a reduction in waste of 77% compared to the previous building.

A rainwater harvesting tank has reduced water consumption within the new building to 1.5 cubic metres per person per year, 50% lower than the SOGE target for water usage.

Defra's Climate Change Plan

Adapting to climate change

Adapting to climate change

1. Adaptation plan: context

Adapting to the changing climate across society and the economy is essential so that we can deal with the impacts of climate change already in train and those we can expect in the future. There will also be opportunities to take advantage of some more positive aspects of climate change in some sectors, for example, agriculture. If the Government, the wider public sector, private organisations and individuals prepare for future climate change now, necessary adaptation can be identified early, planned for, and undertaken in the most cost-effective and sustainable way.

This part of the Climate Change Plan sets out how Defra is responding to the challenges and opportunities presented by climate change and how we are working to embed adaptation into the Department's policies, programmes and systems. It provides a valuable opportunity to develop a conversation with our many stakeholders on the issues that are facing our key policy areas and how we can work together to ensure successful adaptation. It shows how the Department is growing its awareness and understanding, as well as making progress in identifying and assessing risks. And it provides information on our individual policy responses.

Children learning about pond wildlife.

Climate change impacts

The UK Climate Projections 2009[5] show what the major changes to the UK's climate are likely to be on the basis of three different greenhouse gas emissions pathways. Whilst there is inherent uncertainty within the Projections, there is enough certainty that the climate is changing due to human emissions that we need to act now.

Broadly speaking, we can characterise the projected changes as warmer and wetter winters, hotter and drier summers, sea level rise, and more extreme weather events. Based on a 'medium emissions' pathway, which according to the Climate Change Committee (CCC) 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 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, through concerted international action, we could put the World on a lower emissions pathway, resulting in less damaging change.

The potential impacts of these changes include increased water stress, increased risk of flooding and heat waves, and faster coastal erosion. These impacts could have consequences across the country; for example, by posing risks to the functioning of critical infrastructure such as energy, transport and water systems, or by posing risks to public health or the natural environment.

Defra's policy areas

It is clear that, due to past emissions, we are already committed to 30-40 years of temperature rise and over 100 years of sea-level rise. We need to be prepared for these changes, so all of us – individuals, businesses, government and public authorities – will need to adapt our behaviour to respond to the challenges of climate change. The Government has therefore established the Adapting to Climate Change Programme, led by Defra, to bring together the work already being initiated by Government and the wider public sector on adapting to climate change, and to coordinate and drive forward future work.

Defra's core mission is to secure a healthy environment in which we and future generations can prosper. The environment we see around us, in our towns and cities as well as in the countryside, is a result of the interactions between humans and nature and it is constantly changing. Because of climate change, we expect the speed and scale of future changes to be unprecedented. This will present both threats and opportunities to which we as a society will need to adapt. This places successful adaptation to climate change at the heart of the Department's agenda.

Defra considers climate change to be a significant threat to all of its Departmental objectives:

- **food, farming, and land management:** the agriculture and land management sector plays an important role in the country's economy, and covers 75% of our total land area. Climate change could have a major impact on domestic patterns of production, crop yields, and, depending on the impact globally, the level and volatility of food prices. This could have a significant economic

5 Available at: http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=163&Itemid=293

impact. Increases in pests and diseases may also threaten our woodlands, forestry production, crop and animal health.

- **the natural environment:** changes to our climate will impact on our wildlife and the habitats they rely on. Some of our cherished landscapes could change beyond recognition, and some species will face a struggle for survival. But a healthy natural environment is also key to climate change resilience and we have to ensure that natural processes within the environment can function effectively.
- **the quality and supply of water:** pressures such as demographic change, and climate change mean that we need to find ways of using water much more efficiently and sustainably if we are to continue to enjoy current levels of security and quality of supply. The South East and East of England already face increasing demand on finite water availability. Through climate change, droughts are likely to be more common.
- **the marine environment:** our understanding of the potential impacts of temperature changes and ocean acidification is still developing, but we recognise that the consequences for marine and coastal biodiversity could be significant.
- **management of risks from flooding and coastal erosion:** flood events are likely to become more severe and frequent with climate change. This will present greater risks to communities and infrastructure and higher costs of managing flood and coastal erosion risk.

These risks, and the policy and practical responses to them, are all interconnected and we need to ensure that we work in a way which reflects this. The resources and services that we receive from our environment cannot be adequately understood in isolation from one another. We will be able to find more efficient and effective solutions to the challenges posed by a changing climate if we consider individual parts of the system, such as water or biodiversity, agriculture and landscape as components of a greater whole (the 'whole systems' approach).

A robust and well-prioritised strategy is needed to understand these risks and deliver further progress. We are committed to research in many areas to learn more about the impacts of climate change on the natural environment and key sectors. We are assessing the risks to our objectives in all areas and looking at the action we can undertake with our partners to increase the long-term resilience to a changing climate of these vital resources.

The Adapting to Climate Change Programme

The ACC Programme is currently undertaking the groundwork for a National Adaptation Programme to be put in place in 2012.

This phase of work involves:

- developing a more robust and comprehensive evidence base about the impacts and consequences of climate change on the UK.
- raising awareness of the need to take action now and help others to take action.
- working across Government to embed adaptation into Government policies, programmes and systems.
- measuring success and taking steps to ensure effective delivery.

Further information is available at: http://www.defra.gov.uk/environment/climate/index.htm

Defra's priorities

In responding to the challenge of a changing climate, Defra has 3 clear priorities:

- **securing the basics for human well-being:** as a country, we have rightly come to expect some of the highest quality food and water in the World. We are working to provide cleaner, fresher air to breathe and a natural environment that everyone can thrive in. Climate change reinforces the importance of valuing our precious natural resources more effectively, using them wisely and taking responsibility for their protection.
- **enhancing the resilience of ecosystems:** climate change is the most serious long term threat to the natural environment and human well-being, but at the same time our natural environment is our greatest asset: the basis on which we can build a future in a rapidly changing climate. Ecosystems provide the services that clean our air and water, and give us food, medicines, energy, and raw materials. They regenerate soils and pollinate crops, regulate the climate, cool cities; and help to control floods. Defra recognises the importance of enhancing the resilience of ecosystems, and of working effectively with natural processes to offer protection from climate change to homes, infrastructure, livelihoods, and human life.
- **building adaptive capacity:** we are working to enhance capacity to assess and manage climate change risks – across the Department, with our key partners in Natural England, the Environment Agency and the Forestry Commission, and with those sectors of the economy (including water, food, farming and fisheries) that the Department is responsible for. In doing so, our focus is on providing leadership, raising awareness, building partnerships, enhancing the evidence base, and embedding adaptation within key decision-making processes and operations (such as estates management and procurement).

Key adaptation principles

Many of our key operations, policies, investments and buildings will be directly or indirectly affected by a changing climate. Defra needs to consider the risks and opportunities involved and take account of good adaptation principles in developing its responses:

- any adaptation action needs to be **sustainable**. This means that our responses should not add to climate change, or limit the ability of other parts of the natural environment, society or business to carry out adaptation elsewhere. Our responses must avoid any detrimental impacts on other parts of society, the economy or the natural environment.
- action should be **flexible**. Although there is still uncertainty over the future climate, we need to consider options now and make decision that maximise future flexibility – in many cases it is failure to take decisions that locks us into inflexible pathways.
- action should be **evidence-based** – making full use of the latest research, data and practical experience (including the UK Climate Projections 2009) so that decision-making is well-supported and informed.
- our response to climate impacts should be **prioritised** – for example, by focusing more attention on policies, programmes and activities that are most affected by the weather and climate, those which have long timescales for implementation or long-term implications, where significant investment is involved or high values are at stake, or where support for national infrastructure is involved.
- adaptation measures should be **effective** (reducing the risks from climate change without introducing perverse effects), **efficient** (the long-term benefits of adaptation actions should outweigh the costs), and **equitable** (the effects of the activity on different groups should be taken into account and where the costs should fall).

Mountain bikers enjoying the open view of the countryside.

The rest of this part of the plan is structured as follows:

- **sections 2-6** discuss why climate change is crucial to the key policies and programmes that Defra is responsible for, and highlights a range of short- to medium-term actions required for moving forward.
- **sections 7** discusses how Defra is continuing to develop its capacity to assess and manage climate risks and.
- **sections 8** summarises our response and sets out an action plan.

Adapting to climate change

2. Food, farming and land management

This chapter covers the interconnected subjects of food, agriculture, plant and animal health, soils and forestry. Agriculture and associated land uses cover around 75% of the UK and provide a wide range of environmental, social and economic benefits to society – with an influence that goes well beyond their primary purpose of producing food and non-food crops. These benefits include employment and other contributions to thriving rural communities; essential environmental processes such as water cycling and purification, maintaining air quality, reducing soil erosion and flooding, carbon storage and climate regulation; habitats for wild flora and fauna; and land for recreation. The adaptation strategies for these areas therefore need to be closely interconnected with the issues addressed in the other sections of this document, in line with the whole systems approach set out in the Context section above.

Climate change is a new long-term challenge that farmers and land managers will need to respond to. It is one of a range of pressures which may require greater flexibility within the farming sector; for example, changes to global markets, technological development, new and more efficient farming practices, and different working practices. The sector must respond effectively to this range of economic, social and environmental pressures or face the risk that agricultural productivity and profitability could increasingly lag behind the rest of the economy and that of international competitors.

2.1 The global food chain

It is vital to address the impacts of climate change on the food system, particularly as globally we will need to feed a growing population with diminishing resources.

We need to adapt the food system to the unavoidable climatic changes that are already happening and to reduce greenhouse gas emissions to avoid more dangerous environmental effects. The UK enjoys a relatively high level of food security today, but we cannot be complacent. We need a better understanding of the impacts of increasing demand, the effects of climate change, new pressures on land and high energy prices.

Food Chain: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Longer growing seasons and less summer rainfall could lead to a change in what and how much, is produced and where.
	Warmer climate may give rise to different levels of demand for types of food, which may affect either our trade in foods or UK food production/land use.
Drought	Climate driven market pressures to increase production could lead to unsustainable farming practices.
	Lower availability of water for intensive food processing.
	May affect the level and volatility of food prices, both domestically and on global markets.
Increased incidence of extreme weather events	Short-term risks of disruption to food production and distribution from severe weather events may become more common.
	Short-term impacts on the national infrastructure on which food chain relies i.e. energy and fuel, potable water service, transport, distribution and logistics networks, etc.

Policy and Practical Responses

The UK Food Security Assessment, updated in January 2010, is a mechanism for assessing the challenges and risks facing UK food security, our current understanding of the state of our food supplies, and how we plan to continue to deliver sufficient, safe and nutritious food for the UK. The impacts of climate change will be monitored under all of the Assessment's theme areas:

- **global availability:** risks to harvests worldwide, e.g. from drought or pests, leading to potentially volatile supplies and prices. Increasing global temperatures are likely to result in complex changes to food production worldwide.
- **global resource sustainability:** increased stress on natural resources (particularly water) and biodiversity threatening productivity in various regions of the World.
- **UK availability and access:** UK food availability is driven by global supply chains and domestic agriculture.
- **UK food chain resilience:** more frequent extreme weather events testing business continuity planning and infrastructure resilience, including agricultural land availability and use.
- **household food security:** climate change could lead to rising food prices.
- **safety and confidence:** in hotter weather we may need to increase refrigeration to keep food safe. Any failures to keep food sufficiently chilled could potentially increase cases of food poisoning.

The Government's Food Strategy, *Food 2030*, sets out the future challenges for the food industry. The impacts of climate change on food production, globally and in the UK, could range from changes to and loss of farmland to opportunities to grow new crops. The food system and its supply chains will need to be ready for these changes, while meeting increasing demand.

A priority in Food 2030 is a resilient food system – one which can withstand, or recover quickly from, sudden shocks. These can be financial – such as commodity price spikes; caused by natural disasters such as floods; or caused by disruption to fuel supply. As outlined in the section on Agriculture below, an essential element of 'food security' will be to maintain the long term health of natural ecosystems that food production depends on despite the challenge of future climate change.

➜ THE GLOBAL FOOD CHAIN ACTIONS

1. Defra and DfID are jointly sponsoring a Foresight study on Global Food and Farming Futures, which will include consideration of key climate impacts on the global food system up to 2050. An action plan will be published, along with a detailed final report in Autumn 2010. We will review progress in 2011.

2. Defra will make further information available through the UK Food Security Assessment, and review risks as new evidence becomes available. We will actively monitor the climate risks to harvests and the potential for more volatility in supplies and prices, as well as new animal disease and food safety risks.

3. The Government will continue to work with the food industry to promote business continuity planning and resilience to flooding and other climate threats. Major food retailers and trade associations have been invited to report to the Government in 2011 on key climate risks affecting their operations and the steps they are taking to address them (under the statutory Adaptation Reporting Power).

2.2 Agriculture

Climate change will affect, directly or indirectly, all of the important benefits that agricultural land provides to society. Agricultural systems and the ecosystem services they provide are very vulnerable to changes in climate and are among the first to feel the effects. Many of the likely pressures are not new but will be exacerbated and accelerated by climate change. The effects will be felt differently, and over different timescales, in different regions of the country and by different agricultural sectors. Therefore action to ensure agriculture can build resilience and adapt, now and in the future, is crucial, and sustainable adaptation by agricultural systems will be a key part of our overall national response to climate change.

Policy and Practical Responses

Our objective is to maintain, and enhance where possible, the wide range of social, environmental and economic benefits that agricultural systems provide to society. Defra's departmental strategic objective – "*to achieve 'a thriving food and farming sector with an improving net environmental impact*" – envisages by 2020 an English farming sector which is profitable in the marketplace; continuing to produce the majority of the food we consume; making a positive net environmental contribution; and managing the underlying landscape and natural assets.

Farm businesses exist in a complicated and changing risk environment, including:

- **production risks** such as pests and diseases (animal and plant), and weather effects.
- **market risks** such as volatility in the costs of inputs and the price of outputs.
- **finance risks** such as variability of interest rate or value of financial assets and availability of credit.
- **institutional risks**, including trade issues such as import bans/restrictions by other countries, or regulatory changes that can affect costs or returns.

Agriculture: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Some increased yields and less frost; reduced quality and yield of some current crops.
	Opportunity to grow new crops (e.g. olives and apricots) or existing crops further north (e.g. vines).
	Heat stress of livestock and farm workers.
	Increased losses to pests and disease.
	Changes to wild plant and animal communities on farmland.
Drought	Loss of pastures.
	Lack of water for crops and livestock.
	Decreased flow to rivers and groundwater.
	Reduction in crop yield.
	Increased risk of fire.
Increased incidence of extreme weather events	Increased soil erosion and water pollution.
	Disruption of farming activities.
	Increased recharge of water courses and stores.
	Storm and flood damage.
Sea level rise	Reduced water supply, salinisation of land.
	Changes to coastal habitat and loss of land.

Hen houses to provide shade for free range birds in hotter summers

Climate change will exacerbate many of these risks and increase the probability and impacts of shocks to the industry which will challenge its resilience. It represents an additional important pressure – on top of ongoing pressure for farm size and structures to adjust in order to facilitate the move to a more efficient and productive farming sector. While there are likely to be opportunities offered by climate change, particularly in the short-term, the negative impacts of climate change are likely to increasingly outweigh any benefits. For both these reasons, it will be in farmers' own best interests to adapt in order to strengthen resilience and maintain a competitive industry.

Change is inevitable and it is likely that landscapes will look different, ecosystems will change, and so will farming practices, along with what farmers produce, and where and when they produce it. Action to adapt will be essential – but such action (in agriculture, as in all sectors) must be *sustainable*. This means taking a 'whole systems' approach and addressing agricultural production, conservation of the natural environment, and social and economic benefits in an integrated way.

The timing and consequences of climate change are hard to predict, so adaptation by the sector will need to follow a flexible pathway. The first steps to adapt are likely to be small and should benefit both farmers and society whatever the scale and type of future climate impacts. These will allow us to build resilience gradually; benefitting from lower costs and less disruption to business in the long run; and preparing for a range of possible future impacts which, over time, may require more significant transformational changes.

Lavender

Identifying priority actions

Implementing measures to build resilience and adapt to climate change will require action by individual farmers and agricultural organisations, by central and local Government, and by delivery bodies such as the Environment Agency and Natural England. Since 2008, Defra has been working with Natural England, the Environment Agency and the Forestry Commission on a project to identify a range of priority adaptation actions that can reduce vulnerability to climate risks and have multiple benefits for agricultural production, ecosystems and mitigation.

The priority actions that farmers and land managers should consider now, to manage risks and help plan for the future, are those:

- that will increase resilience to likely pressures, (actions such as improving water efficiency, or more careful use of fertiliser and pesticides).
- that also address climate change mitigation (actions such as reducing soil erosion, reducing fertiliser use, planting trees).
- whose benefits require a long time to come to fruition (actions such as planting trees).
- which are sustainable, and have significant multiple objectives, benefitting both agriculture and wider society (these include in particular a range of land management actions that create 'green infrastructure' that will provide important services such as alleviating flooding, maintaining carbon stores, and protecting water supplies (see pages 50 to 53 on green infrastructure and the text box on page 44 on the role of land management in helping society and the environment to adapt).
- that improve ability to cope with extreme events (such as flood management plans).
- that will make their businesses more efficient and productive.

Actions that are in response to more gradual changes in climate, such as changing or diversifying crop and livestock varieties, can be introduced over longer timescales. Action will be needed at different scales, for example: individual farms changing crops independently; farmers co-operating to share information and develop joint contingency plans for extreme events such as floods or fires; managing water resources at a catchment scale; and wider-scale monitoring and management of disease outbreaks.

A recent survey by Farming Futures indicates a reasonably high level of awareness among farmers of the effects of climate change: over half of farmers believe that climate change is having an effect on their farm now; over 60% believe it will have an effect in the next decade; and nearly a third are already taking action to adapt to the impacts of climate change.

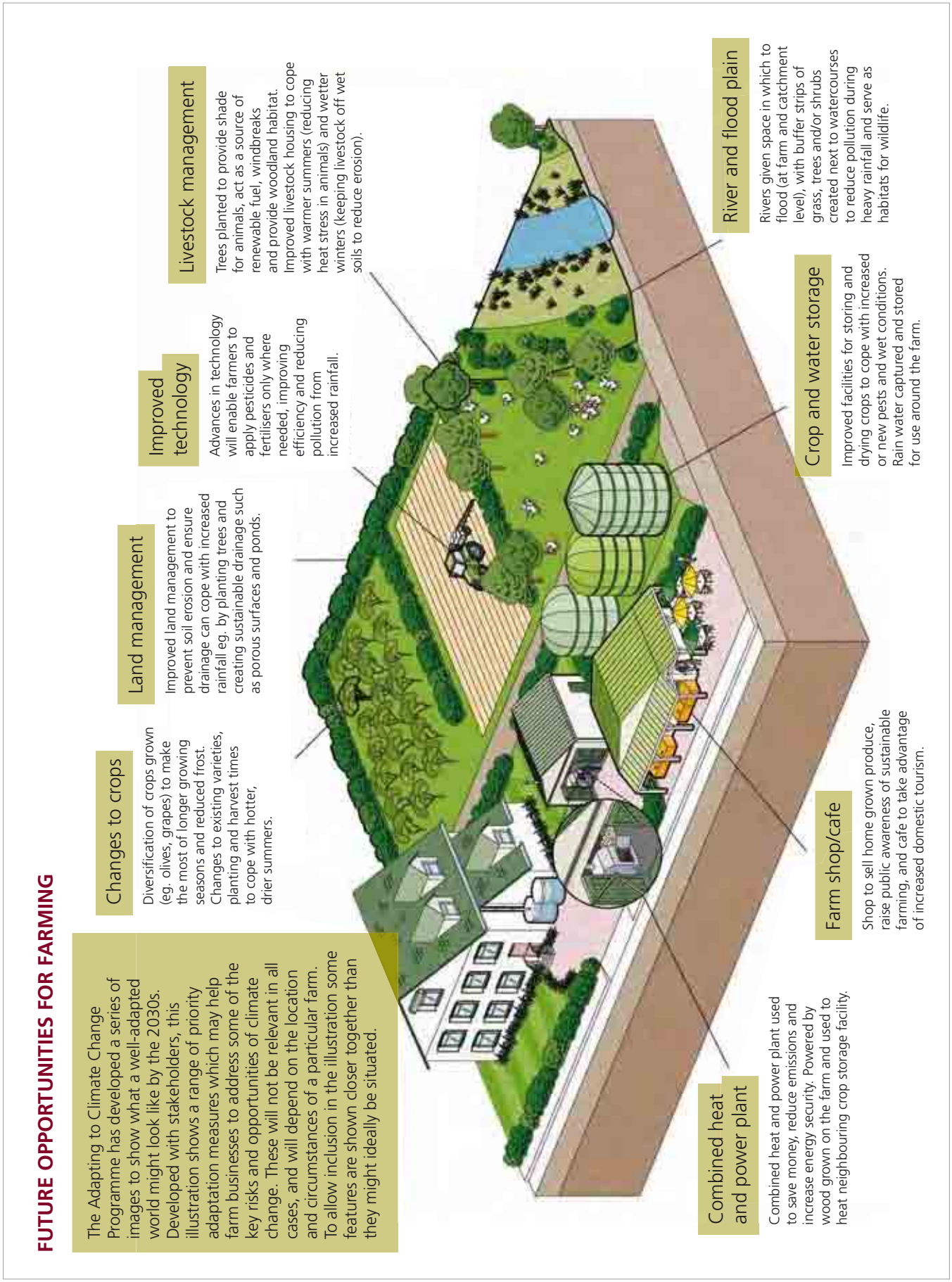


Figure 3: *Some adaptation actions that could be taken by agriculture. (To allow inclusion in the illustration some structures are shown closer together than they might ideally be situated.)*

Working in partnership to provide advice and support

Defra works closely in partnership with delivery agencies, agricultural organisations such as the National Farmers Union (NFU) and Country Land and Business Association (CLA), and wider stakeholders through the Rural Climate Change Forum (RCCF), to address climate change. The **Campaign for the Farmed Environment (CFE)** is an example of a unique new partnership between industry, environmental groups and the Government, which aims to encourage farmers and land managers to voluntarily adopt important land management practices that will benefit the environment, such as joining the Entry-Level element of Environmental Stewardship. The CFE has agreed to meet a number of stretching national targets by 2012, to benefit biodiversity, farm wildlife and resource protection. Many of the measures – such as retaining un-cropped land, putting in buffer strips and using fewer inputs such as fertilisers – will help build resilience to climate change.

A key aspect of all these partnerships is the provision of information and advice to farmers, through a number of mechanisms some of which are funded by Defra. For example:

- advice and guidance is an integral part of cross compliance and agri-environment schemes (see page 34).
- the industry-led initiative **Farming Futures** encourages action on adaptation as well as mitigation, while other bodies already offer information on adaptation, such as sectoral roadmaps for milk, beef and sheep.
- the **Rural Climate Change Forum** (RCCF) brings together industry, non-governmental organisations and Government bodies, to provide a forum for dialogue with, and advice to, Government. It also aims to provide advice, awareness raising and leadership for rural stakeholders, and identify research.[6] A Defra – RCCF stakeholder workshop, *Agricultural Adaptation to Climate Change – Meeting the Challenges to 2020 and Beyond*, was held in December 2009 to inform this section of the plan.

Defra and its agencies are already working with the farming industry to ensure that **targeted training, tools and advice** reach farmers on how best to tackle the challenge of both mitigating and adapting to climate change – through existing mechanisms such as the Farm Advisory Systems, agri-environment schemes, Farming Futures, the Rural Climate Change Forum and the industry-led Agri-Skills Forum – and we will aim to enhance these services, including exploring the scope for demonstrating best practice to farmers.

Many existing and planned Government policies and programmes already contribute to building resilience to climate change, even where adaptation is not the primary purpose. In particular, cross compliance standards, which farmers must meet to receive their Single Farm Payments (around £1.5 billion annually), and agri-environment schemes (£168m spent on Entry Level Stewardship (ELS)/Organic Entry Level Stewardship (OELS); and £54m spent on Higher Level Stewardship (HLS) in 2008/09) indirectly or directly help farmers and land managers to deal with climate change (see text box on the Rural Development Programme for England (RDPE) on page 34). Other supportive domestic legislation includes Animal Welfare legislation, Environmental Impact Assessment regulations, the England Catchment Sensitive Farming Initiative and the Flood and Water Management Bill currently before Parliament. At the EU level, legislation such as the Water Framework and Nitrates Directives also help with adaptation of agriculture.

6 Chaired by Dr John Gilliland (representing the Sustainable Development Commission): the other members of the Forum are Defra, the NFU, CLA, AIC, the Agriculture and Horticulture Development Board, Carbon Trust, Environment Agency, Forestry Commission, National Trust, Natural England, and RSPB.

Pixley Berries

Pixley Berries © at Pixley Court, Herefordshire

In 1998, Edward Thompson of Pixley Court Farm in Herefordshire realised that his blackcurrant crop was being affected by climate change. Soft fruit are particularly vulnerable to heat and rain, and berries rely on the "chill factor" in winter to produce a healthy crop. By researching varieties in other countries, he developed a breeding programme and the "Pixley Black" was born. This new blackcurrant variety can not only survive a longer growing season with warmer, wetter winters and hotter drier summers, it produces an intensely flavoured juice as well.
He also made a range of other changes that will help increase the farm's resilience to climate change. Winter water storage has been increased to allow for hot dry summers. Weather stations are used to monitor the onset of the growing season and of winter, which helps determine when to carry out activities such as harvesting. Low pressure vehicles have been brought in to protect the soil and plant roots during the expected warmer, wetter winters. Edward has also managed to reduce the amount of pesticides used, improving water quality, through promoting biodiversity in coppices, woodland and fields, which has led to an increase in pest-eating wildlife, from barn owls and woodpeckers, to bats, beetles and lacewings. Edward says that without adapting he would have been out of work due to crop failure, and his success has brought new business relationships, proving that 'climate friendly' business is good business.

The Rural Development Programme for England (RDPE) contribution to Climate Change Adaptation

The RDPE is a wide-reaching programme providing funding for agriculture and forestry businesses, environmental land management, energy crops and wider rural development. It is funded jointly by Defra and the EU under Pillar 2 of the Common Agricultural Policy (CAP). Climate change is an EU-wide priority for Pillar 2 expenditure and the current programme makes a contribution to both mitigation and adaptation.

The majority of funds under the RDPE are spent on environmental land management through agri-environment schemes such as Environmental Stewardship. Climate change (mitigation and adaptation) is an overarching objective of Environmental Stewardship; this is one of our most important tools to increase the resilience of habitats, species and ecosystems.

There are already over 58,000 agri-environment agreements in place with land managers (covering nearly 67% of agricultural land in England). Whilst many of the existing agreements contribute to mitigation and adaptation, the roll-out of the new round of agreements from July 2010 will offer the opportunity to expand the scope and extent of helpful measures. Encouraging farmers to join the scheme is a key part of the Campaign for the Farmed Environment. The Government along with agencies and farming groups, will develop training and information to further encourage farmers to take up measures which contribute to adaptation, alongside other objectives such as biodiversity and resource protection.

In addition, adaptive actions, such as improved water efficiency, can be supported under other parts of the programme which provide funding to help the competitiveness of land management businesses and for wider rural development. These are administered by Regional Development Agencies (RDAs) which appraise all funding applications under the Programme using a nationally approved framework to ensure they promote sustainable development which is resilient to climate change.

The Leader Approach is implemented through Local Action Groups and focuses on small-scale projects, several of which are aimed at supporting adaptation, such as the Cheviot Futures project in Northumberland which aims to provide practical real-world solutions to the challenges our communities face due to the effects of climate change. For example, a training event was organised in November 2009 to provide farmers in Northumberland with the opportunity to see modern irrigation techniques and water storage reservoirs in action.

Research and Development

Defra will continue to undertake research and development through ongoing programmes In 2009/10 Defra has committed £64m on agricultural R&D, including research on climate change mitigation and adaptation. Defra will contribute to the first Climate Change Risk Assessment, ensuring that it reflects the needs of the agricultural sector by considering how UKCP09 climate projections can be used alongside relevant research, and the work of partnerships such as Farming Futures and the Rural Climate Change Forum.

In December 2009, the Secretary of State confirmed UK participation in the Global Research Alliance on agricultural greenhouse gas emissions, which will provide a mechanism for sharing research findings, including synergies between mitigation and adaptation, between participating countries.

2.3 Plant health and animal health and welfare

Climate change is likely to significantly change how agriculture in this country, both arable and livestock, will develop. There will be new impacts to manage for both plant health and for animal health and welfare.

➜ AGRICULTURE ACTIONS

4. During 2010, Defra will build on existing project work with NE, EA and the Forestry Commission on priority adaptation measures for agriculture through further analysis of barriers to action, costs and benefits, and identification of research priorities and gaps.

5. During 2010, Defra will work with industry partners to explore the potential to support and encourage further voluntary adaptation action by farmers, including by enhancing existing advice and guidance arrangements.

6. From Spring 2010, 15 new or revised options are available under Environmental Stewardship that can help farmers to adapt to a changing climate. These include options that provide landscape benefits, make farming businesses more resilient, and that will enable habitats and species to adapt.

7. Protection and enhancement of the rural environment should have a central, rather than a peripheral role under a future Common Agricultural Policy (CAP). In ensuring that the CAP is used in future to deliver public goods of European relevance, we will work to ensure that the strategic importance of climate change is adequately reflected in rural development and agri-environment policy.

2.3.1 Animal Disease

Changes to ecosystems and habitats, trade, land use, how livestock are fed and reared, as well as factors such as changes in demand for, or availability of, food, feed availability, and prices for livestock, have the potential to rapidly change practices, as farmers respond to economic pressures and opportunities. This will affect the type and incidence of animal diseases. These need to be considered and anticipated, alongside longer term changes driven by climate change which will further complicate the rise of diseases in the UK.

Animal Health: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	New and different animal diseases; changes in incidence of existing diseases

2.3.2 Policy and Practical Responses

Our approach is to use the structures, ways of working and contingency plans already in place to deal with disease threats and outbreaks. We continuously review our contingency plans to make sure they remain as effective as possible and are preparing for every eventuality, so that we can anticipate likely changes in disease threats at an early stage and manage such risks proactively whilst encouraging livestock keepers to adapt and allow agriculture and food production to thrive.

Bluetongue disease

Vaccinating sheep against Bluetongue

Although there is currently insufficient evidence to say that bluetongue disease arrived in the UK in 2007 as a consequence of climate change, it was among a number of diseases that had been identified by horizon-scanning as a risk that may increase as the result of a changing climate. Our response to the threat of bluetongue shows how we would respond to future disease threats that may be a consequence of climate change. By investing in research and surveillance of exotic diseases before bluetongue arrived in the UK, in September 2007, Defra already had a higher level of policy preparedness. This was supported with work in partnership with industry and experts to ensure that a widely accepted control approach existed. Defra also used Met Office modelling and expert advice to predict likely incursion scenarios to prepare a control strategy in partnership with the livestock industry. The UK was the first EU member state to underwrite vaccine supply and this enabled us to successfully control bluetongue in 2008. The bluetongue threat remains and we continue to refine our modelling and risk assessment so we are prepared for this and other future threats that may occur as a consequence of climate change.

Partly due to the experience of bluetongue, awareness of insect-borne diseases was raised and experience gained. We are now also working in partnership with the equine sector on a control strategy and legislation for dealing with African Horse Sickness, which is transmitted by the same kind of midges as bluetongue disease.

Risk assessment is the basis for our response to mitigate disease threats. A horizon scanning team continually assesses disease threats to the UK and publishes qualitative risk assessments.[7] As a result of such horizon-scanning, preparedness for bluetongue disease was ramped up before the disease arrived in the UK in 2007. We are enhancing the way we work to identify and assess disease threats (including those influenced by climate factors) and escalate more significant risks so that proactive action can be taken to manage them. A Veterinary Risk Group has been set up in Defra to consider information and intelligence about disease risks and ensure that they are addressed appropriately and quickly.

7 Available at: http://www.defra.gov.uk/foodfarm/farmanimal/diseases/monitoring/index.htm

Field of ripening wheat

2.3.3 Animal welfare

Changes to physical conditions and land availability, and increasing occurrence of extremes of weather, could also severely impact on animal welfare.

Animal Welfare: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Increased heat stress leading to requirement for provision of shade and shelter for livestock outdoors.
	Need consideration in design and operation of housing and transport for animals.
	Opportunities to grow new crops and optimise sources of animal feed, as well as improving management of livestock and land use to become more flexible.
Drought	Animal welfare issues.
	Might affect availability of food and water.
Increased incidence of extreme weather events	Animal welfare issues.
	Might affect availability of food and water.

2.3.4 Plant Health

The main risks to plants are likely to come from new pests, other organisms, or changes in weather threatening crops and other plant life.

Plant Health: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Indigenous pests, weeds and diseases becoming more prevalent (or changes in balance between predators and pests).
	Change in temperature/ precipitation threatening crops.
	New pests or other organisms threatening crops.
	Current and approved pesticides not being suitable for dealing with new threats.
Increased incidence of extreme weather events	More difficult to apply pesticides effectively, particularly where drainflow is an issue.

2.3.5 Policy and Practical Responses

Defra has a number of Research and Development projects in plant health specifically related to climate change issues and we maintain contact with the Agricultural Observatory and other sources of information on the climate change implications for cropping patterns and pesticide use.

➜ PLANT HEALTH AND ANIMAL HEALTH AND WELFARE ACTIONS

8. Defra will review existing research and evidence on the likely impacts of climate change on animal health and welfare during 2010; and meet with key stakeholders to raise awareness and discuss the issues. We will use this information to identify and prioritise any evidence gaps to address in 2011/12.

9. Defra provides match-funding for the Pratique Project – an EU-wide initiative co-ordinated by the Food and Environment Research Agency (FERA). which is developing new Pest Risk Assessment tools and techniques which will help us assess risks to plant health in a changing environment. The project, which benefits from £50K of Defra funding, is due to report in June 2011.

10. Defra and the Forestry Commission will support an increased research effort into ways to deal with a number of new and emerging pests and diseases impacting on trees and associated ecosystems. We will work closely with key stakeholders in affected areas to address the threats from a number of recently established pests and diseases (see section below on Trees, Woods and Forests).

2.4 Soils

Changes in temperature, rainfall patterns and increased frequency of extreme weather events are likely to lead to significant and complex changes in soil quality, composition, structure and biota (organisms living within the soil). In addition, it is likely that the indirect impacts of climate change resulting from changes in land use, land management and agricultural practices will be more significant than changes in temperature or rainfall, especially where these exacerbate the risk of erosion, organic matter decline and compaction of soils.

Although the focus of discussions is often on agricultural soils, climate change will also have important implications for soils in the built environment. The behaviour of soils, under different rainfall patterns, may therefore require changes in their management and potentially the need to repair and underpin the foundations of buildings and other infrastructure.

Soils: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Hotter, drier conditions likely to speed up decomposition of organic matter, including the oxidation of peat soils.
	Salinisation more common due to groundwater being drawn upwards and increased use of irrigation which causes the deposit of salts on the soil surface.
Drought	Reduction in moisture content of clay soils, increasing risk of cracking, subsidence and groundwater contamination.
	Loss of soil due to increased wind erosion.
Increased incidence of extreme weather events	Loss of soil due to increase in soil erosion.
	Impacts on land stability e.g. incidence of landslips, subsidence events and problems with drainage and flooding.
Sea level rise	Loss of valuable soils and habitats.

Policy and Practical Responses

Soils Strategy

We published The Soil Strategy for England, *Safeguarding our Soils*, in September 2009 which sets out an ambitious vision to tackle the degradation of soils in England within the next 20 years. Building the resilience of our soils to a changing climate is a key priority, so we are developing the evidence base on

the impact of climate change on soils and ensuring that farmers and other land managers have the information and guidance necessary to be able to secure the resilience of their soils.

Improving the Evidence Base

We are continuing our programme of research on climate change adaptation and soils in conjunction with delivery bodies (in particular the Environment Agency, Natural England and the Forestry Commission), the Devolved Administrations and other research organisations. To improve our understanding of the likely resilience of soils, we are using the latest Climate Projections to model the impact of climate change on soil threats. We have also commissioned new research projects which will report in the next year to explore the impacts of climate change on urban soils, soil biota and soil functionality and peat soils and habitats.

Peak District National Park Authority ©, Peat restoration in the Peak District

Advice and Good Practice

We already have a large range of soil management best practices documents such as *Protecting our Water, Soil and Air: A Code of Good Agricultural Practice* for all Farmers, Growers and Land Managers and Soil Protection Review 2010. A joint Defra, Business Innovation and Skills (BIS) and WRAP *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites* was published in September 2009. These should continue to be suitable in the future, although changes in climatic conditions will almost certainly prompt changes in how and where these are deployed. Similarly, if new crops are grown in the UK, we may need to develop new best practice techniques to deal with any degradation issues and risks to soil that they bring, which could include increases in greenhouse gas emissions.

➜ SOILS ACTIONS

11. In Spring 2010 Defra will publish the results of modelling to illustrate the impact of climate change on soil properties. This will provide the foundation for developing further research in this area over the course of 2010/11.

12. Defra will work closely with Communities and Local Government (CLG) and the Department for Business, Innovation and Skills (BIS) to ensure that planning authorities, developers and the construction industry have the information and tools they need to take account of the impacts of climate change on soils, both in decision making and during the construction process. This will involve developing a new practical toolkit for planners to help them take account of soils in their decision-making processes.

2.5 Trees, woods and forests

Climate change will have major impacts on woodlands and trees and on the forestry sector. These impacts will show large regional variation across England, with the North and West remaining highly productive. Without strategic adaptation responses the South and East are expected to be seriously affected towards the end of this century. The most significant impacts will be driven by changes in water availability.

The forestry sector has to plan ahead (fifty years or more). Adaptive measures need to be appropriate to both current and future climatic conditions, reflect the needs of biodiversity and timber production and maintain the services provided by woodlands to society (including wood product and woodfuel production for carbon abatement). This can all be achieved through drawing on the principles of multi-purpose forestry and sustainable forest management.

Trees, woods and forests: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Increased prevalence of existing and new pests and diseases.
	Potential risks to native biodiversity associated with introducing non-native tree species.
	Helping to reduce the urban heat island effect through both evaporative cooling and the provision of shade.
	Helping biodiversity to adapt to the impacts of climate change.
	Providing shelter and relief for livestock.
	Protecting freshwater habitats and fish populations from thermal stress.
	Increasing timber production where water is not limiting.
Drought	An increased frequency and severity of summer drought.
	By the end of the century, some native tree species are likely to lose 'climate space', particularly in southern England.
	Reduced timber production and changing suitability of individual tree species.
	Drought stress placing trees at increased risk from pest and disease outbreaks.
	Significant changes to the composition, structure and character of woodland ground flora.

Trees, woods and forests: risks, opportunities and impacts of climate change	
Drought (cont.)	Increased risk, extent and severity of forest and heathland fire.
Increased incidence of extreme weather events	Contribution to sustainable drainage systems.
	Reducing diffuse pollution and siltation of water courses by stabilising river banks.
	Stabilising soil, reducing the risk of landslips.
	Limiting wind-driven erosion and runoff of pollutants from contaminated sites.
	Woodland creation upstream of towns and cities to delay and reduce peak flood flows.

Policy and Practical Responses

Management Approaches

Over time, the character and composition of our native woodlands will alter as species ranges change and the competitive balance between species starts to shift. Adaptation strategies for woodland biodiversity will increasingly need to focus on habitats rather than the current species-based approach to nature conservation (see pages 45 to 48 on Biodiversity policy).

The distribution of many components of ancient and semi-natural woodland ecosystems will change, but the current view is that there is no need to intervene beyond existing good woodland management practice. However, there is evidence[8] that habitat quality is declining in a significant area of England's woodlands, limiting the capacity for those woodlands to adapt. New pests and diseases may establish and existing ones become more aggressive. These climate-driven risks are compounded by global trade.

8 Long term ecological change in British woodland (1971-2001) Available at: http://naturalengland.etraderstores.com/NaturalEnglandShop/R653

Monitoring and contingency planning to cover wildfire, windstorm and pest and disease outbreaks, is essential to allow for prompt action in adaptation strategies, as highlighted in the draft *Climate Change Guidelines* that underpin the *UK Forestry Standard*. Many uncertainties remain both about the future climate and the response of trees and woodland ecosystems to climate change. Increasing the range of tree species to improve resilience – at stand or landscape scale – currently represents the most appropriate adaptation response.

Ongoing activity includes:

- **the Delivery Plan for the Strategy for England's Trees, Woods and Forests[9]:** the Delivery Plan includes a broad range of actions to be delivered by woodland and forestry stakeholders across England.
- **UK Forestry Standard and Climate Change Guidelines[10]:** the UK Forestry Standard (UKFS) is currently being revised, including the drafting of new Forestry and Climate Change Guidelines that cover both mitigation and adaptation.
- **climate change action plan for the Public Forest estate:** the Forestry Commission is preparing a *Climate Change Action Plan for the Public Forest Estate in England*. The Plan benchmarks existing management practice and will initiate actions to enhance species diversity and genetic diversity of native species through appropriate provenance mixtures.

Pickering Beck North Yorkshire – "Slowing the Flow"

An example of floodplain creation © the Forestry Commission.

Pickering in North Yorkshire is a market town with a population of 7,000 and a long history of flooding, most recently in 1999, 2000, 2002 and 2007, largely due to intense summer rainfall. Defra have funded the Forestry Commission to lead a two year demonstration project in partnership with the Environment Agency, the North York Moors National Park Authority, Natural England and others on "soft-engineering" approaches to flood alleviation.

Woodland creation is increasingly seen as having a significant contribution to make to flood risk management, as well as delivering other environmental benefits including carbon sequestration and reducing soil erosion and diffuse water pollution. The focus of this project is on engaging with the local community and landowners to explore how changes can be made to the way the land is managed, with the aim of slowing water in the upper catchment, storing water in the middle section and improving conveyance through the town.

All measures will be implemented between now and March 2011. Grant-aid for 85 hectares of woodland creation is being targeted through the RDPE co-financed English Woodland Grant Scheme, supported by top-up payments provided by Yorkshire Forward's Regional Forestry and Flooding Initiative. This new woodland will create a physical barrier for floodwater, slowing the flow and creating temporary floodwater storage. It will reduce the risk of flooding in surrounding areas as well as producing wider environmental benefits.

9 Available at: http://www.defra.gov.uk/rural/forestry/strategy.htm
10 Available at: http://www.forestry.gov.uk/UKFS

- **the England Biodiversity Strategy (EBS)[11]:** the EBS workstream on climate change adaptation is working with the England Woodland Biodiversity Group to consider how climate change adaptation should be incorporated within woodland biodiversity delivery.
- **forestry and adaptation in the urban environment:** a recent assessment of trends in urban tree condition and cover, *Trees in Towns II*[12], highlighted the decline in 'large canopy trees' in the urban environment. The trend runs counter to the future needs of society as there is clear evidence of the role of trees in adapting the urban environment. This decline is being addressed through initiatives including the London Street Tree Programme; the development of guidance for integrating trees into green infrastructure; the Joint Mitigation Protocol, which asks developers to consider and compensate for loss of trees in construction projects and the development of the CAVAT system for valuing the services that urban trees provide. See pages 50 to 53 on Green infrastructure for Further detail.
- **integration of adaptation into Forestry Commission policy:** the Climate Change Strategy Group sets the Forestry Commission's high level position on how it will address the challenge of climate change and also commissioned *The Read Report*[13], which presents a coherent assessment of the contribution that UK woodlands can make to climate change adaptation and mitigation. The Forestry Commission commissioned approximately £10 million worth of research in 2008-09, and has increased the proportion devoted to climate change research over recent years.

➜ FORESTRY ACTIONS

13. We will prioritise and implement research recommendations outlined in the Read Report over the next five years.

14. We will develop a new quantitative measure of adaptation for trees and woodlands in both urban and rural landscapes.

15. By summer 2010, we will make a web-based resource on species choice and wider adaptation issues, available online.

16. In 2010, the Forestry Commission will provide training on climate change for all their public-facing staff, to assist understanding by woodland owners and managers and the general public.

17. The Forestry Commission will work with the UK Fire and Rescue Services, Communities and Local Government (CLG), Natural England and stakeholders to establish improved fire monitoring for forest and heathland fires and develop a risk assessment approach.

18. The Forestry Commission will complete a review of Grants and Regulations in the context of climate change in 2010 and feed into a wider review in 2011.

19. We will complete a climate change action plan for the public forest estate in 2010 and begin its implementation.

20. Climate Change Guidelines to support the revised UK Forestry Standard in 2010 and implement the adaptation measures included as requirements for grants will be published by the Forestry Commission and the Northern Ireland Forest Service.

21. We will work with key stakeholders to develop landscape approaches for adaptation through targeting grants for woodland creation.

22. The Forestry Commission, in conjunction with Defra, FERA and the Scottish and Welsh Governments, will work through its Forest Biosecurity Programme Board to revise the strategy for dealing with pests and diseases and develop a new biosecurity code of practice (see section on Plant Health above).

11 Available at: http://www.defra.gov.uk/environment/biodiversity/documents/biostrategy.pdf
12 Available at: http://www.communities.gov.uk/publications/planningandbuilding/treesintownsii
13 Available at: http://www.forestry.gov.uk/forestry/infd-7y4gn9

Adapting to climate change

3. The natural environment

It is increasingly recognised that our quality of life – from the 'liveability' of our communities to the stability of our economy – is dependent on healthy natural systems. This section brings together the linked areas of biodiversity, landscape and land use, green infrastructure, air quality and water availability and quality – under the broad heading of the Natural Environment; recognising that all areas of Defra's work are explicitly linked to this theme as the section above on Food, Farming and Forestry highlights. Healthy ecosystems are required to underpin sustainable adaptation strategies across all sectors and need to be addressed throughout our adaptive strategies. We know that, on key issues like access to clean water during hotter, drier summers or managing flood risk in the face of increased numbers of extreme weather events, we won't be able to respond effectively without a healthy natural environment.

In this context a range of key adaptation challenges may affect how we will manage competing pressures on land and sustain the vital ecosystem services on which we rely. These pressures include opportunities for expanding existing agricultural production, finding space for new bioenergy crops and woodlands, managing our water resources and providing for a growing population with aspirations for housing, space for outdoor recreation and other infrastructure. This issue is going to affect all sectors, and all places around the country, and there are real opportunities to get the most out of the land in our cities and the countryside that we must seize. We now understand more than ever before about how natural systems work over different land areas and the benefits they provide to us. We can use this knowledge in planning to meet the social, economic and environmental challenges posed by a changing climate.

Over the past year we have been conducting a project focusing on the implications of a changing climate for our vision of a healthy and resilient natural environment. This project has identified that the short-term impacts of climate change will be seen most clearly in natural

National Ecosystem Assessment

The UK National Ecosystem Assessment (NEA) is the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. Part of the Living With Environmental Change (LWEC) initiative the NEA is an inclusive process involving many government, academic, Non-Government Organisation (NGO) and private sector institutions. The NEA will create a compelling and easily understood explanation of the state and value of the UK's natural ecosystem services. It will be useful to institutions and individuals to raise awareness of the importance of ecosystems and the services they provide to society, as well as assisting in strengthening policy-making to ensure effective management in future.

Throughout 2009, the NEA has looked back 60 years to understand how our ecosystems and the services they provide have arrived at their current state and value. This year the assessment will look forward 50 years, developing scenarios for how those ecosystems may change in future, including how climate change is likely to affect them. It will then consider how society might respond to these changes to maintain and enhance the benefits, including adaptation benefits, that we all will continue to get from our natural environment in a changing climate.

The role of land management in helping society and the environment adapt

Appropriate land management can provide some of the most sustainable and cost-effective ways of helping to protect society from the effects of a changing climate, as well as benefiting agricultural production. For example:

- trees and other vegetation increase the sequestration and storage of carbon, thus helping to mitigate climate change; can provide shade and shelter for crops, buildings and livestock; can reduce runoff and soil erosion and slow the movement of floodwater; help to maintain water quality through shading and by filtering pollutants; support wild species including crop pollinators; as well as providing an alternative or additional crop to increase farm income and hedge bets against climate risks. Increasing woodland cover can also have recreation and cultural benefits.
- sustainable drainage systems – which include porous surfaces, infiltration trenches, filter drains, ponds and wetlands, and grass buffers – slow the flow of water and increase its infiltration into the soil. This can help to both capture and store water at wet times of year to reduce the risk of shortages during drier times, and reduce the risk of flood damage to areas downstream. It also benefits biodiversity.
- peat restoration, especially in upland blanket mires, helps maintain huge stores of carbon, and can help to improve water quality and supply and reduce flood risk in areas downstream. It also has significant benefits for the conservation of biodiversity, and helps to maintain a valued landscape that contributes to a well-developed and important tourist industry.

Measures such as these can be seen as providing essential 'green infrastructure' that will help buffer the country as a whole from the effects of climate change, in many cases at less cost and more effectively than would be achieved by technological alternatives. The multiple benefits from good land management, and the role of farmers and land managers in adaptation, will become increasingly important as the climate continues to change.

Land Use Foresight Project

In February 2010, Foresight published its report on the Future of Land Use. This highlights a number of pressures on England and the UK's land system and explores how these pressures could be handled to 2050. In particular, it explores the role a more strategic framework to land use could have in better aligning governance and incentives to maximise the value that can be gained from land. It makes particular reference to adaptation, highlighting the need to have settlement patterns that reflect the impacts of climate change, joined up habitats that allow wildlife to migrate domestically in response to changing conditions, and measures to deal with rising sea levels and adaptive agriculture. The Government is carefully considering the implications of this report for climate change adaptation.

systems and that healthy natural systems are required to underpin the adaptive capability of the economy and society. Working with key partners in the conservation sector and across the Defra network we will publish a discussion document designed to take a lead in setting out our vision of a whole systems approach to policy and delivery in this area.

3.1 Biodiversity

Biodiversity is important both for its intrinsic value and because of the key role it plays in providing the ecosystem services upon which we all ultimately depend and which form the foundation of our adaptive capacity. Changes in climate, together with increased levels of CO_2 and other greenhouse gases, have already had detectable impacts on species and ecosystems. At a global scale approximately 10% of species are projected to be at an increasingly high risk of extinction for every 1°C rise in global mean temperature.

In the short term, some of the more significant threats to biodiversity may result from unintended consequences of societal responses to climate change rather than the direct impacts themselves. Key sectors include the major land uses – agriculture and forestry; those responsible for planning, water and coastal management; and managers of major infrastructure investments. Well planned, sustainable strategies for adaptation and mitigation offer scope for enhancing biodiversity, whilst contributing to the protection of society's assets. However, where these issues are not thought through, some actions could limit the options

Biodiversity: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Shifts in abundance and range of individual species and a loss of 'space' for species and their characteristic habitat.
	Changes to the composition of plant and animal communities.
	Changes in the timings of seasonal events such as spring leaf growth, flowering, and breeding.
	A potential mismatch in the timing of important events such as breeding and food availability.
	Modified species behaviour e.g. bird migration or shifting habitat preferences of butterflies.
	Impacts on ecosystem function, such as the ability of habitats to sequester carbon due to changes in temperature and rainfall.
	Changes in the chemical environment, such as the levels of carbon or deposition of atmospheric nitrogen that may favour fast growing species at the expense of others.
Drought	Increased likelihood and impact of natural fires.
	Significant impacts on some species during very hot periods.

Biodiversity: risks, opportunities and impacts of climate change	
Sea level rise	Squeezing the available habitat for some species.

for safeguarding and enhancing biodiversity and risk reducing the capacity of the natural environment to provide a range of essential ecosystem services. The inevitability of climate-driven impacts on biodiversity and ecosystems means we need to adopt an increasingly dynamic approach to managing these systems and conserving our biodiversity. The challenge is to take timely action to minimise losses, facilitate change and take advantage of new opportunities.

Projecting Future Possible Impacts

MONARCH (Modelling Natural Resource Responses to Climate Change) was a seven-year programme designed to assess impacts of projected climate change on wildlife in Britain and Ireland. MONARCH modelled the potential for changes in the ranges of 120 species and undertook a more detailed analysis of 32 of those species. The UK Climate Impacts Programme's 2002 (UKCIP02) climate scenarios for the 2020s, 2050s and 2080s were used to project future potential climate space for each species. The findings indicated:

- of the 32 species modelled in detail, 15 are projected to gain substantial potential climate space and eight are projected to lose significant potential climate space.
- over 90% of the species modelled show a substantial change in climate space over the timescale, underlining the need for adaptation measures – to help species disperse and establish in new locations as the climate changes.
- any loss or shift in suitable climate space for British and Irish wildlife will be more severe unless greenhouse gas emissions are cut.

Policy and practical responses

Biodiversity Targets and Objectives

The EU has a target to halt the decline in biodiversity by 2010; at an international level, a global target exists to reduce the rate of biodiversity loss by 2010.[14] New targets at both the European and global level are expected to be negotiated in 2010, showing an ongoing commitment to biodiversity conservation and enhancement.

One of the key challenges we have to face is setting conservation targets and objectives for the future that are demanding but sufficiently flexible to cope with the unpredictable nature of climate change and society's response to it. Rather than taking an historical perspective our targets may need to focus more on managing habitat condition so that sites are better able to withstand stresses, encourage the movement of species and provide vital ecosystem services.

Biodiversity Adaptation Principles

Defra plays a key role in developing and disseminating information about the observed and projected impacts of climate change on biodiversity and ecosystems more widely. This evidence has been used to project potential effects in the future on selected species (see box to left on MONARCH). However, it is not realistic to extend this approach to all species and therefore a principles-based approach that enables us to deal with uncertainty is required. In December 2008, The England Biodiversity Group published the '*England Biodiversity Strategy Climate Change Adaptation Principles: conserving biodiversity in a changing climate*.[15] The principles are:

- take practical action now.
- maintain and increase ecological resilience.
- accommodate change.
- integrate action across all partners and sectors.
- develop knowledge and plan strategically.

The England Biodiversity Group climate change adaptation workstream is working to integrate climate change adaptation into conservation practice by 2011.

14 Available at:http://www.cbd.int/2010-target/
15 Available at: http://www.defra.gov.uk/environment/biodiversity/documents/ebs-ccap.pdf

In May 2007 Defra published *Conserving Biodiversity in a Changing Climate: guidance on building capacity to adapt*[16] on behalf of the UK Biodiversity Partnership. This guidance has been influential domestically and on the international stage.

Supporting Networks of Species and Habitats

We know that under climate change, sites that were designated for one set of species may no longer retain them either at all or at the previous levels of abundance, regardless of conservation effort. Iconic species or those that currently characterise a particular habitat may also change their distribution or frequency. In future, the emphasis is likely to be on improving and buffering the capacity of existing sites to cater for a wider range of species and to facilitate the movement of species. This implies providing structural variety, habitat mosaics and other ways of providing suitable microclimate or habitat 'stepping stones' between sites, rather than designating additional sites and de-designating others, on a species-by-species basis.

Taking a more strategic 'landscape scale' approach allows us to protect the best sites, ensure that they are connected to other similar sites and occur in a resilient patchwork of other habitats. Natural England has a number of projects under way, including developing resilience indicators for the natural environment. As part of the implementation of their new Notification Strategy on SSSIs, NE is actively considering how well the existing network of SSSIs will be able to respond dynamically to natural processes and the predicted effects of climate change.

To help us consider these challenges Defra has commissioned Professor Sir John Lawton to lead a review of England's wildlife and ecological network, including its links with our National Parks and its ability to adapt to climate change and other pressures. The review will examine evidence on the extent to which the collection of sites represents a coherent and resilient ecological network capable of adapting to the challenge of climate change and other pressures. It will also examine the evidence base to assess whether a more inter-connected network would

Lakenheath Fen – restoring habitat to support booming bitterns

Bittern wading in reedbed © Andy Hay (rspb-images.com)

Reedbed is a valuable wetland habitat for a wide range of species, and in the UK is under direct threat from the increased storminess and sea level rise associated with climate change. The bittern is a species of heron that depends on reedbed habitat in suitable condition. Once a common sight throughout the UK, the species became extinct here in 1886, but recolonised in the early 20th century, before dropping to a low of 11 booming males in 1997. At that time, the population of bitterns in the UK was highly restricted in range to just a few sites, predominantly on the Norfolk and Suffolk coast, where the freshwater sites are at increasing risk of saline incursion.

The RSPB and Natural England have developed a four point plan to support the adaptation of bittern and other reedbed species: **1. Audit & Restore** existing reedbed sites; **2. Create new reedbed** to compensate for anticipated losses at the coast; **3. Protect** the existing sites on the Suffolk coast in line with strategies for sustainable flood-risk management; **4. Manage** new and existing reedbeds to maintain the right mix of wet reed and open water.

The response is already encouraging. The RSPB's Lakenheath Fen reserve, a key new inland mosaic of wetland habitats re-created from an area of arable farmland, saw two booming bitterns in 2008. Across the UK that year, 75 booming males at 41 sites were recorded.

16 Available at: http://www.ukbap.org.uk/Library/BRIG/CBCCGuidance.pdf

be more effective today and in the future and, if so, how this could be delivered; making costed and prioritised recommendations on any measures that should be taken including how Government and other organisations can work together to deliver the recommended model. The review will report to Defra by end the of June 2010.

It is important that we advance the science in this area and take an adaptive management approach – meaning that we should be prepared to try interventions, monitor their success and adjust our actions according to the response.

Jon Bowers © Bee collecting pollen

➜ BIODIVERSITY ACTIONS

23. In 2010, Defra will publish a discussion document on the natural environment and adaptation. This will build on the work we have done with partners to consider the role of the natural environment in supporting adaptation; and the need for a whole systems approach to adaptation in this area.

24. Prof Sir John Lawton will conclude his group's review of England's wildlife and ecological network, including its links with our National Parks and its ability to adapt to climate change and other pressures. The review will make costed and prioritised recommendations on any measures that should be taken and will report to Defra by June 2010. We intend to respond to the report by end of 2010.

25. In 2010 Defra will encourage closer working between the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) to enhance synergies between climate change and biodiversity issues, particularly on ensuring delivery of biodiversity safeguards in finance mechanisms, and the incorporation of ecosystem-based approaches into adaptation strategies.

26. UK Biodiversity Action Plan (BAP) targets will be reviewed after the October 2010 conference of the Convention on Biological Diversity (CBD) in Nagoya, to update them where necessary and fully factor in climate change impacts.

27. By mid 2010 case studies of practical implementation of the England Biodiversity Strategy adaptation principles at a landscape scale will be published together with policy guidance and best practice notes. Defra will continue to work with partners to extend this best practice guidance.

28. By early 2011, a Defra funded research project will publish guidance on adaptation of biodiversity to climate change including the implications for protected sites, monitoring and setting of objectives, and contributions of Priority Habitats to mitigation of climate change. In parallel, Natural England initiated a project in 2009, which is considering how well the existing network of SSSIs will be able to respond to natural processes and climate change. It will be developed into a full regional review in 2011/12.

29. Natural England has committed £6m over three years concluding in 2011 to undertaking work at a landscape scale designed to support biodiversity to adapt to a changing climate focusing on wetlands such as the Great Fens.

30. In March 2009 Natural England published a detailed assessment of the impact of climate change on four "character areas" (Norfolk Broads, Dorset Downs, Shropshire Hills, Cumbria High Fells). The findings and lessons from these are now being implemented and the process will be rolled out to five new areas across the country, with results expected in 2010.

3.2 Landscapes

Our landscape has continually changed because of industrialisation, urbanisation, changing farming practices and an improved transport infrastructure. In the long term climate change, and the actions we take to mitigate and adapt to it, could significantly affect landscape by influencing the natural flora, fauna and farming practices that shape the land. Because of this combination of direct and indirect impacts, it is difficult to predict what will happen to our landscapes – the one or two degree temperature increases projected by 2050 could have a dramatic impact, particularly on some of our protected landscapes.

Landscapes: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Changes to the plant species that characterise a landscape, including AONBs.
	Changes to farming practices, crops and livestock.
	Loss of mature trees in the landscape.
	Increased likelihood and impact of natural fires.
	Increased visitor numbers and growth in visitor numbers.
Increased incidence of extreme weather events	Closure of footpaths and rights of way; increased maintenance costs of the rights of way network.
	Damage to historic buildings, caused by an increase in soil erosion.
	Falling visitor numbers in certain places and at certain times.
	Trees felled by storm.
Rising sea levels	Inundation and increased rate of coastal erosion leading to significant landscape change and land loss.

Policy and Practical Responses

Engagement

A key component of adaptation will be to aid people's understanding of the drivers of change and to manage their expectations of the nature of the future landscape. We will need to enable people to think about the opportunities as well as the threats. The management decisions we take in response to climate change will need to reflect a range of factors – important amongst these are the views of the communities of place and interest that value different aspects of our natural environment.

Landscape Character

Natural England's developing *Future Landscapes*[17] policy will help us to identify the likely impacts of climate change on landscape character to aid adaptation. Future landscapes should emerge as a result of planned interventions using a landscape character approach. It's not just about how land looks but maintaining and increasing the ecosystem services provided by particular landscapes. Natural England will develop a vision for future landscapes that will take account of change and challenge traditional approaches to landscape conservation.

Defra is co-funding Natural England's *Character and Quality of England's Landscapes* (CQuEL) Project. CQuEL will measure changes in landscape character and assess the quality of these places, as understood by the ecosystem service approach. The project will also, in part, fulfil the UK's commitment under the European Landscape Convention to monitor change in landscape character. The evidence from CQuEL will enable us to assess the changes in landscape character that are likely to occur as a result of climate change and how this may affect landscape quality, in terms of the ecosystem services these places provide. This should better inform all those who make decisions affecting landscape; in particular, the findings of CQuEL should help deliver better planning policies and aid development control.

17 Available at: http://www.naturalengland.org.uk/Images/futurelandscapes_tcm6-8638.pdf

By linking ecosystem service delivery to landscape character and landscape features, we will be better equipped to communicate the likely impacts of climate change to the public.

Flexibility in Policy and Practice

The Marine and Coastal Access Act 2009 includes provision for access to move with eroding coastlines. The Natural England audit showed that some 13% of existing public rights of way around the coast will be lost to erosion over the next 20 years. The new coastal trail will be able to adjust to respond to such situations as they arise. Some sections of coastline are eroding rapidly, year on year. It would often be impracticable for the trail to follow a fixed route in these places. The Marine and Coastal Access Act 2009 will allow us for the first time to identify relevant sections of trail – and the associated access rights – as automatically "rolling back" with any future erosion.

The National Parks

Defra funds National Park Authorities and the Broads Authority to manage the nine English National Parks and the Broads. Through the English National Parks Authorities Association (ENPAA), they have set out how the management of National Parks has a major contribution to make in mitigating the effects of climate change and adapting to the inevitable changes ahead[18].

Wooded valley with far reaching views.

➜ LANDSCAPES ACTIONS

31. In Spring 2010, the Government will publish its vision and priorities for the English National Parks and Broads which will highlight climate change as a key priority.

32. National Parks Authorities will report on the risks from climate change and how they plan to adapt under the Adaptation Reporting Power introduced by the Climate Change Act 2008, with the first reports due in 2010-2011.

33. With the ongoing funding provided by Defra, the National Park Authorities and the Broads Authority will:

- engage with residents and visitors on the future of our National Parks to ensure we all plan for the inevitable changes ahead and to promote understanding of the adaptation work planned and underway.
- protect and develop resilient habitat networks that allow natural environmental adaptation.
- maintain good public access across National Parks by repairing eroded footpaths and bridleways and flood-proofing bridges (ongoing).

34. Natural England's *Character and Quality of England's Landscapes* (CQuEL) Project will assess what changes in landscape character have and are likely to occur and how this affects landscape quality. Using this evidence we will develop landscape policies to help combat climate change and better communicate the likely impacts of climate change to the public.

3.3 Green infrastructure

Green Infrastructure is a strategically planned and delivered network of high quality green spaces and other environmental features. Well-designed and managed Green Infrastructure can deliver a wide range of environmental and quality of life benefits for local communities. Trees, parks and other green spaces, green roofs and walls and water – rivers and waterways, lakes

18 Climate Change Mitigation and Adaptation in National Parks ENPAA 2009

and ponds – can all help to cool urban areas, counter the urban heat island effect, and help to address urban flood risk. Green infrastructure can make the places we live in more resilient to the impacts of climate change. Green spaces play a key role in sustainable drainage systems. The rate of run-off for surfaces with trees and grass is estimated to be 10 to 20%, compared with 60 to 70% for 'hard' urban areas.[19]

Green Infrastructure: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Providing natural air conditioning in urban areas – a cooling effect of 1–2˚C.
	Providing cleaner air by filtering dust and harmful chemicals; roadside trees can trap up to 90% of traffic-related airborne dust particles.
	Changes in water availability will pose a threat to the viability of trees, grass and other green cover.
	Increased levels of pest and diseases pose a threat to trees and green space.
	Increases in algae blooms could affect canals and other standing water and reduce their capacity as providers of recreation and biodiversity.
	A trend of outdoor lifestyles, putting pressure on existing green spaces and increasing the demand for new green infrastructure.
Increased incidence of extreme weather events	Increased levels of damage to community woodlands and street trees.

Policy and Practical Responses

Delivering a "step change"

World Class Places[20] – the Government's strategy for improving the quality of place (May 2009) identified green infrastructure as one of the four elements of quality places. The report identified the need for a step-change in the provision of green infrastructure to help meet the challenges of climate change.

In *Grey to Green*[21], the Commission for Architecture and the Built Environment (CABE) has called for a shift in funding and skills to green our cities to help adapt to climate change and improve people's quality of life. Evidence from local authorities suggests they may lack the key skills to deliver effective green infrastructure. Other evidence highlights labour shortages of over 90% in the landscape architecture and urban design sectors. Adapting green infrastructure to the impacts of climate change will also need new skills in planning, design and management as well as more community involvement and empowerment.

Evidence and Guidance

The Department for Communities and Local Government (CLG) has lead responsibility for cities and regions, planning and urban green space and is considering how best to respond to increasing urban temperatures. Defra is supporting CLG in revising and consolidating the existing planning guidance on landscape, open space and biodiversity. This will recognise the increasing importance of green infrastructure and provide local authorities with clearer information on the role that it can play, particularly in terms of climate change mitigation and adaptation in both rural and urban areas.

19 Urban Green Space Task Force (2006) Green Spaces, Better Places – Final Report. Available at: http://www.communities.gov.uk/documents/communities/pdf/131015.pdf

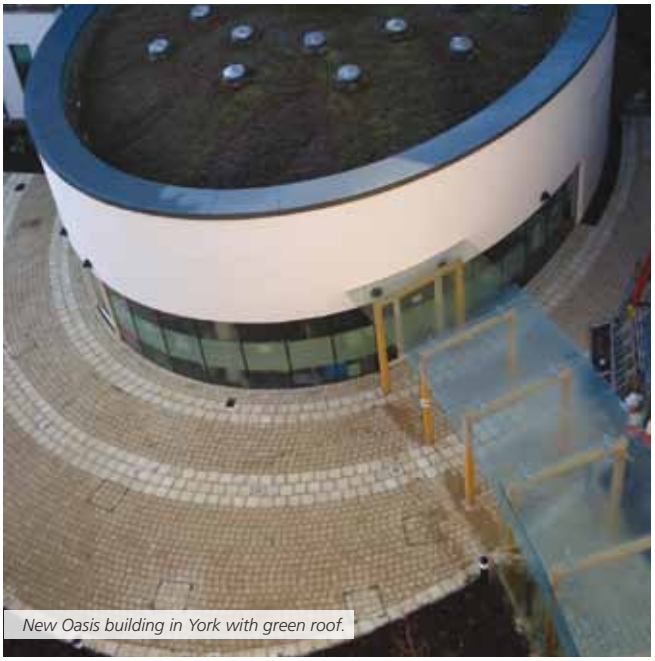
20 World class places: The Government's strategy for improving quality of place, HMG 2009 (available at:http://www.communities.gov.uk/publications/planningandbuilding/worldclassplaces)

21 Grey to green: How we shift funding and skills to green our cities, CABE, 2009. Available at: http://www.cabe.org.uk/grey-to-green

The Defra Network

Defra's delivery partners are actively engaged in promoting and providing green infrastructure throughout England. For example:

- the Forestry Commission is establishing an Urban Regeneration and Greenspace Partnership (URGP) to bring together a range of Government Departments and agencies, local authorities and community and environmental groups to work in partnership to create, manage and promote sustainable green infrastructure in towns and cities.
- Forestry Commission North-West is actively creating green infrastructure through the Newlands project[22].
- Natural England has produced green infrastructure guidance[23] to support frontline staff in their work with local authorities and green infrastructure partnerships. Natural England is working with developers to demonstrate the contribution that green infrastructure can make to urban regeneration[24].



New Oasis building in York with green roof.

East London Green Grid

Docks in east London © Peter Lovás (Dreamstime)

The Thames Gateway, one of the largest developments in Europe, involves large-scale housing development to the east of London. The Green Grid will help to regenerate areas including Barking and Lea Valley. The Green Grid initiative is developing a network of open spaces and river corridors, which will connect urban and residential areas of east London to the River Thames, the Green Belt and beyond. It will enhance existing wildlife sites on Sites of Special Scientific Interest (SSSIs), including Rainham and Walthamstow Marshes, as well as creating new wildlife habitats and improving biodiversity. It will improve the quality of life for residents by opening up the landscape to recreational and leisure uses as well as promoting healthy living.

The initiative is responding directly to the issues of climate change and environmental risks such as flooding and air pollution. An important element of the Green Grid project is improved management of water – reducing the risk of flooding, as well as water collection, storage and cleaning. The Green Grid initiative will help east London adapt to climate change and provide a beautiful, diverse and managed green infrastructure to be enjoyed by both people and wildlife.

22 Newlands website (available at: http://www.forestry.gov.uk/newlands)
23 Natural England's Green Infrastructure Guidance.
Available at: http://naturalengland.etraderstores.com/NaturalEnglandShop/Product.aspx?ProductID=cda68051-1381-452f-8e5b-8d7297783bbd
24 A Natural Development. Available at: http://www.naturalengland.org.uk/about_us/news/2009/031109.aspx

➜ GREEN INFRASTRUCTURE ACTIONS

35. Existing planning guidance on the natural environment will be revised and consolidated in 2010 as a new Planning Policy Statement. This will serve to minimise vulnerability of places, people, and wildlife to the impacts of climate change and contribute to effective climate change adaptation measures by maintaining, creating and improving networks of green infrastructure within both urban and rural areas.

36. Defra and CLG have jointly commissioned work to synthesise the available evidence on the benefits, costs and status of green infrastructure, which is due to be published by April 2010. This will help to show local authorities how green infrastructure can help to deliver local, regional and national policy objectives.

37. Defra will contribute to a new built environment project under the cross-Government ACC Programme, which has identified that the urban heat island effect is a key challenge that needs addressing. A priority for the project in 2010 will be to explore the policy levers and delivery options which can increase the level of green infrastructure in our towns and cities.

38. We are currently consulting on our proposed strategy for the inland waterways of England and Wales – *Waterways for Everyone*. This includes examples of how we believe the waterways can help us mitigate and adapt to the effects of climate change.

39. The Forestry Commission will publish guidance for planners to support the role of trees and woodlands in green infrastructure in 2010.

3.4 Air quality

It is well established that exposure to air pollutants has a detrimental impact on health. Air pollutants can also have wide-ranging environmental impacts, from localised effects including loss of biodiversity and reduced crop yields, to a potential contribution to future climate change.

Air quality in the UK and across the EU has improved significantly in the last two decades but annual health costs alone are still estimated at some £15 billion, and there remains evidence of environmental damage. Air pollutants of greatest concern in the UK now are particulate matter (PM), ground-level ozone (O_3) oxides of nitrogen (NO_x) and ammonia (NH_3). Ground level ozone (also a powerful greenhouse gas) has been shown to cause loss of EU arable crop production worth an estimated €6.7 billion in 2000[25].

Actions to reduce greenhouse gas emissions are likely to bring large-scale emissions reductions for other air quality pollutants as they often have similar sources. For example, action to decrease energy demand and, in the longer-term, to decarbonise the economy, is expected to lead to very large reductions in the emission of pollutants from key sources such as power generation and transport. Efforts are therefore focussed on getting the best outcomes from climate change mitigation. The public health and ecosystem benefits from that are expected to outweigh any negative effects arising from a changing climate, where there is emerging evidence of both positive and negative impacts.

Adaptation actions in other sectors may also affect air quality. For example, changes to forestry practices may impact on emissions of volatile organic compounds (VOCs). In addition, changes in socio-economic behaviour may result in altered patterns of emissions and people's exposure to air pollution. Currently these interactions are not well understood.

25 Royal Society, 2008. Ground level ozone in the 21st century: future trends, impacts and policy implications. Available at: http://royalsociety.org/Ground-level-ozone-in-the-21st-century-future-trends-impacts-and-policy-implications-/

Air Quality: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Hotter and sunnier weather, particularly in southern England, is likely to promote photochemical smog with high ozone concentrations and reduce the capacity of plants to take up ozone thereby increasing ambient concentrations.
	Changes in global emission patterns are already leading to a small but steady increase in hemispheric levels of ozone. A warmer climate could accelerate this process with implications for human health, ecosystems, and crops.
Increased incidence of extreme weather events	Pollutants may be washed out of the atmosphere more quickly which will reduce ambient air concentrations (and therefore health risks).
	However, it will increase deposition to land (and increase environmental damage).

Policy and practical responses

In March 2010, Defra and the Devolved Administrations published *Air pollution: Action in a Changing Climate*. This examines the links between air quality and climate change policies and sets out the short-term challenges and longer term opportunities for improving human health and the environment, looking ahead to 2050. In the short term, meeting outstanding air quality and emission reduction targets for PM10 and NO_2/NOx as soon as possible is a priority. As these pollutants are also ozone precursors this should help to reduce the incidence of summer smog during heat waves.

Complexities of atmospheric chemistry and climate modelling mean that there is much we have yet to understand about the impacts of a changing climate on UK air quality and the associated health and environmental costs. Improving our evidence base will be important in shaping future actions in relation to climate change adaptation.

➜ AIR QUALITY ACTIONS

40. In March 2010, Defra and the Devolved Administrations published *Air pollution: Action in a Changing Climate*.

41. By 2011, we will use the UK Climate Projections to carry out air quality modelling studies to evaluate the impacts of future climate on air pollutant concentrations.

42. Over the next 2 years we will carry out a review of the available evidence on how climate change will alter both social and environmental responses to air pollution to inform future research and policy development.

3.5 Water: availability and quality

Water is essential for life, and is a central issue influencing almost all the sections of this plan. Climate change, and other pressures such as demographic change, all mean that we need to find ways of using water much more efficiently and sustainably if we are to continue to enjoy high

standards and current levels of security of supply. Climate change is already a major pressure. With projections for the UK of rising temperatures, wetter winters, drier summers, more intense rainfall events and greater climate variability, we can expect to experience higher water demand, more widespread water stress with increased risk of drought, more water quality problems, as well as more extreme downpours with a higher risk of flooding.

For all these reasons, finding ways to use water more sustainably is essential from an adaptation perspective. But it also matters for our mitigation efforts. Water usage has a significant carbon footprint, due to the energy intensive processes we rely on to supply us with clean water. So using water more efficiently will help us cut emissions, as well as ensuring we adapt to the warming climate. Pages 122 to 124 explain what Defra is doing to cut emissions in the water sector.

In England, our public water supply systems take advantage of rainfall from October to March to replenish reservoirs and aquifers, with relatively little dependence on summer rainfall. However, climate change will affect the spatial and temporal distribution of rainfall in this country. Summer rainfall is expected to reduce, particularly in southern England, and less water may be available for abstraction, such as from rivers for irrigation. Climate projections suggest that winter rainfall will increase in some regions by as much as 30% by the 2080s, while rainfall intensity could increase. Recent work[26] by the Environment Agency suggests that the net effects of changing rainfall patterns could reduce river flows by 15% by the 2050s. These changes to the overall pattern of rainfall arising from climate change represent a major challenge to the water sector.

Water: risks, opportunities and impacts of climate change	
Drought	Less water for crop irrigation.
	Impacts on trees, grass and other green cover.
	Low flows on waterways affecting tourism.
	Increased stress for fragile habitats and species.
	Low flows in sewers increasing risk of blockage and premature operation of overflows, or surcharge and flooding when rainfall occurs.
	Possible restriction of supply for non-essential uses.
Increased incidence of extreme weather events	Increased surface water run-off affects water and soil quality: • Transporting pollutants from houses, roads and parks into sewers. • Removing nutrients and soil from agricultural land to watercourses.
	Overflowing sewers, washing foul sewerage into rivers, watercourses and the ocean.
Sea level rise	Saline intrusion affecting fresh water sources.

26 Reported in Water for People and the Environment, Environment Agency 2009 water resources strategy

Policy and practical responses

Future Water,[27] the Government's water strategy for England, set out how we want the water sector to look by 2030, and some of the steps we will need to take to get there. It is a vision where rivers, canals, lakes and seas have improved for people and wildlife, with benefits for angling, boating and other recreational activities, and where we continue to provide excellent quality drinking water. It is a vision of a sector that values and protects its water resources; that delivers water to customers through fair, affordable and cost-reflective charges; where flood risk is addressed with markedly greater understanding and use of good surface water management; and where the water industry has cut its greenhouse gas emissions.

The vision shows a sector that is resilient to climate change, with its likelihood of more frequent droughts as well as floods, and to population growth, with forward planning fully in tune with these adaptation challenges. To achieve this vision, our water requirements must be assessed over the long-term, as well-managed changes take time to put in place. In recent years, regular planning processes have been introduced, such as Water Resources Management Plans and River Basin Management Plans. The use of Sustainable Drainage Systems (SUDS), which manage surface water more effectively by replicating natural systems, is being encouraged. These processes provide mechanisms to embed adaptation into the way we manage water.

The new Adaptation Reporting Power established under the Climate Change Act 2008 allows Government to require public authorities and 'statutory undertakers' (including the economic regulator, Ofwat, and individual water companies) to report to Government on their assessment of current and future predicted impacts of climate change on their functions; their proposals and policies for adapting to climate change; and their assessment of their progress. The first reports are expected to be returned in 2011. The reports will be looked at by the Adapting to Climate Change Programme and water policy leads within Defra. This way, key risks, barriers to or gaps in adaptation will be picked up and will feed into the Government's National Adaptation Programme. The reports may also highlight areas for Government intervention.

Defra will continue to participate in the new Climate Change Water Resources Forum, with the EA, Met Office, Defra, Ofwat, WaterUK and UK Water Industry Research (UKWIR). This aims to identify the main strategic and policy challenges which climate change introduces to the management of water resources, and to identify, prioritise, and address the evidence gaps.

Managing demand for water

The Environment Agency's abstraction licensing regime is the primary mechanism for achieving sustainable management of water resources and avoiding excess claims on available water. We will be changing the scope of the licensing regime to bring all significant abstractions under control. This means that all sectors could have their allocations of water changed, if necessary, to respond to climate impacts.

Water Resource Management Plans (WRMPs) look ahead 25 years to secure a sustainable balance between supply and demand for water, taking account of the impact of climate change. These plans are reviewed annually and revised every five years. Ministers have agreed that 18 of the first cycle of WRMPs (covering the period from 2010 to 2035) can now be published by water companies in their final form. Further work by Defra and the Environment Agency on the impacts of climate change on rivers flows and groundwater will inform our guidance to the water industry for the next cycle of plans (from 2015 onwards).

Improving water efficiency

Climate change and a growing population mean that the way we currently use water is damaging our natural environment and is not sustainable. More efficient use of water is a key adaptation and mitigation issue:

27 Available at: http://www.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf

- leakage from the water supply system has reduced by around 37% since 1994-95 Government is working with water companies to increase operational efficiency.
- in 2008, the Government published its water strategy for England, *Future Water*, which set out a vision for water by 2030 and the framework for water management in England. *Future Water* outlined an ambition to reduce a person's average daily water consumption from 150 litres to 130 litres. Communities and Local Government (CLG) are introducing a new minimum water efficiency standard of 125 litres per person per day for all new homes from April 2010. New publicly-funded social housing is already being built to Code Level 3 which includes a water efficiency standard of 105 litres per person per day.
- an Act on CO_2 publicity campaign was launched in September 2009 to highlight the importance of saving water, and to provide tips to help households waste less water.
- metering can reduce average household water use by about 10%. Currently 37% of households in England and Wales have water meters. Under the Ofwat Price Review of water charges in 2009 (PR09), the rate of water metering for households in England and Wales is planned to increase to 50% by 2014-15. This will encourage improved water efficiency in the home. The Government is considering metering policy in light of the Walker review which was published in December 2009.
- Defra and Communities and Local Government (CLG) are working with the Department of Energy and Climate Change (DECC) to provide incentives for water and energy companies to work co-operatively with local authorities to retrofit existing homes with energy and water efficiency measures through schemes including CERT (the Carbon Emissions Reduction Target), CESP (Community Energy Saving Programme) and HEMS (Household and Energy Management Strategy). With cross-Whitehall support, CLG has also launched a series of "local carbon framework" pilots to explore how much more authorities can do to mitigate climate change.

Maintaining water quality

Climate change is a growing pressure which could have serious impacts for water quality: low flowing rivers will have reduced capacity to dilute pollutants, and extreme weather events capable of producing problems such as sudden surface water run-off which washes pollutants into rivers, watercourses and sewers will occur more frequently.

Lamb Drove – Sustainable Drainage Systems (SUDS)

An attenuation pond in Bicester
© Environment Agency

SUDS can help to slow the volume and flow of water in peak rainfall as well as improving the quality of water flowing to sewers and watercourses. SUDS can also tackle water scarcity by preventing surface water run-off simply flowing to sewers, instead enabling the water to attenuate and infiltrate.

Lamb Drove is a ground-breaking project which demonstrates sustainable water management techniques. Through the management of water and reducing the impact of urbanisation on flooding, Cambridge City Council and their partners have shown that Sustainable Drainage Systems (SUDS) are a practical alternative to traditional approaches.

Retro-fitting the Lamb Drove development site with SUDS and other flood proofing and water management measures, including swales, filter strips, wetland basins, green roofs, water butts and permeable paving has significantly reduced the impact of development on flooding and on new housing development. Additional benefits include improved water quality and the creation of new habitats in urban watercourses and open spaces.

The Water Framework Directive established a catchment-based approach to water management, which is now being implemented through River Basin Management Plans. The first of these plans, covering the period from 2010 to 2015, were published in December 2009. They will be updated every five years. The Environment Agency has carried out 'climate proofing' assessments to ensure that measures set out in the plans take account of the latest climate evidence.

£2.5 billion is being invested in the Thames Tideway Scheme, to reduce the level of untreated sewage overflowing from London's sewers into the River Thames and the River Lee. This will significantly boost the capacity of the sewerage system, so that it is better able to cope with changes in precipitation patterns and to protect water quality in the Thames for decades to come.

Future investment

Ofwat is the economic regulator for the water industry and has a key role to play in encouraging the regulated water and sewerage companies to adapt to climate change and share best practice across the sector. Ofwat published its "PR09" Price Review of water charges for the period 2010-15 on 26 November 2009. Investment levels for the water industry were set at £22 billion for the next five years, including £4.6 billion worth of investment to improve drinking water and the environment.

Adaptation had a high priority in PR09. Ofwat scrutinised all proposals to ensure the case for investment was backed by clear evidence. Significant adaptation investments were allowed; for example, to increase the resilience of water supplies to extreme weather events. Recognising that new evidence on climate change (such as from the UKCP09 projections) will emerge between Price Review periods, Ofwat has enabled companies through the change protocol process to come forward with proposals before the next price review in 2014 to fund investment to meet climate change impacts.

Agriculture

In general, climate change – in particular higher temperatures and drier summers – is likely to increase the demand for agricultural irrigation in the summer.

Broadland Agricultural Water Abstractors Group – Andrew Alston

Lake on farm – created for storage of water for use on farm

Water resources are already a big issue for farmers and land managers, and hotter, drier summers and a growing population will place greater pressure on supplies. Nearly a third of UK water catchments are already over-abstracted, and the Environment Agency predict that water demand could increase by 25% by 2020.

In 1997 a group of farmers in the East of England set up the Broadland Agricultural Water Abstractors Group after farmers felt growing pressure to protect water supplies. Andrew Alston, a local farmer and Chief Executive of the Group, says there used to be no support on water resources for farmers in the area. The Group were awarded the Environment Agency's Water Efficiency Award in 2007. Today the Group includes breweries, glasshouses, and processors amongst its 180 members, covering 22 water catchments and surrounded by 28 Broadland Sites of Special Scientific Interest. They work together to use their supplies efficiently, share knowledge and resources, while sub-groups target particular locations or issues. More efficient irrigation systems and five reservoirs are currently being developed.

However, changes to farming practice, crop type or variety, can reduce the demand for water from agriculture, and research and knowledge transfer can also help address water use.

Nearly £13 million a year is being invested in the England Catchment Sensitive Farming Delivery Initiative which provides farmers in priority areas with capital grants and tailored advice to develop more water-friendly farming practice and also establishes strategic partnerships, workshops and events to improve farmer awareness and reduce the impact of agriculture on the environment. Catchment Sensitive Farming techniques are increasingly recognised as an important way to deal with diffuse water pollution, soil protection, reductions in greenhouse gas emissions, flood management and pesticide control.

Defra is currently developing an inventory of methods and their effects on diffuse water pollution, greenhouse gas emissions and ammonia emissions from agriculture. This guidance will encourage improved environmental management practices on agricultural land to reduce the likelihood of pollutants being released into water courses and the loss of soils.

Rural Park – children kayaking.

➜ WATER AVAILABILITY AND QUALITY ACTIONS

43. The Flood and Water Management Bill, currently making its way through Parliament, will improve the process for temporary bans on water use during droughts, strengthen mandatory building standards for sewers, and make more robust arrangements for the approval, adoption and maintenance of SUDS.

44. Defra will consult on national standards for sustainable drainage systems (SUDS), and on SUDS regulations under the Floods and Water Management Bill, in 2010.

45. Private sewers and lateral drains connecting to the public network will be transferred into the ownership of water and sewerage companies in England from 2011. This will improve and better integrate the management of our domestic sewerage system.

46. Defra has recently consulted on new proposals to time limit existing abstraction licences, providing a further way to manage the impacts of climate change on catchment areas. A revised approach will be announced this year.

47. New research to improve our understanding of home owner perceptions, attitudes and behaviours towards adopting water related efficiency retrofitting measures in their properties will become available in 2010 to inform future policy- and decision-making.

48. The Government is considering metering policy as part of its wider consideration of recommendations from the independent Walker Review of Charging for Household Water and Sewerage Services (December 2009). Ministers are considering the recommendations ahead of a public consultation.

49. The Water Supply (Water Fittings) Regulations are being reviewed to explore the scope of setting new performance standards for key water-using fittings to complement whole house performance standards to be set in Building Regulations.

Adapting to climate change

4. Flooding and coastal erosion

Flooding and coastal erosion cause significant damage and disruption in England, as events in Cumbria in November 2009 showed. Across the country, around 5.2 million properties are currently at risk of flooding; climate change will increase both the level of risk and the damage it can cause. The Environment Agency estimates that investment in flood and coastal risk management assets needs to almost double by 2035 (not taking into account inflation) to maintain current levels of protection against river and sea flooding, due to a combination of deterioration of existing defences and the impacts of climate change (based on the "medium" emissions scenario in UKCP09).

Flooding: risks, opportunities and impacts of climate change	
Increased incidence of extreme weather events	Increased frequency and intensity of all types of flooding and coastal erosion.
	Risks to life and limb, critical infrastructure, the economy, the natural environment and health and wellbeing of individuals will increase.
	Not economically, technically or environmentally sustainable to maintain all our current defences in the future.

Flooding in Cockermouth, Cumbria (November 2009); 900 homes and businesses were inundated.

Coastal flooding in Newquay © Environment Agency

Policy and practical responses

Future Investment

Future investment is guided by Shoreline Management Plans (SMPs) and Catchment Flood Management Plans (CFMPs), which give an overview of the flood and erosion risk over a given area and consider how it should be managed over a period of up to 100 years.

The Environment Agency's Long Term Investment Strategy sets out the scale of investment needed in flood and coastal defences over the next 25 years, taking account of climate impacts. Spending on flood and coastal erosion risk management would need to increase from £570m in 2010-2011 to around £1 billion by 2035 to protect roughly the same number of properties that can be protected today from river and coastal flooding. However, the benefits of doing this outweigh the costs many times over. Private as well as public benefits are involved, and therefore we should not assume all costs should be met by central Government. Defra is working with the Environment Agency and HM Treasury to review how investments are prioritised and how costs might be shared in future, recognising that budgets beyond the current spending period have not yet been agreed.

Investments in flood and coastal erosion risk management may have a lifetime of 100 years, so it is vital when building and maintaining defences, or developing wider plans for managing flood and

Car stranded in floodwater – the cleanup from floods is expensive and takes time.

Action on flooding

Significant action has already been taken to protect communities from the risk of flooding:

- the Government has doubled its overall investment in flood and coastal erosion risk management in the last ten years to a record £2.15 billion over the current 3-year spending period.
- through the Environment Agency, 106 flood defence schemes have been delivered since the 2007 summer floods. These are protecting over 63,800 additional homes in England.
- a new £7.7m Flood Forecasting Centre, jointly run by the Environment Agency and the Met Office, is already providing important services to local authorities and emergency responders, helping them to be better prepared for potential flooding.
- Government is implementing all the recommendations of the Pitt Review to improve the management of flood and coastal erosion risk in England – the Floods and Water Management Bill is an important element of this.

erosion risk, to consider how they will cope in a changed climate. Defra has already issued guidance on this; for example, operating authorities are advised to allow for a 20% increase in peak river flows by 2080. Defra is reviewing the latest evidence to establish if this guidance needs to be updated.

New and alternative approaches to adapt to flood and coastal erosion risk

In the future, we need to make use of a wider range of approaches for managing the risks of flooding and coastal erosion. The Department is working to develop alternative approaches for adapting to flood and coastal erosion risk that work better with natural processes, are more cost effective and deliver multiple benefits. For example:

- a £5.5 million local authority grant scheme to fund property level defences (like flood boards) to householders at high risk of flooding where large scale defences are unlikely to be built in the near future. This scheme helped a number of properties in Appleby to avoid damage during the recent flooding in Cumbria.
- an £11 million Coastal Pathfinder Programme to road-test new and innovative approaches for adapting to coastal change. The lessons learned by the pathfinders will inform development of future policy and/or guidance.

Defra is working with the Environment Agency and other delivery bodies to ensure that the Government's investment in flood and erosion risk management contributes to wider objectives to sustain and improve the natural environment. For example: restoring wildlife rich wetlands and natural flood retention areas could reduce flood risk downstream; and restoring habitats such as woodland in catchments and improving land and soil management could reduce run-off and local flood damages as well as sustaining the capacity of land to support agriculture in the long term.

Wallasea Island, Essex

A Shelduck in flight © ukjesters (Dreamstime)

The "Wild Coast" project at Wallasea is restoring distinctive landscape and reducing long-term flood risks by returning arable farmland to salt marsh and recreating the transition zone that existed centuries ago between land and sea.

A process of "managed realignment" has allowed the tide back onto its old flood plain. The risk of flooding has been reduced and the newly created wetlands are providing opportunities for recreation and leisure, with a series of open spaces and 4km of footpaths. They also provide a habitat for brent geese, oystercatchers, grey plovers, dunlins, shelducks, curlews, avocets, little terns, and otters.

➜ FLOODS ACTIONS

50. Defra has an extensive joint research programme with the Environment Agency, including a number of current projects to inform policy on climate change adaptation: building on UKCP09 for example, making properties more resilient to flooding and understanding how the development of "blue corridors" could help make space for water in urban areas.

51. The Flood and Water Management Bill is currently before Parliament. This will put us in a better position to cope with the additional challenges posed by climate change, including through the creation of a new lead role for local authorities in tackling local flooding.

52. In 2010-11, Defra will continue to work with the Environment Agency and HM Treasury to review how investments in flood and coastal risk management are prioritised and how the costs might be shared in future.

53. Shoreline Management Plans outlining the management policies for each section of the coast and taking account of climate change will all be published by the end of 2011.

54. Defra will review latest scientific evidence and take a view as to whether further guidance is needed on allowing for climate change impacts when building and maintaining defences, or developing wider plans for managing flood and erosion risk. An announcement will be made later this year.

55. A new supplement to Planning Policy Statement 25 on coastal flooding will be published by CLG in 2010. Defra is working to support this process.

The Flood and Water Management Bill

The Flood and Water Management Bill aims to provide better, more sustainable management of flood risk for people, homes and businesses, help safeguard community groups from unaffordable rises in surface water drainage charges and protect water supplies to the consumer. The Bill currently before Parliament will put us in a better position to cope with the additional challenges posed by climate change:

- the Bill will implement Sir Michael Pitt's recommendations needing legislation following his review of the 2007 floods.
- responsibilities for managing all flood risks are clearly defined; Local Authorities will have responsibility for surface water flooding – the first time this has been assigned in law.
- local people will have greater input to shaping local flood and coastal erosion risk management strategies.
- sustainable drainage systems must be considered for new developments and re-developments to help prevent surface run-off overloading the sewer system.
- new powers will help water companies better control non-essential domestic uses of water during periods of water shortage.

Erosion defences © Environment Agency

Adapting to climate change

5. Oceans and seas

Seas and oceans cover around 70% of the Earth's surface. The ecosystem services they provide include gas regulation, nutrient cycling, food production, raw materials and recreation, and they are criss-crossed with infrastructure, much of which is critical to the national economy. Key pressures and potential implications for the UK marine environment include:

Climate change: likely impacts on oceans and seas	
Ocean acidification	Affects the ability of certain organisms to form shells and skeletons, which in turn could impact on food webs and ecosystems. This may have implications for aquaculture and commercial fisheries, although the social and economic impacts of ocean acidification are not yet well understood.
Increasing sea surface temperatures	Implications for marine ecosystems, with plankton and fish populations shifting distribution and some bird and marine mammal species having to adapt to changing prey. Also greater numbers of invasive species may become established, and perhaps more shellfish- borne pathogens and harmful algal blooms posing risks to human health. New opportunities might include fisheries or aquaculture for warm-water species, better conditions for tourism, and melting of Arctic sea ice may offer savings through shorter shipping routes.
Changes to ocean currents and circulation	Impacts on fish production. Invasive species could be carried into new areas.

Climate change: likely impacts on oceans and seas	
Changes in storm intensity	Increased or reduced storminess may have implications for infrastructure (such as ports, offshore wind turbines and oil and gas rigs) and coastal habitats. New opportunities might include enhanced conditions for offshore wind and wave-based power generation, however flash-flooding and intense precipitation events may lead to release of nutrients and contaminants with consequences for marine life and human health.
Relative sea-level rise	Potential increase in the frequency of extreme high-water level events, coastal erosion, flooding and inundation of aquifers and infrastructure. Sea level rise will be less severe in Scotland where the land is rising, compared to SE England which is subsiding.

Seal swimming in water at a seal sanctuary in Gweek Creek, Cornwall.

Policy and practical responses

We are already working with a range of organisations to improve our understanding of the impacts of climate change on the marine environment. Defra is one of several partners in the Marine Climate Change Impacts Partnership (MCCIP), which was set up to fulfil a recommendation in *Charting Progress: An Integrated Assessment of the State of the UK Seas*[28], which identified climate change and unsustainable fishing as the two main threats to our marine environment (and the benefits that we draw from it). The aim of MCCIP[29] is to provide a co-ordinating framework for the UK to transfer evidence on climate change impacts on the marine environment to policy advisors and decision makers.

We are also working with the Natural Environment Research Council (NERC) and DECC on the UK Ocean Acidification Programme, a 5 year £12m research programme launched last year that will improve our understanding of ocean acidification, its impacts on biodiversity and on the Whole Earth System including commercial fisheries.

28 Available at: www.defra.gov.uk/environment/marine/science/stateofsea.htm
29 www.mccip.org.uk

Lundy – Marine Conservation Zone

Jewel Anemones, Lundy © Sally Sharrock

Lundy is an island off the north Devon coast. Its surrounding waters became England's first Marine Conservation Zone (MCZ) on 12 January 2010, under the Marine and Coastal Access Act 2009. The healthy marine habitats of natural reefs, sandbanks and sea caves host a wide variety of wildlife including grey seals and many different species of coral.

The Marine and Coastal Access Act allows local byelaws to be put in place to protect the marine life within these MCZs from potentially damaging human activities. MCZs, which will include existing Marine Protected Areas, will aim to support the resilience of marine biodiversity against various pressures, including climate change. The provisions of the Marine and Coastal Access Act enable MCZs to be changed or moved, which will help us to respond if, for example, climate change alters species distribution. The potential impact of climate change on species distribution is currently being researched on behalf of Defra.

Defra provides support for the Cefas Coastal Temperature Network, a series of 39 coastal monitoring sites around England and Wales, some of which have been recording sea surface temperature continuously since the early 1900s. Defra, in association with the Met Office and Environment Agency, also support the Wavenet monitoring network of offshore buoys. These buoys provide near real-time information on incoming wave heights as well as sea temperature, that are used by flood managers, local authorities and stakeholders to assess flood risk and provide an early warning capability.

We are taking forward research to help us to understand what changing sea surface temperature and circulation might mean for the movement of species and for the new Marine Conservation Zones (MCZs) that will be established under the Marine and Coastal Access Act 2009. The Marine and Coastal Access Act 2009, the first of its kind anywhere in the World, introduced a single piece of legislation for the protection of the marine environment. Through a new marine planning system we are able to manage our environmental, social and economic needs together, and there will be a new ecologically coherent network of Marine Conservation Zones by 2012. The new Marine Management Organisation (MMO) will be a centre of marine expertise, as well as licensing authority for various activities.

➜ OCEANS AND SEAS ACTIONS

Adaptation action in the marine environment is still at a relatively early stage. In many areas, we are still working on improving our understanding of how climate change will affect UK and global seas. However, there are still actions that can be taken now to ensure that adaptation is built into longer term planning, to ensure other pressures on the marine environment are reduced so that it becomes more resilient to change, and to strengthen co-operation with stakeholders and the general public to prepare for change.

Defra is improving its evidence and understanding of climate change impacts and adaptation requirements by:

56. Commissioning research into new or emerging adaptation issues. In March 2009, a joint Natural Environment Research Council, Defra and DECC Ocean Acidification Research Programme, worth £12 million, was launched. The programme will run over 5 years, and outputs will support our work on adaptation.

57. Supporting the Marine Climate Change Impacts Partnership from 2010 to 2015.

58. Ensuring effective management and use of marine climate data through the Marine Science Coordination Committee, which published the first UK Marine Science Strategy in February 2010.

59. Ensuring that new domestic and EU strategies and guidelines take account of climate impacts for example, the UK Marine Planning Statement, which will be issued for consultation during 2010 and the Marine Management Organisation which will be preparing marine plans from 2011.

60. Developing a programme of measures designed to achieve or maintain good environmental status, which will be put into practice by 2016; ensuring that adaptation is factored into implementation of the Marine Strategy Framework Directive by 2015.

61. Introducing a network of Marine Protected Areas, including new Marine Conservation Zones in our own waters by 2012, which will improve resilience.

62. Seeking reform to the EU Common Fisheries Policy that will achieve sustainable fish stocks, reduce discards, and provide increased certainty and flexibility over access to fisheries for the industry. We expect the European Commission to submit a formal proposal to the European Parliament in early 2011 and will seek to ensure that adaptation is embedded in any reforms.

63. Publishing the findings of the Environmentally Responsible Fishing Scheme in 2010.

64. Supporting a pilot for 'climate smart' working in 2011, which will be co-ordinated by MCCIP, helping sectors and communities using the marine environment to adapt to climate change. The 2010 annual report card will draw on the UK Climate Projections 2009, helping us to build a better understanding of potential impacts on the marine environment.

Adapting to climate change

6. Sustainable consumption and production & waste

Defra's strategic objectives include a vision of *sustainable, low carbon and resource efficient patterns of consumption and production*. We are working towards an economy where products and services are designed, produced, used and disposed of in ways that minimise carbon emissions, waste and the use of non-renewable resource. Our approach is to work with business to improve their understanding of the impacts of the products and services they provide, and to reduce the use of all forms of natural resources in their production processes. As the climate changes, citizens' understanding of the links between resource use and climate change is likely to stimulate greater demand for 'greener' products, services and the skills to deliver them. This will provide economic opportunities across many sectors.

Defra leads for Government as champion of sustainable development (SD) to ensure it is delivered nationally, regionally and locally and sees sustainable development as the solution to many of the challenges identified in this plan. In many ways, adapting to climate change can be seen as a specific sub-section of sustainable development. The objective is to enable sustainable development in all areas of society, economy and environment, in the light of a particular risk to achieving that – the risk of a changing climate.

Defra's Adapting to Climate Change Programme contributes to our activity on sustainable development, and Defra's *Sustainable Development Action Plan*[30] contains a section on adapting to climate change which describes the relationship between these two areas and how the Adapting to Climate Change Programme is helping to deliver sustainable development principles.

Section 6.1 looks at the impacts of climate change on waste and waste management, in particular waste infrastructure.

30 Available at: http://www.defra.gov.uk/sustainable/defra/action-plan.htm

6.1 The waste sector

The impacts of climate change in the waste sector will vary depending on the characteristics of the waste management activity concerned. Landfill sites are likely to experience a distinct set of impacts. Other than landfill, the impacts are largely dependent on whether the waste management activity (e.g. recovering energy-from-waste, recycling, waste treatment and sorting) takes place in the open air or within a building. Climate change may also impact on the supporting waste collection systems and the composition, quantity and nature of waste arisings.

Based on research commissioned by the Environment Agency[31] the most important risks and impacts to waste and waste management relate to:

Bottle bank © WRAP

Waste: risks, opportunities and impacts of climate change	
Hotter, drier summers and warmer, wetter winters	Open air waste activities particularly affected by: • increased disease transmission, • increased nuisance from pests, odour and dust • increased bioaerosol release.
	At landfill sites: • reduced methane gas production • Impacts on gas management.
Wetter winters	Impacts on landfill site hydrology.
	Increased run-off and pollution from sites.
Increased incidence of extreme weather events	Impacts on the stability of land, particularly at landfill sites including: • reduced slope stability • increased risk of subterranean subsistance and heave.
	Impacts of flooding especially: • increased pollution of the environment and consequent impacts on human health • impacts on site infrastructure and waste collection.
Sea level rise	Flooding of coastal facilities.

Policy and practical responses

Defra is working closely with the EA, the Waste and Resources Action Programme (WRAP) and others to improve our understanding of the potential impacts of climate change and to ensure that advice on action to address these impacts is promulgated as part of our respective roles in engaging with the waste sector.

31 Potential Impacts of Climate Change on Waste Management (2003).
Available at: http://publications.environment-agency.gov.uk/pdf/SX1-042-TR-e-p.pdf?lang=_e
The impact of Climate Change on waste Regulation (2008) http://publications.environment-agency.gov.uk/pdf/SCHO0508BODA-e-e.pdf

Understanding the impacts of climate change

Our knowledge is not complete and climate change projections are improving all the time. We will keep under review the need to update our assessment of impacts on waste and waste management in light of:

- the most recent climate change projections (e.g. UKCP09).
- the continuing shift in waste management infrastructure away from landfills towards other types of waste management facilities (e.g. anaerobic digestion, energy-from-waste). These new technologies need to be resilient to climate change so our understanding of the impacts must account for the likely shape of the waste management sector in 20-30 years.

Ensuring the waste sector is resilient to climate change

Defra, the Environment Agency, WRAP and others are working to embed, where appropriate, messages on climate change adaptation within the range of guidance and regulatory and advisory services they collectively provide to the waste sector. This will help individuals and organisations involved in making decisions about how to manage waste at the local and regional level to account for the effect that climate change may have on their strategies, plans and waste management operations.

Examples of where climate change adaptation messages have already been successfully embedded include:

- the Planning Policy Statement on Climate Change (published by CLG in December 2007), underlines that tackling climate change should sit at the centre of all planning considerations. At the heart of the PPS is the principle of ensuring that the nature and location of development – which includes waste management facilities minimises vulnerability, and provides resilience, to the impacts of a changing climate.
- the Environment Agency is continuing to work with planning authorities and regional partners to ensure that local and regional plans such as regional strategies and municipal waste management strategies contain appropriate measures and strategies to adapt to a changing climate.
- Environment Agency staff, when undertaking their regulatory duties at waste management facilities, consider whether the facilities are resilient to the risks posed by climate change and provide advice and guidance as appropriate. To help inform their activities, the Environment Agency have, for example, developed a list of landfill sites that may be affected by coastal and river flooding.
- Defra, in partnership with the Commission for Architecture and the Built Environment (CABE), has produced guidance on the design of waste facilities: *Designing Waste Facilities, a key guide to modern design in waste*[32]. The guide contains best practice advice on climate change mitigation and adaptation, including how to make new waste infrastructure resilient to unavoidable climate change.

➜ WASTE ACTIONS

65. During 2010, Defra and the Environment Agency will review international approaches to the management of waste in countries that are already coping with vulnerability (e.g. flooding in the Netherlands) or are currently experiencing climatic conditions consistent with those that we anticipate for the UK in decades to come (e.g. US, Europe).

66. Defra is working with WRAP to identify how they can play a greater role in helping the waste sector adapt to climate change, for example, embedding adaptation messages within its advice to local authorities on household collections. We will ensure that WRAP's new remit is appropriately reflected within its corporate business plan for 2010/11.

67. Defra will consider how to embed adaptation in guidance on procurement, particularly in relation to waste infrastructure by September 2010. This includes making use of the proposed joint OGC/ ACC guide, due to be published in Spring 2010, on how to incorporate climate change adaptation within procurement decisions in the public sector.

32 Available at: http://www.defra.gov.uk/environment/waste/localauth/facilities.htm

Adapting to climate change

7. Embedding adaptation to climate change in Defra

Defra has a Departmental Strategic Objective (DSO1) which focuses the Department on delivering: *a society that is adapting to the effects of climate change, through a national programme of action and a contribution to international action.*

The national programme of action on adaptation in England is being taken forward by the Adapting to Climate Change Programme, which is a cross-Government programme led by Defra.

This DSO shapes the delivery of all of our departmental priorities (for example, our approach to flood defences) as well as the delivery of cross-government objectives.

Leadership

Climate change adaptation cuts across virtually all of Defra's policy responsibilities, including farming and food, animal and plant diseases, ecosystems, water management, floods, and conservation. Reflecting this, Defra places a high priority on effective senior-level involvement with adaptation issues.

The Department's Ministerial champion for adaptation is responsible for encouraging action and engagement within Defra and with stakeholders. In the next 12 months, the Ministerial champion will:

- meet key Non-Government Organisations (NGOs) and Defra delivery partners, for example by chairing meetings of the existing Adaptation Partnership Board which meets quarterly to bring in stakeholder perspectives on the ACC Programme.
- set out the importance of adaptation in terms of Defra's policy interests and how the Department is responding, at a number of events involving Defra stakeholders and other people and organisations that we need to influence.
- commission and scrutinise the results of an annual report on progress in implementing Defra's Adaptation Plan.
- speak at a staff event in Spring 2010, following the publication of Defra's Climate Change Plan, on the crucial importance of addressing climate change in order to meet our key Departmental objectives.
- with the Minister for the Natural Environment, launch a discussion document focused on the role of the natural environment in underpinning our adaptive capacity.
- chair at least one Ministerial-level meeting on adaptation to further encourage coherence and co-ordination of work across central Government.

Defra's Management Board carries out a quarterly review of the Department's DSOs, including DSO 1 on adaptation. The ACC Programme is also one of 12 priority Board Programmes for the Department which means that it is also scrutinised in greater detail by the Management Board. Ministers and the Management Board receive regular face-to-face briefings on climate issues – most recently in the context of publishing the Department's new Evidence Investment Strategy, which positions climate change as one of the three main policy and evidence challenges that the Department faces.

The Director of Climate Change Adaptation, Air Quality, Landscape, and Rural Affairs (CALR) is the Senior Responsible Owner (SRO) for the Adapting to Climate Change Programme and chairs the Adapting to Climate Change Programme Board, which brings together and co-ordinates action in partnership with all the main Government Departments. The CALR Director is also the "Senior Owner" for adaptation within Defra, providing leadership and ensuring a clear focus on identifying and responding to climate risks across the full range of Defra policy responsibilities and our estate. A standing Defra Adaptation Group, chaired by the SRO, brings together policy-makers at Director level to encourage engagement and action across the full range of issues that Defra is responsible for. The Group has played an important role in supporting the development of Defra's Departmental Adaptation Plan and will continue to monitor progress and maintain momentum.

Over the past year we have been conducting a project focusing on the implications of a changing climate for our vision of a healthy and resilient natural environment. This project has identified that the short term impacts of climate change will be seen most clearly in natural systems and that healthy natural systems are required to underpin the adaptive capability of the economy and society. Working with key partners in the conservation sector and across the Defra network we will publish a discussion document designed to take a lead in setting out our vision of a whole systems approach to policy and delivery in this area.

Adaptation is increasingly being embedded within Defra policy units. In many cases (such as the Farming for the Future Programme and all policy divisions contributing to the Natural Environment PSA) officials are now in place with specific responsibility for considering climate change impacts and how these may affect policy decisions or how such decisions can support effective adaptation. These officials have been closely involved in the development of Defra's Climate Change Plan and represent a growing community of understanding across the Department. We will continue to use this network as a valuable way to discuss the latest evidence on climate impacts, and to share information and best practice.

Building awareness and understanding

To support the successful launch of the UK Climate Projections 2009, the ACC Programme and the UK Climate Impacts Programme (UKCIP) held a major series of 'Projections in Practice' (PiP) events from May to December 2009. These events were attended by more than 150 Defra staff, who have also benefitted from attending UKCIP's classroom-based User Interface training to help them engage with the Projections at a practical level.

The Department makes full use of a range of internal communications tools to ensure that climate risks and the need for effective adaptation are maintained as 'here and now' and 'front of mind' issues for Defra staff. For example, at the launch of the latest UK Climate Projections:

- many of our staff attended presentations on the science and the future that we need to plan for by the Secretary of State and the Department's Chief Scientific Adviser.
- all staff received a tailored 'Defra Briefing' on the Projections, their significance, and the underlying science.
- most staff participated in the Department's summer 'Discuss Defra' briefings, which provided people with an opportunity to discuss the Projections in more detail in their policy and operational teams.

Articles and information on climate change feature regularly in the Department's 'Landscape' newsletter and on our internal website. Last autumn, as part of the preparations for Copenhagen, staff received briefings on the importance of adaptation as part of the global response to climate change.

As part of the process of developing Defra's Departmental Adaptation Plan, staff from the ACC Programme have sponsored or participated in a range of workshops and 'challenge sessions' with policy colleagues across the Department. This has helped further to raise the profile of adaptation in Defra. Work has also been done with key operational teams in Defra; for example, Defra's procurement team have provided opportunities to discuss adaptation with the Department's suppliers and other procurement partners through a standing Suppliers Forum.

Corporate processes

Defra is working to make sure that climate change adaptation is fully embedded in key appraisal and decision-making processes. Some progress has already been made, but we recognise that there is still much more to do.

To-date, progress has been achieved in the following areas:

- **investment appraisal:** work is being done to ensure that supplementary guidance on adaptation for the HM Treasury's *Green Book: Appraisal and evaluation in central government* (which was published alongside the launch of the Projections in June 2009) has a high profile and is being used to inform decision-making in Defra. In 2010, Defra will review take-up and impact of the guidance and take steps to ensure that usage is maintained.
- **procurement:** the ACC Programme is developing guidance setting out why and how climate change adaptation should be incorporated within public procurement, which will be published in 2010. Defra will set out a plan for implementing the guidance with the Department's central procurement team, so that climate change risks are increasingly built into our specific contractual arrangements with suppliers. Defra is also working with Buying Solutions (the national procurement partner for UK public services) to develop a new framework agreement for environmental services, which will provide Defra with quicker access to private sector expertise on climate change adaptation.
- **horizon-scanning:** Defra has a programme of futures analysis and horizon scanning. This is designed to analyse technological, environmental, economic and political trends which might present threats and opportunities to the Department and help to improve the evidence or to challenge the assumptions that underpin policy-making. Climate change is already one of the principal areas of attention for the Defra Evidence Programme, which provides the Department's centre of expertise on horizon scanning. Defra's animal health team also maintains a strong horizon scanning facility to assess disease threats to the UK, which can be influenced by climate factors.
- **risk management:** the Defra Management Board annually reviews the key concerns and themes emerging from the long-term horizon scanning programme. In addition, the Board carries out a formal, quarterly review of progress with DSOs, including delivery of DSO 1 (on climate change adaptation).

Again, a lot more needs to be done to ensure that climate risks are fully embedded within Defra's key decision-making processes. In 2010, the Department will set out a plan of action to strengthen the incorporation of climate change risks within core processes such as the Defra policy cycle, impact assessment, and business planning.

Evidence

The Department needs to be able to make sustainable adaptation decisions, at the right time to maximise the benefits and minimise the costs. To make these decisions and to be able to influence others we need good quality evidence. Defra's new Evidence and Innovation Strategy (January 2010) recognises climate change as one of the major interlinked evidence challenges facing the Department. It also stresses the growing challenge in providing more specific knowledge of climate drivers and impacts; in particular, to support long-term procurement, estates management and policy decisions.

Defra's total expenditure on research related to adaptation was approximately £9.2m in 2009-10. However, the evidence contributing to climate change is spread across the Department; for example, relevant research is partly funded under the ACC Programme (£6.8m of the 2009-10 total), but also through parts of the farming and water programmes and elsewhere. (Relevant research activity is highlighted and discussed as part of the coverage of individual policy areas elsewhere in this document.) The new Strategy recognises the need to foster better communication and coordination across current boundaries so that gaps can be plugged and synergies exploited.

Defra staff conservation volunteering.

Policy actions around the challenges of climate change, sustainable food supply, and protecting ecosystem services all rely on an interdisciplinary approach to gathering evidence. Social research is recognised as a critical part of this disciplinary mix as it is people upon whom these policy actions will both impact and rely – people as individuals, households, organisations, communities and society. Defra's Strategy commits the Department to enhancing social research capability in the period from 2010-13 and beyond.

Within the ACC Programme, a dedicated evidence team is in place to identify and prioritise the most pressing gaps in the existing knowledge base for addressing climate change adaptation. Defra is well placed to use the UK Climate Projections to assess the climate change adaptation needs of all Defra policy areas, including farming and food, animal and plant disease, water management, floods, and conservation. The Adaptation Evidence Team consists of natural scientists, social researchers, operational researchers and economists. It supports the ACC Programme and other policy and research programmes across the Department in producing robust responses to climate risks by synthesising and deploying evidence from a range of different sources and disciplines.

Key Defra delivery partners

The Environment Agency
Climate change is a corporate priority for the Environment Agency. All major delivery functions have undertaken a climate change risk assessment and considerable progress is being made. The Agency's Long Term Investment Strategy for Flood and Coastal Risk Management, which sets out the investment priorities for the next 25 years, is based on modelling using the UK Climate Change Projections 2009 (UKCP09). The Thames Estuary 2100 project has developed a tidal flood risk management plan to protect London from sea level rise, which is at the leading edge of adaptation policy. It is a strong example of how to implement the Green Book's Supplementary Guidance on Adaptation. The Agency has a Climate Change Training Programme being rolled out to all staff, with specific modules in development to increase knowledge and skills for particular roles, such as engineers, environment protection, flood risk, and water resources.

Natural England
Since its inception in October 2006 Natural England has placed sustainable adaptation at the heart of its operational policy, decision making and advice. In March 2009, Natural England published landscape scale climate change adaptation strategies for the Norfolk Broads, Cumbria High Fells, Shropshire Hills and Dorset Downs. The project has now been extended across England into five more study areas: London, South East Northumberland Coastal Plain, Humberhead Levels, Sherwood, and a regional scale study in the South East of England. Natural England also administers approximately £0.5 billion a year of agri-environment monies and has integrated climate change considerations into Environmental Stewardship schemes so that adaptation is increasingly well delivered by private land managers and landowners. Natural England is working to develop a coordinated embedding programme to assess threats and opportunities from climate change across all its areas of work, and to identify opportunities to contribute to wider adaptation and mitigation goals.

Forestry Commission
The Forestry Commission has already established a comprehensive climate change research programme (largely undertaken by its research Agency, Forest Research) and a climate change communications initiative. The Forestry Commission has also set up a new Centre on Forests and Climate Change to study the effects of environmental and climate change on forestry, and how the sector can play its part in adaptation and mitigation of climate change. Key adaptation objectives for the Forestry Commission are: to increase the resilience of trees, woods and forests to climate change; to increase the role of trees and woodland in adapting the rural landscape to climate change; to enhance the role of street trees and urban woodland in minimising the impacts of climate change on our towns and cities; and, to use trees, woods and forests to help communicate and improve understanding of climate change issues and bring about behavioural change.

Partnership working

Close working with a range of delivery partners, other Government Departments, local and regional government, and NGOs is essential for Defra to achieve its key climate adaptation goals.

The Climate Change Act 2008 gives the Secretary of State a power to direct certain organisations to produce reports on how they are adapting to climate change. The Environment Agency is one of around 90 organisations which has been issued with a direction and will be submitting its adaptation report in September 2010. A number of other Defra delivery partners have also been invited to report voluntarily. These include: the National Park Authorities and the Broads Authority; Natural England; the Forestry Commission; and British Waterways. Each of these organisations has expressed its willingness to be

involved. For example, Natural England have agreed to be amongst the first to report, by the end of September 2010. Its report will provide an excellent example of how climate risks to the natural environment might be managed. The National Park Authorities have agreed that they will embed adaptation into their long term National Park Management Plans and aim to be exemplars of landscape scale adaptation.

Scrutiny

There are a number of mechanisms that will ensure continued scrutiny and constructive challenge of Defra's adaptation planning:

- the independent Adaptation Sub-Committee of the Committee on Climate Change intends to review a strategic selection of Departmental Adaptation Plans post-publication.
- the progress made by Defra and other Departments to improve the preparedness of their estates to the impacts of climate change will be monitored formally through the new framework for sustainable development in Government. Reporting against this target is expected to begin in 2011-12.
- by end-March 2011, Defra will carry out a full review of progress in implementing its Adaptation Plan. Key findings will be reported on the Department's website. To ensure that the review is as objective and meaningful as possible, we will consider the possibility of involving Defra's Internal Audit team to support or lead this process.
- through the Department's formal DSO reporting framework and priority Board reporting, the Management Board will continue to receive quarterly updates on how effectively Defra is adapting.
- Defra's Sustainable Development Action Plan (SDAP) includes important commitments by March 2011 to develop a more resilient Departmental estate and to further develop and encourage the use of 'sustainable adaptation' as a key principle, both internally and at all levels across Government. The Department's progress in meeting these commitments will be audited by the Sustainable Development Commission as part of its normal watchdog function.

➜ CAPACITY BUILDING ACTIONS

68. In 2010 Defra will appoint a new Ministerial Champion for adaptation responsible for encouraging action and engagement within Defra and amongst our stakeholders.

69. Lead officials for adaptation have been identified across Defra's policy areas. In 2010 we will establish a new information sharing network to exchange evidence and best practice approaches.

70. In 2010 Defra will set out a plan of action to incorporate climate change risks within core processes such as the Defra policy cycle, impact assessment and business planning processes.

71. By the end of March 2011 Defra will carry out a full review of progress in implementing its adaptation plan. Key findings will be published on the Defra website.

Adapting to climate change

8. Summary of actions

Food, Farming and Land Management

The Global Food Chain

The UK enjoys a relatively high level of food security today, but we cannot be complacent. We need a better understanding of the impacts of climate change.

1.	Defra and DfID are jointly sponsoring a Foresight study on Global Food and Farming Futures, which will include consideration of key climate impacts on the global food system out to 2050. An action plan will be published, along with a detailed final report in Autumn 2010. We will review progress in 2011.
2.	Defra will make further information available through the UK Food Security Assessment, and review risks as new evidence becomes available. We will actively monitor the climate risks to harvests and the potential for more volatility in supplies and prices, as well as new animal disease and food safety risks.
3.	The Government will continue to work with the food industry to promote business continuity planning and resilience to flooding and other climate threats. Major food retailers and trade associations have been invited to report to Government in 2011 on key climate risks affecting their operations and the steps they are taking to address them (under the statutory Adaptation Reporting Power).

Agriculture

It is in farmers' own best interests to adapt in order to strengthen resilience, seize opportunities and maintain a competitive industry. The first steps to adapt are likely to be small, allowing us to build resilience gradually; benefitting from lower costs and less disruption in the long run.

4.	During 2010, Defra will build on existing project work with NE, EA and the Forestry Commission on priority adaptation measures for agriculture through further analysis of barriers to action, costs and benefits, and identification of research priorities and gaps.

5.	During 2010 Defra will work with industry partners to explore the potential to support and encourage further voluntary adaptation action by farmers, including by enhancing existing advice and guidance arrangements.
6.	From spring 2010, 15 new or revised options are available under Environmental Stewardship that can help farmers to adapt to a changing climate. These include options that provide landscape benefits, make farming businesses more resilient, and that will enable habitats and species to adapt.
7.	Protection and enhancement of the rural environment should have a central, rather than a peripheral role under a future Common Agricultural Policy (CAP). In ensuring that the CAP is used in future to deliver public goods of European relevance, we will work to ensure that the strategic importance of climate change is adequately reflected in rural development and agri-environment policy.

Plant Health and Animal Health and Welfare

Climate change is likely to have impacts for both plant health and for animal health and welfare. A significant body of research already exists and we need to identify and prioritise our evidence needs and build on what has already been done.

8.	Defra will review existing research and evidence on the likely impacts of climate change on animal health and welfare during 2010; and meet with key stakeholders to raise awareness and discuss the issues. We will use this information to identify and prioritise any evidence gaps to address in 2011/12.
9.	Defra provides match funding for the Pratique Project – an EU-wide initiative co-ordinated by the Food and Environment Research Agency (FERA), which is developing new Pest Risk Assessment tools and techniques which will help us assess risks to plant health in a changing environment. The project, which benefits from £50K of Defra funding is due to report in June 2011.
10.	Defra and the Forestry Commission will support an increased research effort into ways to deal with a number of new and emerging pests and diseases impacting on trees and associated ecosystems. We will work closely with key stakeholders in affected areas to address the threats from a number of recently established pests and diseases.

Soils

We are developing the evidence base on the impact of climate change on soils and ensuring that farmers and other land managers have the information and guidance necessary to be able to secure the resilience of their soils.

11.	In Spring 2010 Defra will publish the results of modelling to illustrate the impact of climate change on soil properties. This will provide the foundation for developing further research in this area over the course of 2010/11.
12.	Defra will work closely with Communities and Local Government (CLG) and the Department for Business, Innovation and Skills (BIS) to ensure that planning authorities, developers and the construction industry have the information and tools they need to take account of the impacts of climate change on soils, both in decision making and during the construction process. This will involve developing a new practical toolkit for planners to help them take account of soils in their decision-making processes.

Forestry	
The forestry sector has to plan ahead (fifty years or more). Adaptive measures need to be appropriate to both current and future climatic conditions so detailed planning and capacity building is required now. The Forestry Commission and Defra will work in partnership in order to build adaptive capacity and implement adaptive actions.	
13.	We will prioritise and implement research recommendations outlined in the Read Report over the next 5 years.
14.	We will develop a new quantitative measure of adaptation for trees and woodlands in both urban and rural landscapes.
15.	By summer 2010 we will make a web-based resource on species choice and wider adaptation issues, available online.
16.	In 2010 the Forestry Commission will provide training on climate change for all their public-facing staff, to assist understanding by woodland owners and managers and the general public.
17.	The Forestry Commission will work with the UK Fire and Rescue Services, Communities and Local Government (CLG), Natural England and stakeholders to establish improved fire monitoring for forest and heathland fires and develop a risk assessment approach.
18.	The Forestry Commission will complete a review of Grants and Regulations in the context of climate change in 2010 and feed into a wider review in 2011.
19.	We will complete a climate change action plan for the public forest estate in 2010 and begin its implementation.
20.	Climate Change Guidelines to support the revised UK Forestry Standard in 2010 and implement the adaptation measures included as requirements for grants will be published by the Forestry Commission and the Northern Ireland Forest Service.
21.	We will work with key stakeholders to develop landscape approaches for adaptation through targeting grants for woodland creation.
22.	The Forestry Commission, in conjunction with Defra, FERA and the Scottish and Welsh Governments, will work through its Forest Biosecurity Programme Board to revise the strategy for dealing with pests and diseases and develop a new biosecurity code of practice.

The Natural Environment

Our natural environment is our greatest asset: the basis on which we can build a future in a rapidly changing climate. Ecosystems provide the services that clean our air and water, and give us food, medicines, energy, and raw materials. They regenerate soils and pollinate crops, regulate the climate, cool cities, and help to control floods.

Biodiversity

Changes in climate have already had a detectable impact on species and ecosystems, we need to build flexibility into both policy and practice.

23.	In 2010, Defra will publish a discussion document on the natural environment and adaptation. This will build on the work we have done with partners to consider the role of the natural environment in supporting adaptation; and the need for a whole systems approach to adaptation in this area.
24.	Prof Sir John Lawton will conclude his group's review of England's wildlife and ecological network, including its links with our National Parks and its ability to adapt to climate change and other pressures. The review will make costed and prioritised recommendations on any measures that should be taken and will report to Defra by June 2010. We intend to respond to the report by end of 2010.
25.	In 2010 Defra will encourage closer working between the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) to enhance synergies between climate change and biodiversity issues, particularly on ensuring delivery of biodiversity safeguards in finance mechanisms, and the incorporation of ecosystem-based approaches into adaptation strategies.
26.	UK Biodiversity Action Plan (BAP) targets will be reviewed after the October 2010 conference of the Convention on Biological Diversity (CBD) in Nagoya, to update them where necessary and fully factor in climate change impacts.
27.	By mid 2010 case studies of practical implementation of the England Biodiversity Strategy adaptation principles at a landscape scale will be published together with policy guidance and best practice notes. Defra will continue to work with partners to extend this best practice guidance.
28.	By early 2011, a Defra funded research project will publish guidance on adaptation of biodiversity to climate change including the implications for protected sites, monitoring and setting of objectives, and contributions of Priority Habitats to mitigation of climate change. In parallel, Natural England initiated a project in 2009, which is considering how well the existing network of SSSIs will be able to respond to natural processes and climate change. It will be developed into a full regional review in 2011/12.
29.	Natural England has committed £6m over three years concluding in 2011 to undertake work at a landscape scale designed to support biodiversity to adapt to a changing climate focusing on wetlands such as the Great Fens.

30.	In March 2009 Natural England published a detailed assessment of the impact of climate change on four "character areas" (Norfolk Broads, Dorset Downs, Shropshire Hills, Cumbria High Fells). The findings and lessons from these are now being implemented and the process will be rolled out to five new areas across the country, with results expected in 2010.
Landscapes	
A key component of adaptation will be to aid people's understanding of the drivers of change and to manage their expectations of the nature of the future landscape.	
31.	In Spring 2010 the Government will publish its vision and priorities for the English National Parks and Broads which will highlight climate change as a key priority.
32.	National Parks Authorities will report on the risks from climate change and how they plan to adapt under the Adaptation Reporting Power introduced by the Climate Change Act 2008, with the first reports due in 2010-2011.
33.	With the ongoing funding provided by Defra, the National Park Authorities and the Broads Authority will: • engage with residents and visitors on the future of our National Parks to ensure we all plan for the inevitable changes ahead and to promote understanding of the adaptation work planned and underway; • protect and develop resilient habitat networks that allow natural environmental adaptation; • maintain good public access across National Parks by repairing eroded footpaths and bridleways and flood-proofing bridges (ongoing).
34.	Natural England's *Character and Quality of England's Landscapes* (CQuEL) Project will assess what changes in landscape character have and are likely to occur and how this affects landscape quality. Using this evidence we will develop landscape policies to help combat climate change and better communicate the likely impacts of climate change to the public.
Green Infrastructure	
Green infrastructure can make the places we live in more resilient to the impacts of climate change. We need to work with partners across Government to embed awareness of its potential and influence future policy and delivery.	
35.	Existing planning guidance on the natural environment will be revised and consolidated in 2010 as a new Planning Policy Statement. This will serve to minimise vulnerability of places, people, and wildlife to the impacts of climate change and contribute to effective climate change adaptation measures by maintaining, creating and improving networks of green infrastructure within both urban and rural areas.
36.	Defra and CLG have jointly commissioned work to synthesise the available evidence on the benefits, costs and status of green infrastructure, which is due to be published by April 2010. This will help to show local authorities how green infrastructure can help to deliver local, regional and national policy objectives.

37.	Defra will contribute to a new built environment project under the cross-Government ACC Programme, which has identified that the urban heat island is a key challenge that needs addressing. A priority for the project in 2010 will be to explore the policy levers and delivery options which can increase the level of green infrastructure in our towns and cities.
38.	We are currently consulting on our proposed strategy for the inland waterways of England and Wales – *Waterways for Everyone*. This includes examples of how we believe the waterways can help us mitigate and adapt to the effects of climate change.
39.	The Forestry Commission will publish guidance for planners to support the role of trees and woodlands in green infrastructure in 2010.

Air quality

Complexities of atmospheric chemistry and climate modelling mean improving our evidence base will be important in shaping future actions in relation to climate change adaptation 39

40.	In March 2010, Defra and the Devolved Administrations published *Air pollution: Action in a Changing Climate*.
41.	By 2011, we will use the UK Climate Projections to carry out air quality modelling studies to evaluate the impacts of future climate on air pollutant concentrations.
42.	Over the next 2 years we will carry out a review of the available evidence on how climate change will alter both social and environmental responses to air pollution to inform future research and policy development.

Water Availability and Quality

Water is essential for life, and is a central issue influencing all sections of this plan. We need to find ways of using water much more efficiently and sustainably if we are to continue to enjoy high standards and constant supply.

43.	the Flood and Water Management Bill, currently making its way through Parliament, will improve the process for temporary bans on water use during droughts, strengthen mandatory building standards for sewers, and make more robust arrangements for the approval, adoption and maintenance of SUDS.
44.	Defra will consult on national standards for sustainable drainage systems (SUDS), and on SUDS regulations under the Floods and Water Management Bill, in 2010.
45.	Private sewers and lateral drains connecting to the public network will be transferred into the ownership of water and sewerage companies in England from 2011. This will improve and better integrate the management of our domestic sewerage system.
46.	Defra has recently consulted on new proposals to time limit existing abstraction licences, providing a further way to manage the impacts of climate change on catchment areas. A revised approach will be announced this year.

47.	New research to improve our understanding of home owner perceptions, attitudes and behaviours towards adopting water related efficiency retrofitting measures in their properties will become available in 2010 to inform future policy- and decision-making.
48.	The Government is considering metering policy as part of its wider consideration of recommendations from the independent Walker Review of Charging for Household Water and Sewerage Services (December 2009). Ministers are considering the recommendations ahead of a public consultation.
49.	The Water Supply (Water Fittings) Regulations are being reviewed to explore the scope of setting new performance standards for key water-using fittings to complement whole house performance standards to be set in Building Regulations.

Floods

Climate change is set to increase the frequency and severity of flooding and coastal erosion, and it is vital that we prepare for the impacts of climate change in the way we manage the risks.

50.	Defra has an extensive joint research programme with the Environment Agency, including a number of current projects to inform policy on climate change adaptation: building on UKCP09 for example, making properties more resilient to flooding and understanding how the development of "blue corridors" could help make space for water in urban areas.
51.	The Flood and Water Management Bill is currently before Parliament. This will put us in a better position to cope with the additional challenges posed by climate change, including through the creation of a new lead role for local authorities in tackling local flooding.
52.	In 2010-11, Defra will continue to work with the Environment Agency and HM Treasury to review how investments in flood and coastal risk management are prioritised and how the costs might be shared in future.
53.	Shoreline Management Plans outlining the management policies for each section of the coast and taking account of climate change will all be published by the end of 2011.
54.	Defra will review latest scientific evidence and take a view as to whether further guidance is needed on allowing for climate change impacts when building and maintaining defences, or developing wider plans for managing flood and erosion risk. An announcement will be made later this year.
55.	A new supplement to Planning Policy Statement 25 on coastal flooding will be published by CLG in 2010. Defra is working to support this process.

Oceans and seas

Whilst the main focus is on improving our understanding of how climate change will affect UK and global seas there are actions that can be taken now to ensure that adaptation is built into longer term planning, to ensure other pressures on the marine environment are reduced so that it becomes more resilient to change, and to strengthen cooperation with stakeholders and the general public to prepare for change.

56.	Commissioning research into new or emerging adaptation issues. In March 2009, a joint Natural Environment Research Council, Defra and DECC Ocean Acidification Research Programme, worth £12 million, was launched. The programme will run over 5 years, and outputs will support our work on adaptation.
57.	Supporting the Marine Climate Change Impacts Partnership from 2010 to 2015.
58.	Ensuring effective management and use of marine climate data through the Marine Science Coordination Committee, which published the first UK Marine Science Strategy in February 2010.
59.	Ensuring that new domestic and EU strategies and guidelines take account of climate impacts for example, the UK Marine Planning Statement, which will be issued for consultation during 2010 and the Marine Management Organisation which will be preparing marine plans from 2011.
60.	Developing a programme of measures designed to achieve or maintain good environmental status, which will be put into practice by 2016; ensuring that adaptation is factored into implementation of the Marine Strategy Framework Directive by 2015.
61.	Introducing a network of Marine Protected Areas, including new Marine Conservation Zones in our own waters by 2012, which will improve resilience.
62.	Seeking reform to the EU Common Fisheries Policy that will achieve sustainable fish stocks, reduce discards, and provide increased certainty and flexibility over access to fisheries for the industry. We expect the European Commission to submit a formal proposal to the European Parliament in early 2011 and will seek to ensure that adaptation is embedded in any reforms.
63.	Publishing the findings of the Environmentally Responsible Fishing Scheme in 2010.
64.	Supporting a pilot for 'climate smart' working in 2011, which will be co-ordinated by MCCIP, helping sectors and communities using the marine environment to adapt to climate change. The 2010 annual report card will draw on the UK Climate Protections 2009, helping us to build a better understanding of potential impacts on the marine environment.

Waste	
We are working towards an economy where products and services are designed, produced, used and disposed of in ways that minimise carbon emissions, waste and the use of non-renewable resource.	
65.	During 2010, Defra and the Environment Agency will review international approaches to the management of waste in countries that are already coping with vulnerability (e.g. flooding in the Netherlands) or are currently experiencing climatic conditions consistent with those that we anticipate for the UK in decades to come (e.g. US, Europe).
66.	Defra is working with WRAP to identify how they can play a greater role in helping the waste sector adapt to climate change, for example, embedding adaptation messages within its advice to local authorities on household collections. We will ensure that WRAP's new remit is appropriately reflected within its corporate business plan for 2010/11.
67.	Defra will consider how to embed adaptation in guidance on procurement, particularly in relation to waste infrastructure by September 2010. This includes making use of the proposed joint OGC/ACC guide, due to be published in Spring 2010, on how to incorporate climate change adaptation within procurement decisions in the public sector.
Capacity Building	
68.	In 2010 Defra will appoint a new Ministerial Champion for adaptation responsible for encouraging action and engagement within Defra and amongst our stakeholders.
69.	Lead officials for adaptation have been identified across Defra's policy areas. In 2010 we will establish a new information sharing network to exchange evidence and best practice approaches.
70.	In 2010 Defra will set out a plan of action to incorporate climate change risks within core processes such as the Defra policy cycle, impact assessment and business planning processes.
71.	By the end of March 2011 Defra will carry out a full review of progress in implementing its adaptation plan. Key findings will be published on the Defra website.

The Defra Estate	
72.	Defra is planning a number of major new build and significant refurbishment projects over the next five years. These projects will each incorporate a formal adaptation assessment at the design stage.
73.	We are working with our suppliers to raise their awareness of the need to implement adaptation measures, through: • Defra's Supplier Engagement Programme – through which we are encouraging suppliers to carry out reviews of their business models, check that their processes are 'fit for purpose' and climate-proof. • provision of adaptation advice via our suppliers web site which contains advice to suppliers on what they can do to adapt, and links to tools such as Defra's "adaptation wizard", a "business assessment tool" and a risk framework.
74.	We will be implementing the joint Defra/OGC guidance on how to embed adaptation within the public procurement process (due to be published in 2010). Defra will look to be an exemplar organisation in its adoption and use of the new guidance.
75.	Defra is supporting the introduction of a process for sharing best procurement practice on adaptation at the corporate level across Defra.
76.	The Government is currently finalising the review of the SOGE targets. The new framework is expected to include a new adaptation target to improve the preparedness of departmental estates to the impacts of climate change by 2015 and ensure that progress is reviewed on an annual basis. In 2010, Defra will set out a plan of action to deliver early progress for our own estate.

Defra's Climate Change Plan

Reducing emissions

Reducing emissions

9. Farming and food

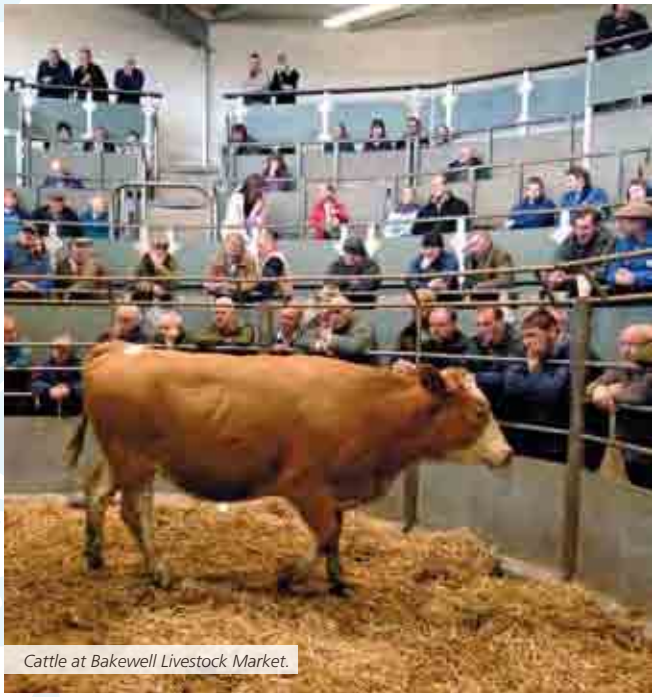
The challenge

Farming and land use were together responsible for emissions of 46.4 $MtCO_2e$ in 2008, or about 7.4% of total UK greenhouse gas emissions. Most of these emissions are caused by livestock, fertilisers, and fuel use in farming. The remainder are from changes in natural carbon balances caused by the way land is used and managed.

Summary

- The Government favours an industry-led approach to reducing emissions from farming, and supports the industry's *Greenhouse Gas Action Plan*.
- Defra will work with the industry to ensure that the *Action Plan* is robust, and will support its delivery.
- The Government is considering its options if the industry-led approach is not successful, including regulation and economic incentives.

The Government and the farming industry agree that the challenge is to reduce agricultural emissions at the same time as safeguarding the environment, improving food production sustainably and competitively, and coping with a changing climate.



Cattle at Bakewell Livestock Market.

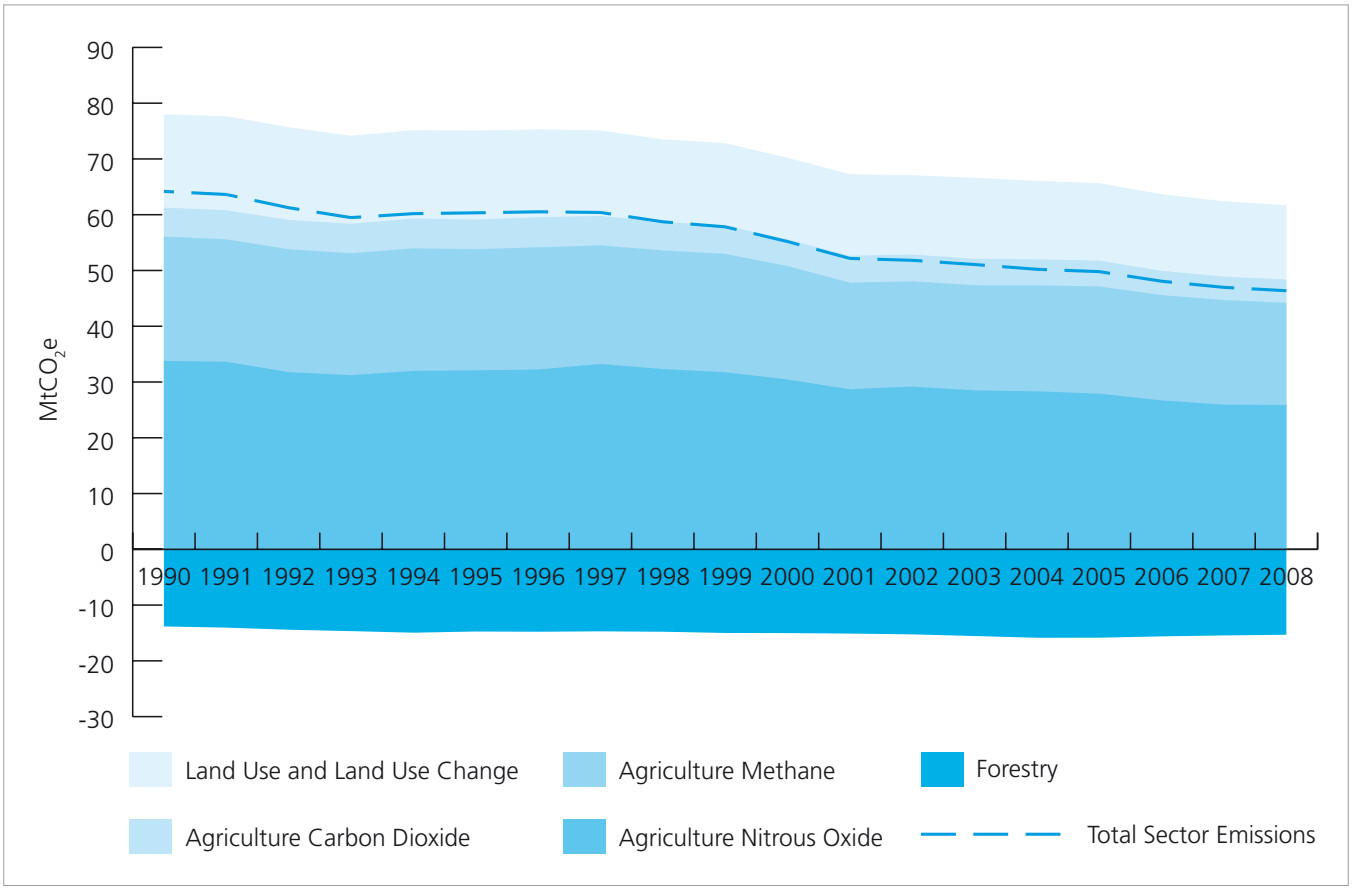


Figure 4: *UK emissions and removals from agriculture, forestry, and land management, 1990 to 2008*

There are unique challenges to reducing agricultural emissions:

- there are large scientific uncertainties in estimating agricultural emissions and predicting the effects of changing practices. For example, the amount of nitrous oxide released from spreading fertiliser can depend on the soil type, the weather conditions, when and how the spreading was done, and many other factors.
- there are physical limits to how far emissions from agriculture can currently be reduced, because farming involves complex biological cycles.
- the UK imports and exports food and agricultural products, and this will continue in the future. We need to make sure, however, that our pursuit of domestic emissions reductions doesn't simply transfer the emissions from our food overseas.

In the *UK Low Carbon Transition Plan*[33], the Government called on the industry to take action, so that in the third carbon budget period (2018 – 2022) annual agricultural emissions in England will be 3 $MtCO_2e$ lower than they would be if current practices continued. A 3 $MtCO_2e$ saving is equivalent to 11% of emissions from English farming in 2007. The industry and the Government agree that action needs to start now if we are to achieve the 3 $MtCO_2e$ target, and to prepare for future carbon budgets.

33 http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

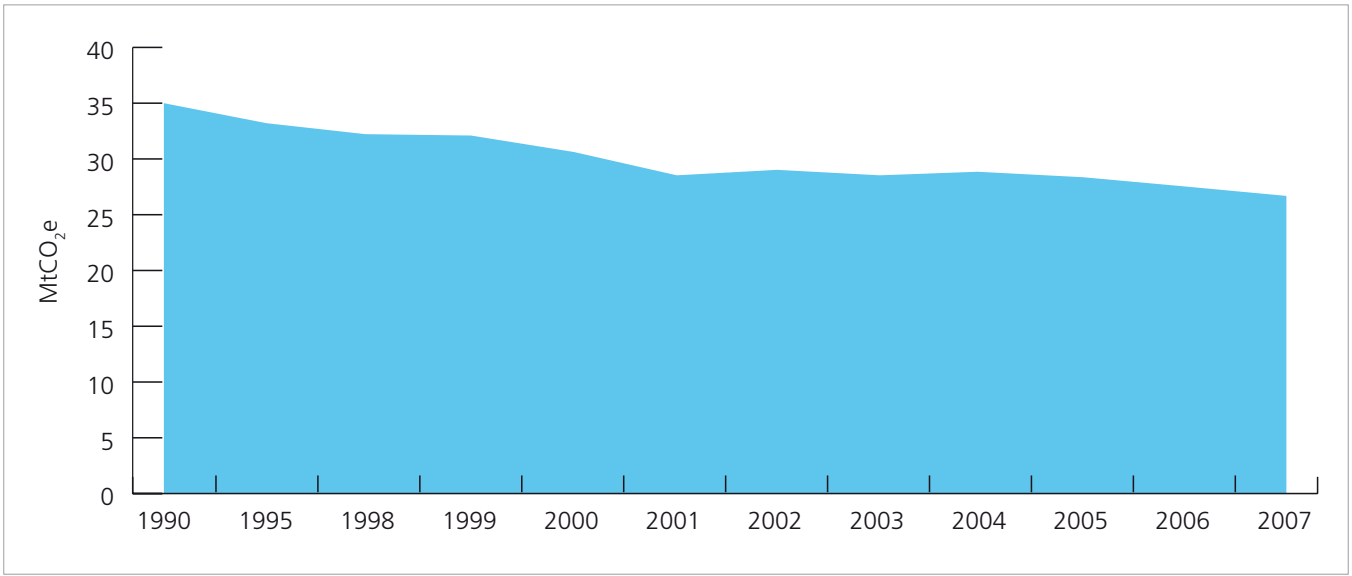


Figure 5: *English emissions from agriculture, 1990 to 2007. Agricultural emissions have fallen since 1990, primarily because of animal disease outbreaks, the decoupling of subsidies from production, increased fertiliser prices, and improved nitrogen use efficiency in crop production. Future agricultural emissions are very uncertain but are likely to be influenced by the continued decrease in agricultural subsidies from the European Common Agricultural Policy (CAP), the future level of biofuels and biomass production, and possible European regulation, for example to improve water and air quality. Defra has commissioned research to improve the projections (see Chapter 21).*

Achieving this requires a concerted effort by the entire industry, sector by sector, across all regions, supported by the Government. The *UK Low Carbon Transition Plan* called for the industry to produce an action plan to set out how English farmers will make the required emissions reductions – most of which will save money or boost productivity. The Government believes that this approach is likely to be the most effective in achieving emissions reductions in a way which delivers business benefits for farms.

In parallel with reducing emissions from livestock and fertilisers, farmers can make important wider contributions to tackling climate change, through improving energy efficiency, helping to reduce the carbon intensity of the energy sector through the development of renewable power, providing the feedstocks for the production of low carbon materials for use by industry and wider society, and protecting and enhancing our natural stores of carbon in soils and trees.

Meeting the challenge

The industry's Greenhouse Gas Action Plan

The agricultural industry's Climate Change Task Force (a partnership between the National Farmers' Union (NFU), Country Land and Business Association (CLA), and the Agriculture Industries Confederation (AIC)) has produced a *Greenhouse Gas Action Plan*[34]. The Government supports the positive response and commitment demonstrated by the *Action Plan*, which is a good first step on the path to reducing emissions cost-effectively.

The *Action Plan* recognises the need to deliver a measurable, reportable, and verifiable contribution to meeting the UK's carbon budgets to 2020 and beyond. It details, sector by sector, how the wider adoption of resource-efficient farming and land management can reduce emissions and improve competitiveness, without compromising levels of productivity. The *Action Plan* focuses on using resources more efficiently through:

34 http://www.nfuonline.com/Our-work/Environment/Climate-change/GHG-emissions---reducing-agricultural-emissions/

- better use of nitrogen in animal and crop nutrition, where improvements in use of feed, manures and fertilisers reduce nitrous oxide emissions and help to reduce agriculture's contribution to diffuse pollution in water and air.
- better management systems for livestock, where production efficiencies can reduce methane and nitrous oxide emissions.
- better use of on-farm energy and fuel, which can achieve reductions in carbon dioxide emissions.

It is a living document which will be responsive to new evidence and policy development.

Field of potato crop in flower in Yorkshire Dales.

Bostock Hall Farm

© Andy Green – The owner of Bostock Hall Farm.

At Bostock Hall Farm in Cheshire, Andy Green has saved money and emissions by careful use of muck from his calf rearing unit, which provides up to 250kg nitrogen per hectare for his farm and helps him meet the requirements of his *Higher Level Stewardship* environmental scheme agreement.

At peak time he will have up to 600 cattle in the sheds, which are fed mostly grass silage plus about 0.5kg per head of a 15% protein blend. Andy says that "if the silage is excellent we will feed nothing else, but if the muck becomes loose we will add a little good barley straw or dry haylage to the diet. Everything is kept as simple as possible. The pens are cleaned out about every four to six weeks and the muck mostly spread at the optimal time in January and February. We work our way across the farm, spreading on the drier land first leaving the wetter ground until it starts to dry out in spring."

Andy uses soil analysis to monitor the nutrients in the soil and to decide application rates for the muck. By managing the applications, he has not used any artificial fertiliser on the farm for the past four years and spot sprays to control weeds.

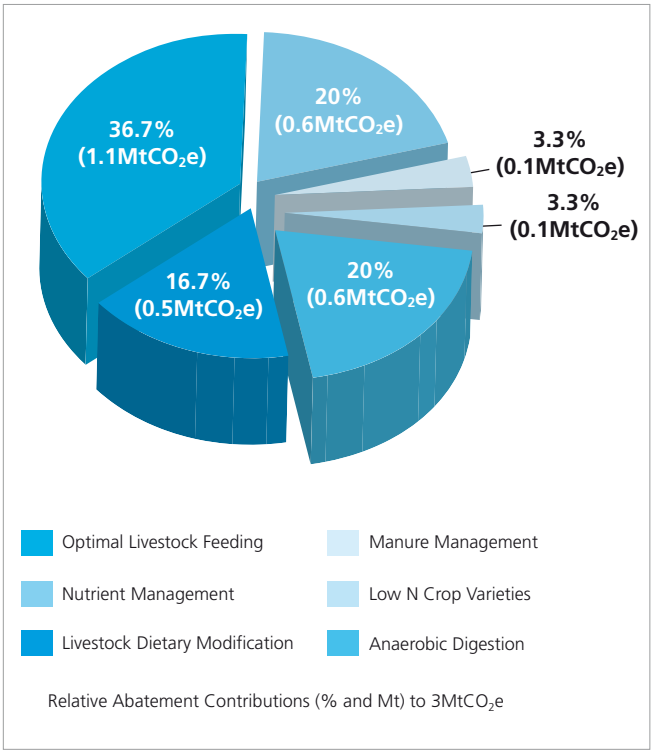


Figure 6: *Emissions savings from the Greenhouse Gas Action Plan*

The *Action Plan* sets out a framework for action in England. The Government and the Climate Change Task Force will work together, and with other industry stakeholders and delivery bodies, to take the *Action Plan* forward. The next phase will involve identifying specific targets for the uptake of best practice by farm business sectors, agreeing how that uptake will be monitored and reported, and promoting and expanding the industry's existing channels for knowledge transfer and advisory services, so that change is delivered on the ground.

The Government also welcomes the progress being made across different industry sectors in developing guidance for farmers on practical steps to reduce emissions and other environmental best practice. *The Dairy Roadmap* is a good example of world-leading best practice in this area, and the sector is well on its way to meeting its initial benchmarks. Similar work is also underway in the beef, sheep meat, and pig meat sectors.

The role of the Government

Supporting the industry-led approach

To help ensure the industry's Action Plan is robust and is implemented successfully, Defra will:

- **have the Action Plan independently assessed** to ensure it is fit for purpose.
- **support the establishment of a joint Defra-industry delivery board** to ensure successful implementation of the Action Plan, through collaborative support from a range of delivery organisations.
- **work with the industry to measure progress** on actions to reduce emissions. Alongside Defra's work to develop indicators to measure progress (set out in Chapter 20), this will include agreeing which indicators to use to assess the impact of the Action Plan on emissions in key farming sectors.

Defra will also directly support the industry's efforts by:

- **promoting advice on cutting emissions,** by coordinating and building on existing advisory services. Defra aims to launch improved low-carbon advice in early 2011.
- **investing in the evidence base** (see Chapter 21) to:
  - better understand and measure emissions from biological systems.
  - develop a more accurate emissions inventory that can reflect mitigation activities initially through a recently established Government-funded research programme.
  - explore what further potential there is to reduce emissions, and at what cost.
  - foster innovation and the development of new technology.
- **continuing to work closely with the Welsh Assembly Government, the Scottish Executive, and the Northern Ireland Executive** to develop a coordinated approach across the UK, including by setting up a coordinated research platform. (See pages 136 to 138.)

Three sows (gilts) in field.

- **working with all the parts of the food supply chain** to support the reduction of emissions from the food system from primary production through to final consumption. Food production is the UK's biggest manufacturing sector and employs 3.6 million people in businesses from farms to retail. *The Food 2030 Strategy*[35] sets out the Government's aim for the UK to have an efficient, low-carbon food system. Achieving this aim will require harnessing the full potential of a food supply chain approach, encouraging all parts of the sector to:
  - share information, including with consumers.
  - disseminate best practice up and down the chain.
  - take a holistic approach to research and development to improve efficiency.

Developing alternative options

Government and industry have been working together in many areas to prepare the farming industry for the future. The progress we have made in agreeing on the Campaign for the Farmed Environment (CFE) – the voluntary agreement to recapture the environmental benefits of set-aside – shows what we can achieve when Government and industry work closely together.

A successful voluntary approach makes sense both for the industry and for the Government. However, achieving the emissions targets required under the Climate Change Act is a legal requirement, and a full contribution from the farming sector is needed. If progress is insufficient, and the industry-led approach is not working well enough, the Government will need to intervene more directly.

There are two possible broad approaches which the Government is considering using, if the voluntary approach does not deliver, and intervention is required:

- **Regulation.** There are two main regulatory options, which could be implemented separately or in combination. **The first would be to build on existing regulation, such as the Nitrates Action Programme**. Additional measures to achieve water quality improvements under the Water Framework Directive, for example through improved nutrient management, could also help deliver greenhouse gas emissions reductions. But it would be difficult to use existing regulation to achieve some of the changes needed: for example, farmers need to improve the way that manures and slurry are stored, and adopt new animal feeding and husbandry practices, in addition to improving crop nutrient management. **The second regulatory option**

35 http://www.defra.gov.uk/foodfarm/food/strategy/

➜ GOVERNMENT ACTION

The Government is already helping farmers to improve their practices:

- Legislation to protect water quality requires farmers in 70% of England to plan and limit their nitrogen inputs, install manure storage facilities, and avoid spreading at times when crops cannot take up the nutrients – all of which can reduce greenhouse gas emissions;
- Through the England Catchment Sensitive Farming Delivery Initiative that is helping to reduce the impact of agriculture on water quality as part of the Water Framework Directive, farmers in some areas can access free advice on nutrient use and soil management, capital grants for targeted low-cost infrastructure investments to tackle pollution, and free soil nutrient testing;
- Through agri-environment schemes under the Rural Development Programme for England (RDPE), such as Environmental Stewardship, funding is available to farmers to manage their land in ways which protect and enhance the environment. Some ES options may lead to reductions in greenhouse gas emissions (e.g. limited agricultural inputs on arable land) and increase carbon storage (e.g. establishing grassland in fields that were previously arable). Guidance given to farmers, including the newly developed Entry Level Stewardship Training and Information Programme (ETIP), will encourage take up of appropriate options;
- In addition the RDPE provides support to reduce greenhouse gas emissions in a number of different ways. For example, the Programme's Energy Crops Scheme encourages the cultivation of short rotation coppice and Miscanthus. And a number of the RDPE initiatives delivered by the Regional Development Agencies help farmers invest in resource efficiency, such as the South West Agricultural Resource Management Initiative which provides £22m of RDPE funding to deliver advice, training, and small capital grants to help farms manage resources more efficiently;
- Anaerobic digestion can reduce methane emissions from manures and slurries, while at the same time producing renewable energy in the form of biogas and digestate that can be used as a fertiliser. *The Anaerobic Digestion Implementation Plan*, published by Defra in March 2010, provides a framework for joint action by Government and industry to drive a major increase in the use of anaerobic digestion. Pages 114 and 115 describe Government action to support anaerobic digestion, including a £10 million demonstration programme;
- Defra worked with DECC, the Carbon Trust, and the industry to make interest-free loans for energy-saving equipment available to farm businesses from 1st February 2010.

would be new regulation under the Pollution, Prevention and Control Act 1999, to set a baseline of relevant good practice for farms. This would allow a more integrated approach and a more equitable coverage of farms in England. Such new regulation could also be adapted to help meet any new European environmental requirements, avoiding the need to adopt separate legal instruments for each requirement;

- **Economic incentives.** Regulation would be a blunt instrument, requiring all farm businesses to adopt particular practices relevant to their sectors. However, there will be some cases where there are net costs to reducing emissions which outweigh the benefits to society. Economic incentives could be more cost-effective, allowing farm businesses more scope to judge where action is appropriate. This could work by requiring farmers who wish to receive a particular financial benefit from the public sector, or avoid particular costs, to take the emissions reduction actions relevant to their business. The Government will continue to consider the nature of the penalties which would apply under this option to farms who fail to implement the necessary measures.

Straw baling.

Preparing for future carbon budgets

Delivering the target for the third carbon budget is only the first step. In the future the sector will be required to make further emissions reductions, as part of the national effort to reduce UK emissions to 80% below 1990 levels by 2050. **Defra will work with the industry, and wider stakeholders, to agree on the potential to deliver further emissions savings during the fourth carbon budget period (2023 – 2027) and beyond.**

Sainsbury's Dairy Development Group

Sainsbury's sells over 470 million litres of fresh milk and 18 million litres of fresh cream each year. In 2006, Sainsbury's launched its Dairy Development Group to help its 325 milk farmers become more sustainable businesses through on-farm efficiencies. Sainsbury's has invested £16m in the Group to date and recently announced plans for a further £40m over the next three years. The scheme is now being extended to Sainsbury's UK beef, lamb, and cheese producers, with pork and poultry suppliers to follow shortly.

Reducing greenhouse gas emissions is one of the four key work streams. Following an on-farm environmental assessment, provided by Sainsbury's, farmers in the Group complete an environmental scorecard on various aspects of their farming practices. Smart software then provides them with an emissions figure per cow and per litre of milk. The scheme has removed more than 5,000 tCO_2e from Sainsbury's dairy supply chain over the past year, as well as delivering significant cost savings for farmers.

Sainsbury's says it is on a continuous learning curve in terms of sustainability and how best to communicate the complexities involved to consumers. The success to date of the Dairy Development Group, and its ambitious plans to roll-out to other farming sectors, suggests that they are learning fast.

Anaerobic Digestion Facility.

Defra will:

- develop the evidence on the potential to reduce agricultural emissions over the fourth carbon budget period, and assess the potential to reduce emissions from the sector in 2030 and 2050 (see page 152 for more detail on this strand of work);
- continue to engage with the international community as discussions on the role of agriculture in reducing greenhouse gas emissions develop;
- work with DECC, the agriculture industry, and wider stakeholders to develop scenarios for possible agriculture and land use in 2050;
- continue to work with other Government Departments on the project, led by the Food Standards Agency, to develop integrated advice on food sustainability issues, including information on the greenhouse gas impacts of food;
- take a whole food supply chain approach to achieving reductions in food-related emissions in a low-carbon economy, including through an improved understanding of the potential for, for example, successful reduction of food waste to lead to reductions in emissions from agricultural production.

Glen Ample variety raspberries.

Finally, in ensuring that the Common Agricultural Policy (CAP) is used in the future to deliver public goods of European relevance, the Government will want to ensure that the strategic importance of climate change is adequately reflected in rural development and agri-environment policy.

Reducing emissions

10. Soils

The challenge

The 2009 Soil Strategy for England, *Safeguarding our Soils*[36], set out the incredibly important role our soils play in climate regulation. They are the UK's largest terrestrial carbon store, containing around 10 billion tonnes of carbon – equivalent to more than 50 times the UK's annual greenhouse gas emissions. More than half of this carbon is stored in peatlands, and around 80% of it is found in Scotland.

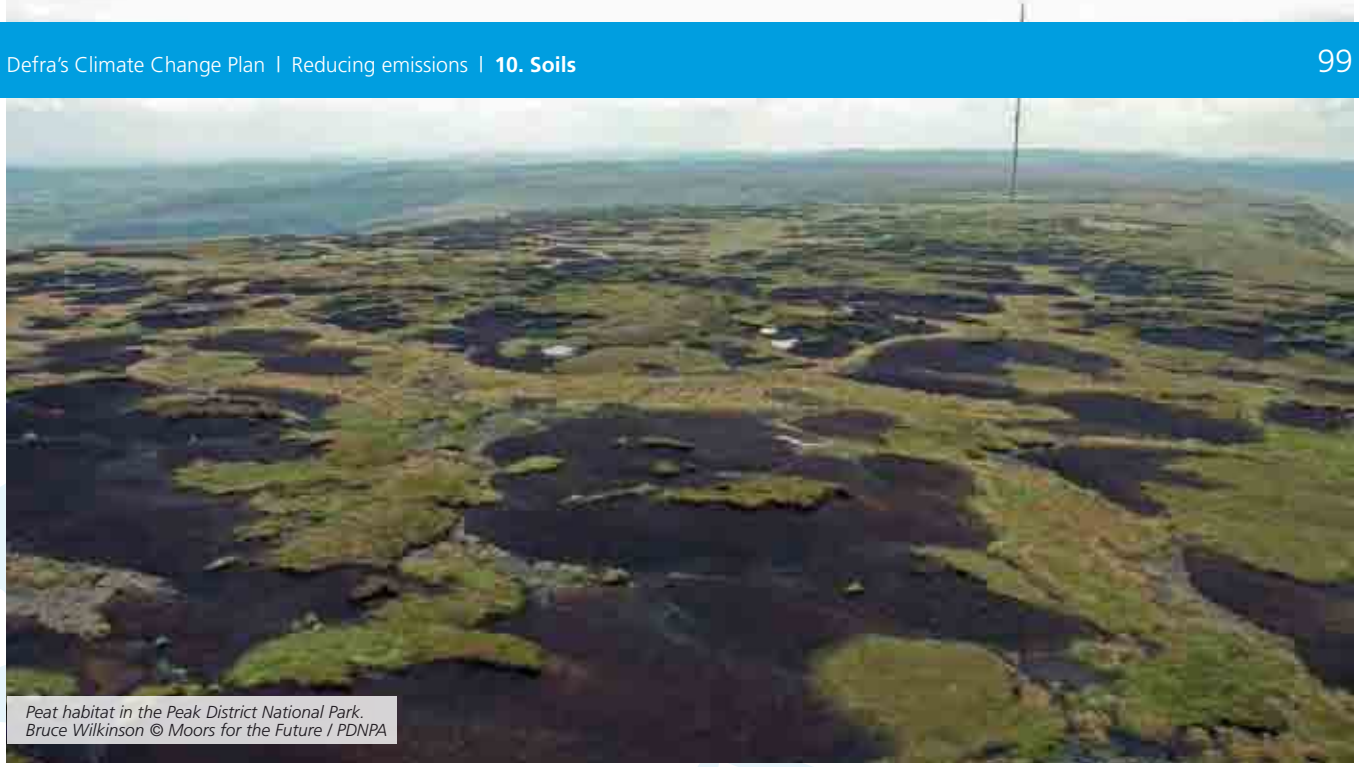
Soil carbon is both gained and lost (including as carbon dioxide and methane) as a result of changes in the way land is used and managed and other climatic factors, including temperature and rainfall. Soils can also emit other greenhouse gases, notably nitrous oxide. Given the complexities, there are scientific uncertainties about current emissions from soils and future trends, but there is certainly a long-term risk that soils will become an increasing source of emissions in the future as the climate changes, particularly where they are already degraded or otherwise more vulnerable to changing climatic conditions.

The UK Greenhouse Gas Inventory currently estimates that the UK is losing soil carbon at a rate of around 14 $MtCO_2e$ per year as a result of changes in the way that land is used – for example, losses that result from urban development or the ploughing up of grasslands and drainage of carbon-rich soils for agriculture.

Summary

- UK soils contain over 10 billion tonnes of carbon, more than half of which is in peatlands.
- *The 2009 Soil Strategy* set out the Government's approach to safeguarding our soils. Defra will publish additional guidance this year on how farmers can best protect their soil.
- Later this year Defra will consult on a new Peat Framework for Action and publish the results of research on how best to protect our vital peatlands.

36 http://www.defra.gov.uk/environment/quality/land/soil/sap/index.htm



Peat habitat in the Peak District National Park. Bruce Wilkinson © Moors for the Future / PDNPA

It is much more difficult to estimate gradual changes in soil carbon concentrations as a result of land management, when the land is used for the same purpose (e.g. arable farming) but is managed in different ways (e.g. with different cultivation or cropping practices). This is where the evidence base now needs to be strengthened.

Meeting the challenge

Managing our land

Farmers have an important role to play in keeping soils in good condition, and the Government welcomes the commitment demonstrated in the industry's *Greenhouse Gas Action Plan*[37] to enhancing soil carbon stores.

Two national surveys have agreed that there has been a decrease in carbon levels in agricultural soils since the late 1970s as a direct result of intensive agricultural practices. The Government's *Code of Good Agricultural Practice* includes advice for farmers on ways to protect soil carbon on their land, and a number of existing Government policies encourage take-up of these practices, including:

- *the Soil Protection Review* (part of cross compliance under the Common Agricultural Policy), which was updated this January;
- Environmental Stewardship schemes, which include a range of measures that contribute to protecting or enhancing carbon stores, including peat soils;
- the England Catchment Sensitive Farming Delivery Initiative.

Defra has committed to publish, later in 2010, additional guidance on good agricultural practices to protect and increase soil organic matter and soil carbon.

Moors for the Future

Moors for the Future is one of several important partnership restoration projects. Launched in 2002, they are focusing on restoring large areas of degraded peat habitat in the Peak District National Park that are internationally important for biodiversity, wildlife, and the valuable carbon that it stores. To date, 6km^2 of damaged moorland has been re-vegetated and stabilised.

37 See http://www.nfuonline.com/Our-work/Environment/Climate-change/GHG-emissions---reducing-agricultural-emissions

Protecting our peat

Peat bogs in good condition are able to accumulate carbon almost indefinitely, but this happens extremely slowly. As well as the carbon they store, peat soils and habitats provide important ecosystem services for society, including as a home for valuable biodiversity and wildlife and playing a vital role in the water cycle.

However, our peatlands are already significantly degraded, and continue to be degraded, as a result of human activities including intensive agriculture, drainage, afforestation, industrial emissions and extraction. A recently published report by Natural England provides a useful summary of current impacts on the condition of English peatlands and the implications of this for greenhouse gas emissions.

In 2007, Defra joined with a number of partner organisations to launch the Partnership Project on Peat[38], which is focused on improving the evidence base on peat and exploring the potential for policy changes to strengthen peat protection and promote restoration in both upland and lowland peatlands.

Later this year, Defra will:

- publish an online summary of new knowledge gained as a result of research commissioned by the Partnership Project on Peat.
- consult on a new Peat Framework for Action, which will consider potential policy changes to strengthen peat protection and include proposals for measures to further reduce the horticultural use of peat when the current target expires at the end of 2010.

Improving our knowledge

The Soil Strategy for England recognises that the evidence base on a wide range of soils and climate change issues needs to be strengthened. In particular, Defra is committed to improving soil carbon and greenhouse gas monitoring and data on the impacts of land management practices, including in relation to peat soils. For example, Defra and a number of partner organisations are contributing to important research to design a greenhouse gas monitoring programme for UK peatlands. Other research funders are also carrying out extensive work that will contribute to data and evidence improvements – for example, by monitoring carbon losses from peat using satellite remote sensing.

As well as protecting our existing soil carbon, there is much debate about whether it is possible to permanently increase soil carbon levels, particularly in agricultural soils. Because soils are a dynamic natural system, actions taken to increase levels of soil carbon are usually easily reversible, unless something can be done to convert the carbon into more stable forms. There is also a danger that action to increase soil carbon will release other, more powerful greenhouse gases (methane and nitrous oxide). Defra is funding research to review land management options, as well as emerging technologies such as biochar, which could offer future opportunities to permanently sequester carbon in soil.

38 http://www.defra.gov.uk/environment/quality/land/soil/peat/partnership-project.htm

Reducing emissions

11. Forestry

The challenge

The value of forestry in tackling climate change

As new trees grow, they reduce the UK's overall emissions by removing carbon dioxide from the atmosphere, storing the carbon as wood. Left untended, carbon uptake by woodlands will eventually reach zero when carbon loss through natural tree mortality and decay is balanced out by re-growth. But when woodlands are actively managed, trees are felled to provide timber, which makes space for new trees to grow.

This sustainable approach to woodland management also benefits biodiversity, provides opportunities for climate change adaptation (see Chapter 2), and supports the rural economy.

The wood produced from managed woodlands is also valuable in reducing emissions:

- it can be used instead of other materials, for example in the construction sector. This avoids the emissions associated with producing the other materials, and keeps the carbon locked up in the wood.
- it can be used as a fuel, instead of burning fossil fuels. This releases the carbon absorbed during the trees' growth back into the atmosphere, but avoids emissions from burning coal, oil, or gas. As part of the sustainable forest management cycle, the carbon will once again be removed from the atmosphere when the woodland re-grows.

Summary

- In the long-term forestry is a cost-effective way to reduce the UK's emissions.
- The Government wants to see a major increase in the level of woodland creation and will establish a Woodland Carbon Task Force to help drive it forward.
- The Government will consult a wide-range of stakeholders, including business and environmental NGOs, on the potential for company reporting guidance to deliver additional carbon sequestration through stimulating new investment.
- Existing woodlands represent a renewable energy resource that Defra and the Forestry Commission will help to unlock through implementing the Woodfuel Strategy.

On many types of soil, woodland creation also leads to an increase in the amount of carbon stored in the soil, a process that can continue for many hundreds of years.

The need for woodland creation

Overall, more woodland is being created in the UK than is being removed – about 8,000 hectares of new woodland were created in 2008. However, the planting

rate was higher during the 1950s to 1980s, when new woodland creation peaked at 43,000 hectares in 1971.

The rate at which our forests remove carbon dioxide from the atmosphere is predicted to decline between now and 2020. This is mainly because many of the woodlands planted in the second half of the last century are reaching economic maturity and will be felled for timber. These forests will be re-planted, as required by law, but the new trees will take some time to become established and reach the high growth rate of "mid-rotation" woodlands.

As set out in the *UK Low Carbon Transition Plan*[39], the Government would like to see a major increase in the level of new woodland planting. The recently published Read Report, *Combating Climate Change: a Role for UK forests*[40], concluded that while changes in the management of our existing woodlands could deliver some carbon benefits, greater woodland creation offers the greatest opportunities in the medium to long term. For example, planting an additional 10,000 hectares of sustainably managed woodland per year in England for the next 15 years could absorb 50 $MtCO_2e$ by 2050, and the wood produced could reduce UK emissions by a further 37 $MtCO_2e$.

Lancashire County Council: Woodlands from Waste

Lancashire County Council has a 25-year waste management contract with Global Renewables, which is based on zero waste going to landfill. Organic waste that would have been landfilled will be converted to a soil improver that can be applied to derelict and brownfield land. From Autumn 2010, trees will be planted on these sites to create new community woodlands. Over the 25 years, 100,000 trees will be planted each year. This will create 1,200 hectares of new woodland by 2032, increasing Lancashire's woodland cover by almost 10%. The initiative is a truly integrated approach to climate change mitigation, delivering abatement through reduced methane emissions from landfill, increased soil carbon levels in brownfield and degraded land, carbon uptake into the new woodlands and future potential for those woodlands to provide woodfuel and timber products to reduce fossil fuel use.

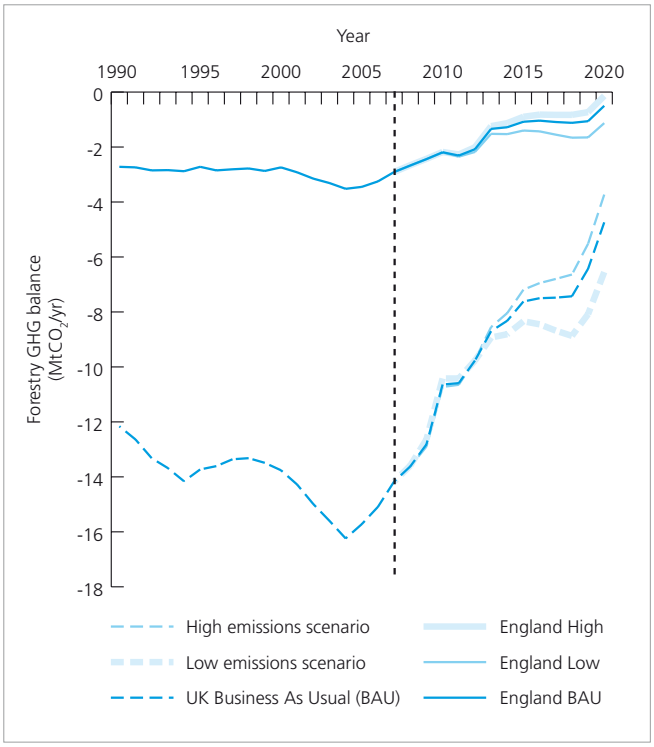


Figure 7: *Carbon dioxide removals by the forestry sector have generally been rising slowly since 1990, but – unless there is a significant increase in woodland planting – are expected to decline rapidly to 2020, even under a low emissions scenario.*

Forestry is also a cost-effective way to reduce the UK's emissions over the long term: new woodland planting can absorb carbon dioxide for as little as £20 to £40 per tonne over the lifetime of the trees.[41]

But there are challenges to achieving a step change in the rate of woodland planting:

- most of the cost comes upfront, when the trees are planted.
- new woodlands take up land, which changes the landscape and can have implications for food

39 http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx
40 http://www.tsoshop.co.uk/bookstore.asp?FO=1159966&DI=622276
41 The exact costs depend on factors including land prices, timber prices, the type of woodland, and the previous use of the land.

production, biodiversity, water availability, and the local economy and community.

Meeting the challenge

Planting new trees on the scale needed will require a concerted effort by everyone: the Government, businesses, landowners, and individuals. To support this effort, and working with partners, Defra and the Forestry Commission will:

- **establish a Woodland Carbon Task Force** to mobilise action across society and establish the business models and market conditions needed to stimulate large scale investment (see box) in woodland creation.
- **uphold the principle of the "the right tree in the right place".** In addition to existing regulations, Defra and the Forestry Commission will develop a high-level spatial framework to help locate new woodlands where they can best deliver a wide range of environmental, social, and economic benefits. Defra, the Forestry Commission, and Natural England will also ensure the right balance of woodland planting (for climate change objectives) and woodland removal (to restore priority open habitats).
- **continue to fund woodland creation and management through the Rural Development Programme for England (RDPE),** and consider how best to place woodland measures in the development of the new Programme beyond 2013.
- **provide standards for sustainable forest management,** to ensure that the carbon benefits of woodland are accurately measured, reported, and verified. In addition to the existing UK Forestry Standard and its Climate Change Guidelines, the Forestry Commission will publish a *Code of Good Practice for Forest Carbon Projects* later in 2010.
- **implement the *Woodfuel Strategy for England*;**[42] focusing on bringing existing undermanaged woodlands into management.
- **improve the measurement of emissions and removals from land use and forestry,** including through a new assessment of forest carbon stocks through the National Forest Inventory.
- **consult a wide range of stakeholders,** including environmental NGOs and business, on the potential for company reporting guidance to encourage new investment;
- **work with the Devolved Administrations**[43] to help unlock the potential of the forestry sector across the UK.

Defra and the Forestry Commission will also continue to explore a range of possible initiatives, including private sector investment vehicles and the role of local authorities, for encouraging woodland creation.

The Woodland Carbon Task Force

The Task Force will be a multi-disciplinary team working to establish the conditions for significant private sector investment in woodland creation, increased supply and demand of woodfuel, and greater uptake in general of sustainable forest management practices. It will seek to create a step change in woodland planting in England in support of the aspirations set out in the *UK Low Carbon Transition Plan*. Its work will explore a range of mechanisms including company GHG reporting guidance and the potential of investment vehicles, and whether a commitment from the Government to purchase the carbon sequestered by new woodlands could unlock significant private sector investment. The Task Force, working with stakeholders, will establish criteria to indicate where new woodland planting will best deliver the many potential co-benefits of woodlands within the existing sustainable woodlands framework. A key theme will be understanding and addressing barriers to woodland creation and management through dialogue with landowners – those that have woodland and those that don't; from local authorities to 'city institutions' and from small farms to large estates – providing the key to unlocking the abatement potential of the forestry sector.

42 http://www.forestry.gov.uk/england-woodfuel
43 The work of the Devolved Administrations on forestry is discussed briefly in chapter 18.

Reducing emissions

12. Sustainable consumption & production

The challenge

The products and services that we buy, use and dispose of account for 75% of an average UK individual's carbon footprint, when emissions embedded in the production, distribution, use and disposal phases of a product's life are factored in.

Summary

- The Sustainable Consumption and Production Programme will help reduce emissions across the economy, by helping individuals, organisations and the Government operate in a more sustainable and lower-carbon way.
- Defra is helping businesses become more resource efficient by providing advice, reporting guidance and standards.
- Defra is driving up standards across a range of products, and supporting more sustainable behaviour among consumers.
- Product roadmaps will deliver emissions savings throughout the supply chain.

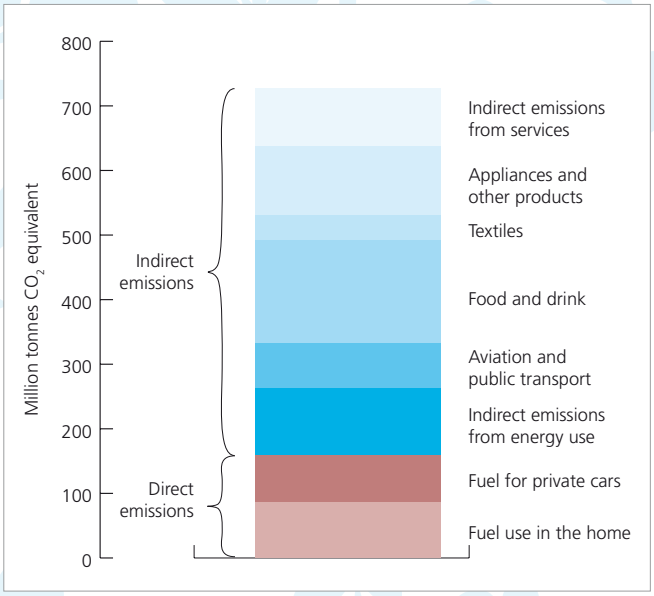


Figure 8: *Estimated greenhouse gas emissions from UK household consumption, 2006*

If we are to successfully reduce emissions on the scale needed over the next few decades, we need to radically change our patterns of consumption and systems of production. Individuals, businesses, and the Government all need to operate in a more sustainable fashion.

Meeting the challenge

Defra works to make the UK's economy more sustainable, by looking at the whole life-cycle of products and services (from manufacture, through use, to disposal) and focusing on those with the highest environmental impacts. By improving these activities within the UK and in the global supply chains which feed the UK, Defra's policies can reduce greenhouse gas emissions (in the UK and abroad), pollution, waste, and natural resource use.

Making entire supply chains more sustainable reduces emissions across a number of different sectors of the economy, including power generation, transport, workplaces, and homes and communities. Parts of these sectors are covered by the EU Emissions Trading Scheme (EU ETS), where Defra's policies make it cheaper for businesses in the UK to meet the current emissions cap, and easier for the Government to negotiate for tighter caps to be set in the future.

Defra's approach focuses on:

- the operations and behaviour of businesses, public bodies and other organisations.
- products and services placed on the market.
- consumer choices and behaviours in buying and using products and services, and disposing of them at the end of their lives.

Making the public and private sectors more sustainable

Helping businesses to become more resource efficient

Defra supports UK businesses to save money and reduce their environmental impacts, by improving the way they use natural resources such as energy, water and other raw materials. Defra's approach is to:

- spread best practice and innovation.
- support market development where there is a market failure (for example, by promoting the potential of energy from waste).
- raise awareness (for example, through the Real Help to Business Now top ten tips campaign).

In 2006-07, Defra's business resource efficiency policies delivered approximately 2.5 $MtCO_2e$[44] of emissions savings, spread across several UK carbon budget sectors (including those covered by the EU ETS) and including some reductions in emissions overseas.

WRAP

The Waste and Resources Action Programme (WRAP) is Defra's principal delivery body responsible for implementing the Government's policies to minimise waste and improve material resource efficiency. They are currently focusing on four priority areas of packaging, food waste, collection systems and quality of materials.

WRAP is steadily moving the focus of its activities further up the supply chain, from waste management and recycling to improved product design, reuse, and waste minimisation. On 1st April 2010, WRAP will be expanded into a new delivery body[45] with a wider focus.

Helping organisations to report their emissions

On 1 October 2009, Defra and DECC published *Guidance on how to measure and report your greenhouse gas emissions*[46]. The Guidance aims to help all organisations to measure and account for their direct and indirect emissions, and to set targets to reduce emissions in the future.

Defra is currently reviewing the contribution that reporting of emissions makes to meeting the UK's

44 This figure includes the work of the Carbon Trust, which was set up by this Defra programme but is now funded by DECC

45 Ministers announced in March 2009 that the seven bodies responsible for delivering the Department's material resource efficiency policies would be brought together under the umbrella of WRAP by April 2010. The bodies covered by this measure are the Waste & Resources Action Programme (WRAP), Envirowise, National Industrial Symbiosis Programme (NISP), Construction & Resources Waste Programme (CRWP), Centre for Remanufacturing & Reuse (CRR), Action Sustainability and the BREW Centre for Local Authorities.

46 http://www.defra.gov.uk/environment/business/reporting/index.htm

climate change objectives, and will lay a report before Parliament by 1 December 2010. The Climate Change Act specifies that by April 2012, the Government must make regulations that require companies to measure and report their emissions, or explain to Parliament why they are not doing so.

Providing trusted standards and methodologies

Businesses need assessment tools and methods to enable them to measure the environmental impacts of their products and services and to benchmark their performance. Defra supported the British Standards Institute (BSI) in developing the world's first standard for the carbon footprinting of products, "PAS2050". This standard has been downloaded more than 17,000 times from the BSI website and has been used on thousands of products (5,000 by the Carbon Trust alone). Defra is now playing a leading role in the debate to develop global standards, underpinned by PAS2050, and is supporting a review of PAS2050 to improve usability and boost uptake.

It is important that businesses and consumers can trust claims about the environmental impacts of products and services. Defra publishes guidance[47] to businesses on ensuring green marketing claims are accurate, credible, and substantiated. This guidance is currently being updated, for consultation in 2010.

Making public procurement sustainable

The public sector spends £220 billion each year on procurement. Defra aims to bring this purchasing power to bear on some of the most important sectors selling goods and services in the UK market. Defra's *Buy Sustainable Quick Wins* purchasing specifications are part of the Government Buying Standards, which are mandatory for central Government Departments. In 2009, new procurement specifications for information and communications technology were published, to be followed by revised standards for paper and furniture.

Defra works with procurers and key suppliers in sectors with large environmental impacts (e.g. construction, transport, and food) to assess and reduce carbon emissions down their supply chains. As announced in the Pre-Budget Report 2009, the Government is creating a *Supplier Charter for Departments* to communicate high level procurement objectives, which include low carbon and resource efficiency.

Reducing the environmental impact of products and services

Improving the energy performance of products

Improving the energy efficiency of products, such as white goods, TVs, and heating and cooling systems, helps consumers save on their energy bills while at the same time reducing their carbon emissions.

Defra is improving the energy performance of products by:

- **setting minimum energy efficiency and energy labelling standards** at European level, which manufacturers must meet if they wish to sell their products across the European Single Market. Standards have been agreed for ten energy-using products so far, including televisions and domestic lighting. By 2020, these ten standards should reduce UK emissions by over 7MtCO_2e per year and save the UK economy £900 million per year. Defra is negotiating strongly in Europe for further standards, including for heating systems and commercial refrigeration, which could save the UK at least another 7MtCO_2e each year and £14 billion between now and 2030. EU standards also help the development and marketing of more efficient products outside the EU.
- **developing voluntary initiatives with manufacturers and retailers** to improve the efficiency of their products – for example the phase-out of inefficient light bulbs. Defra is working on further initiatives, including on televisions.
- **strengthening the enforcement of standards and labels** through product testing. Defra will consult, later this year, on giving the UK Market Surveillance Authority new powers to create a more flexible enforcement regime (including the ability to impose administrative penalties as well as criminal penalties).

47 http://www.defra.gov.uk/environment/business/marketing/glc/code.htm

- **working towards harmonisation of international standards** and developing internationally agreed product testing procedures.

Developing "product roadmaps"

Working with businesses, Defra is piloting an approach called "product roadmapping". A roadmap gathers together evidence of the environmental impacts of a product's whole life-cycle, shows the actions that are already being taken to reduce them, and highlights gaps. As part of the roadmap, Defra can work with the supply chain and others involved to agree a voluntary Action Plan to address these gaps. There are 10 pilots covering a wide range of products: milk, fish, clothing, plasterboard, windows, toilets, cars, TVs, lighting, and commercial electric motors.

Defra aims to have all the ten Action Plans agreed by December 2010. If these pilots are successful, the aim is to get the 'roadmap' approach adopted by many more business sectors, with less direct involvement from the Government.

Supporting more sustainable behaviours

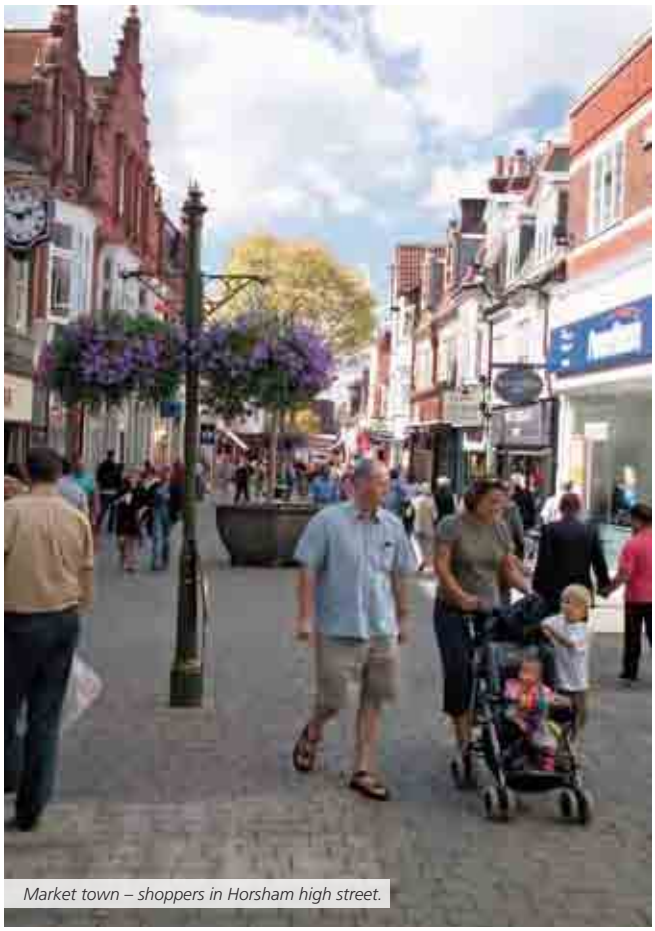
Individuals and communities can make a real contribution to protecting and improving our environment. Defra works to support and encourage this action by undertaking ground-breaking research and developing best practice on influencing behaviour change. This shapes Defra's own policy development, and provides advice to the Government and others on delivering change. For example, this work supports the Government's Act on CO_2 campaigns.

The Sustainable Clothing Action Plan

The Sustainable Clothing Action Plan sets out agreed stakeholder actions (individual and collaborative) from the clothing and fashion industries and supports organisations to improve the sustainability of clothing in the following priority areas:

1. improving Environmental Performance across the supply chain
2. consumption trends and behaviour
3. awareness, media, education & networks
4. creating market drivers
5. traceability across the supply chain (ethics, trade & environment)

Over 90 actions are in the current Action Plan which is updated as new actions are added. The Action Plan can be seen at the following website: http://www.defra.gov.uk/environment/business/products/roadmaps/clothing/action-plan.htm



Market town – shoppers in Horsham high street.

In 2008, Defra published the *Pro Environmental Behaviours Framework*[48] which sets out the actions people can take to live more sustainably. Most of the actions help to reduce emissions, covering food and drink, personal travel, homes and household products, and travel tourism. The *Framework* also segments the population into seven groups based on their beliefs and values towards the environment, which enables policy and communications to address people's different motivations and barriers. A wide range of people and organisations in the public, private and third sectors are actively using the different components of the *Framework*.

The Greener Living Fund

Defra's Greener Living Fund[49] is using the research and approach set out in the Pro Environmental Behaviours Framework. It is providing over £5 million between 2009 and 2011 to third sector organisations, so they can run projects to help individuals and communities in England to live more sustainably.

For example, the National Union of Students' "Degrees Cooler" project aims to embed behavioural change in higher education institutions in England. The project's Student Force for Sustainability and Greener Living Assistants are supporting initiatives including:

- **Student Switch Off:** an energy competition between student halls at 11 universities. In 2008/09, 4,964 students became Eco-Power Rangers and reduced electricity usage in their universities by an average of 8.1%.
- **Green Impact**: an environmental accreditation scheme for departments at the University of Bristol. Over the 2008/09 pilot year, 46 departments took part, covering half of all the staff at the University. As a result, 31 departments now induct all new staff on environmental issues, 29 departments have created vacation shutdown plans, and 16 departments have refreshed energy-saving stickers and posters in the last six months.
- **People & Planet, Go Green**: A student-led grassroots campaign to green 30 higher education institutions.

48 http://www.defra.gov.uk/evidence/social/behaviour/
49 www.greenerlivingfund.org.uk

Reducing emissions

13. Waste

The challenge

In 2008, the direct greenhouse gas emissions from waste were 22.7 $MtCO_2e$ overall, accounting for around 4% of total UK emissions.

Around 90% of these emissions came from landfills where biodegradable wastes[50] decompose, often over many decades, to release landfill gas which is roughly 60% methane and 40% carbon dioxide. A proportion of this gas is captured for energy recovery or flaring[51] (currently assumed to be 75%), but a significant amount does escape into the atmosphere. The rest of the emissions from the waste sector come from the incineration of wastes, or dealing with waste water from homes and businesses.

According to the UK greenhouse gas inventory, emissions from the waste sector have fallen by 57% since 1990 (Figure 9), largely as a result of the successful implementation of policies like the landfill tax and the Landfill Allowance Trading Scheme (LATS), which provide strong incentives not to put waste into landfills.

Summary

Emissions from the waste sector have fallen by 57% since 1990. The Government is confident it will achieve further emissions savings of 1 $MtCO_2e$ by 2020 through:

(a) working with industry and consumers to reduce the amount of biodegradable waste produced.

(b) making it harder to send biodegradable waste to landfill, and promoting alternatives such as recycling and energy generation from waste.

(c) capturing more methane from landfill sites.

50 Organic materials, such as food, wood, paper, green waste, and textiles, which decay through the action of bacteria.
51 Methane flaring: the direct conversion of methane to carbon dioxide through burning, but without energy recovery.

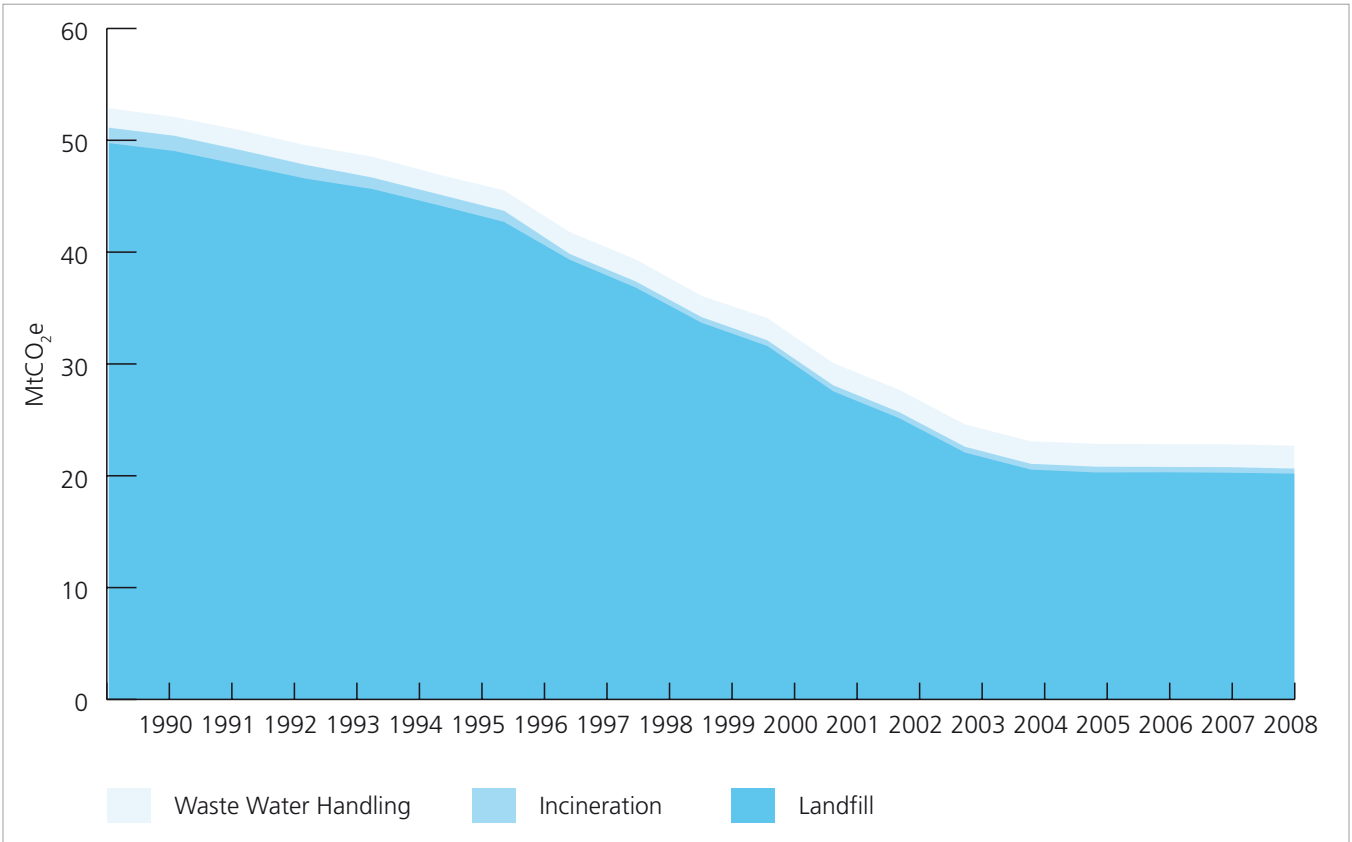


Figure 9: *Greenhouse gas emissions from the waste sector, 1990 – 2008*

Emissions from waste are projected to fall further to 21.1 $MtCO_2e$ by 2020, as a result of policies to reduce the amount of waste sent to landfill. But in the UK *Low Carbon Transition Plan*, Defra estimated that even greater reductions – an additional $1MtCO_2e$ by 2020 – could be achieved through the introduction of additional policy measures. This will bring the total reduction in waste emissions since 1990 to 62% – almost double the 34% reduction target sought across all sectors of the UK economy.

This chapter sets out how the Government intends to drive down emissions in the waste sector. It focuses exclusively on tackling emissions from landfills, as this provides the biggest opportunity for savings. Waste water is dealt with in chapter 15.

In parallel with reducing emissions from landfills, action in the waste sector can make important wider contributions to tackling climate change, through reducing demand for new raw materials, reducing energy used in replacing goods and transporting waste, and providing a source of renewable energy (see the case study on page 114 as an example).

There are unique challenges to reducing emissions from landfill. There are significant uncertainties in estimating waste emissions, for instance in relation to estimating the methane capture rate at landfill sites, accurately measuring the amount of waste going to landfill (particularly from commercial and industrial sources) and predicting the effects of new policies. These issues are explored further on pages 154 to 156, which set out Defra's plans to improve understanding of waste emissions. There are also limits to how far emissions from landfills can be reduced, because waste materials already in landfills will continue to produce landfill gas, potentially for many decades to come. Where landfills are no longer actively managed, it can be difficult to implement actions to increase the amount of landfill gas captured.

Landfill site © WRAP

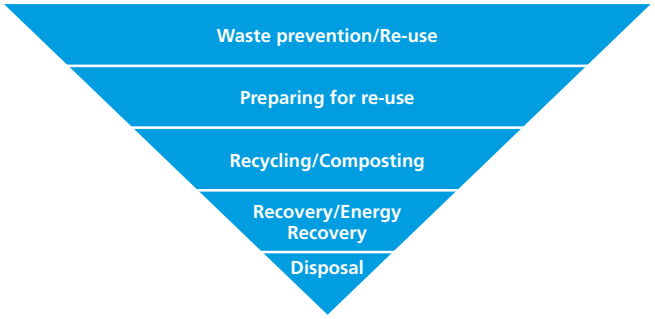


Figure 10: *The waste hierarchy*

In spite of these challenges, Defra is confident that the actions outlined in this chapter will reduce waste emissions by at least the target set in the *Low Carbon Transition Plan* of 1 $MtCO_2e$ by 2020.

Meeting the challenge

The waste hierarchy

The Government's approach to managing waste is based on the 'waste hierarchy'[52] (Figure 10). Options towards the top of the hierarchy are more sustainable ways of managing waste than those lower down – for example preventing waste from being created in the first place is more resource and carbon efficient than recycling it or disposing of it in another way.

Defra's plan for the waste sector is underpinned by this hierarchy and centres on three themes:

1. reducing the amount of biodegradable waste produced.
2. diverting more biodegradable waste away from landfill.
3. capturing and treating more methane from landfill.

Reducing the amount of biodegradable waste produced

Waste prevention and re-use are at the top of the waste hierarchy, because they prevent the unnecessary loss of resources, reduce overall demand for resources, reduce energy used in replacing goods and transporting waste, and reduce the amount of waste going to landfill.

Reducing food waste

Every year in the UK we throw away approximately 18 – 20 million tonnes of food waste. It is estimated that each year, in total, householders could avoid throwing away food worth around £12 billion.

52 A consultation on draft Regulations transposing the revised Waste Framework Directive in England is due to be launched later this year. This will require the application of the waste hierarchy as a priority order in law, although departures from the hierarchy will be allowed where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste.

Defra plans to reduce food waste through the following actions:

- through the Waste and Resources Action Programme (WRAP), working with the grocery sector to secure more demanding food waste reduction targets in phase two of the "Courtauld Commitment", a voluntary agreement due to be launched in March 2010, which is sponsored by Defra and the Department for Business, Innovation, and Skills (BIS).
- funding WRAP's 'Love Food Hate Waste' campaign, which reduced household food waste by 110,000 tonnes between 2007 and 2008 through raising consumer awareness of food waste and providing practical tips to prevent it. Defra has extended this funding to 2011 and set a higher waste reduction target of 250,000 tonnes.
- working with WRAP and the Food Standards Agency to reduce food waste by improving the clarity and consistency of date labels and improving consumer understanding of food storage and usage guidance.
- through WRAP, piloting food waste reduction initiatives in schools. The outcomes of these pilots will inform the development of guidance for schools more widely.
- funding research on food waste from the hospitality sector to inform development of policy actions in this area.

Reducing wood waste

Every year we throw away around 4.6 million tonnes of wood waste in the UK, about half of which comes from the construction sector. The joint Government and industry *Strategy for Sustainable Construction*, published in June 2008, included the ambitious target of halving construction and demolition waste going to landfill by 2012 (compared to 2008 levels). Defra is working closely with BIS and with the industry to drive forward delivery of this target. Actions include WRAP support for individual signatories to the target, guidance for small builders, resource efficiency plans for individual construction sectors (e.g. the British Wood Federation's work with joiners and window-makers), and working towards a target to reduce construction packaging waste by 20%.

Defra also values action from the third sector which is helping to reduce wood waste. For example, the Furniture Reuse Network, which is part of REalliance[53], is supporting charitable organisations across the UK to reduce poverty by collecting unwanted furniture and passing it onto low income households.

Reducing other types of biodegradable waste

Defra supports work to reduce paper and card waste, through:

- a voluntary agreement between WRAP and the home improvement industry to reduce packaging by 15% and waste to landfill by 50% by 2012.
- a number of industry-led opt-out mailing schemes, which allow householders to sign up and reduce the amount of direct mail they receive.
- *the Strategy for Sustainable Construction.*

The Sustainable Clothing Roadmap (page 107) is reducing textile waste, and the third sector plays an important role in encouraging the reuse of clothing, for example through the wide network of charity shops.

Diverting biodegradable waste away from landfill

We need to deal with the waste that is produced in better ways than sending it to landfills. Defra is driving this by making landfilling harder, and making the alternatives easier – including using waste as a resource to generate new products or energy.

Making landfilling harder

The Government introduced the landfill tax in 1996, making it progressively more expensive to send waste to landfill. Budget 2009 announced that the cost of sending waste to landfill would continue to rise by £8

53 The four principal networks that support third sector organisations concerned with reuse, recycling, compost and waste minimisation have come together to form REalliance CIC: Community Recycling Network, London Community Resource Network, Community Composting Network, and Furniture Reuse Network

per tonne each year until at least 2013. Defra estimates that these increases will divert approximately 3 million tonnes of waste away from landfill per year by 2013/14.

A consultation launched this year asks for views on whether introducing landfill restrictions or bans for certain waste materials, e.g. metals, glass, plastic and some biodegradable wastes (food, wood, paper/card, green waste) would make an effective contribution to reducing emissions and increasing resource efficiency. If, following consultation, landfill restrictions were found to be an effective way to do this, their introduction could lead to significantly more biodegradable waste being diverted from landfill by 2020.

Making the alternatives easier

The Government will encourage more sustainable methods of waste management by:

- ensuring the necessary infrastructure and collection, sorting and processing systems are in place.
- creating and stimulating markets for waste.
- driving behaviour change through working with industry.

Defra established the Waste Infrastructure Delivery Programme to help local authorities accelerate the building of the infrastructure needed to treat residual waste. To date, £2.6 billion in Private Finance Initiative credits has been committed to 38 projects.

Supporting recycling & composting

The UK has already achieved a paper and card recycling rate of about 70%. Defra is due to launch a consultation in March 2010 on higher targets for recovering and recycling packaging waste (as part of revising the Packaging Regulations), and later this year will start to review the voluntary agreements it has with the paper industry to ensure its recycling targets remain challenging.

Wood waste recycling rates in the UK are currently about 75%. *The Strategy for Sustainable Construction* will help to increase wood recycling rates, and further policy development in this area will be informed by the outcome of an ongoing wood waste research project.

Green-Works furniture reuse programme

© Green-Works

Green-Works is an environmental social enterprise and registered charity. The Green-Works furniture reuse programme sees high quality furniture from large organisations sold back into local communities – charities, small businesses, and volunteer organisations – for a fraction of their original price, or donated to poor communities overseas.

Nothing is wasted at Green-Works. Items get stripped down for component parts and different materials for use elsewhere, old desks are remanufactured in-house to create new items that will last for years; recycling is a last resort for unreuseable metal and plastic components and scraps of wood.

The reuse programme has been running for 10 years. Over that time GreenWorks have diverted more than 63,000 tonnes of office and school furniture from landfill. In 2009, 313,573 items of furniture were diverted through a combination of reuse, remanufacture and recycling. The skills involved in these processes mean that for every 1000 tonnes of furniture reused Green-Works has created more than 20 jobs. Consequently Green-Works has created volunteer opportunities and paid training for over 200 people from deprived areas across the country.

Slough Heat and Power supplies electricity, hot water and steam to local businesses

Slough Heat and Power's combined heat and power (CHP) plant, a wholly owned subsidiary of Scottish and Southern Energy plc, has a potential generating capacity of 80 megawatts. It produces electricity and heat, with the latter being distributed via a steam and hot water distribution network. There are also around 100 kilometres of underground electricity cables connected to the power station and local grid which supply the surrounding Slough Trading Estate.

The CHP plant is the UK's largest dedicated biomass energy facility. Its main sources of fuel are wood chips, biomass and waste paper. The plant uses approximately 3,500 tonnes per week of clean, untreated waste wood from pallets, packaging and demolition and 1,250 tonnes per week of non-recyclable packaging, paper and card. The lifetime emissions savings achieved by diverting this amount of waste from landfill is approximately 100 $ktCO_2e$ per year that the diversion occurs, with additional savings made by producing heat and electricity from biomass.

Defra provides a range of targeted support to help encourage composting of food and green waste. For example, WRAP has worked with local authorities and other partners to improve the uptake of home composting through the distribution of approximately 1.6 million home composting bins to households across the country, which has meant that over 260,000 tonnes of waste have been diverted from the waste stream each year.

Anaerobic digestion is a proven technology for recovering organic waste to land. Organic matter is broken down to produce renewable energy in the form of biogas and the treated material (or digestate) can be used as a fertiliser and soil conditioner. The Government is taking forward a wide range of actions to promote anaerobic digestion. For example, the WRAP Organics Capital Grant Programme provides financial assistance towards the capital costs of plant equipment and infrastructure for food waste processing capacity, including anaerobic digestion and in-vessel composting. Other anaerobic digestion support measures are covered below.

Supporting energy from waste

In general, biodegradable waste that cannot be prevented, re-used or recycled should be used to generate energy including electricity, heat or fuel for use in transport. Defra is working closely with a number of other Departments – including BIS, the Department of Energy and Climate Change (DECC), the Department for Transport (DfT), and the Department for Communities and Local Government (CLG) – to remove the barriers to recovering energy from waste, which include the lack of infrastructure, security of waste supply, and collection and sorting arrangements which are not fit for purpose.

The *Renewable Energy Strategy*[54], published in July 2009, sets out in detail what the Government is doing to increase the generation and use of energy from renewable sources, including waste.

54 Available via DECC's website http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx.

The Government's policies to encourage energy from waste include the following:

Financial support

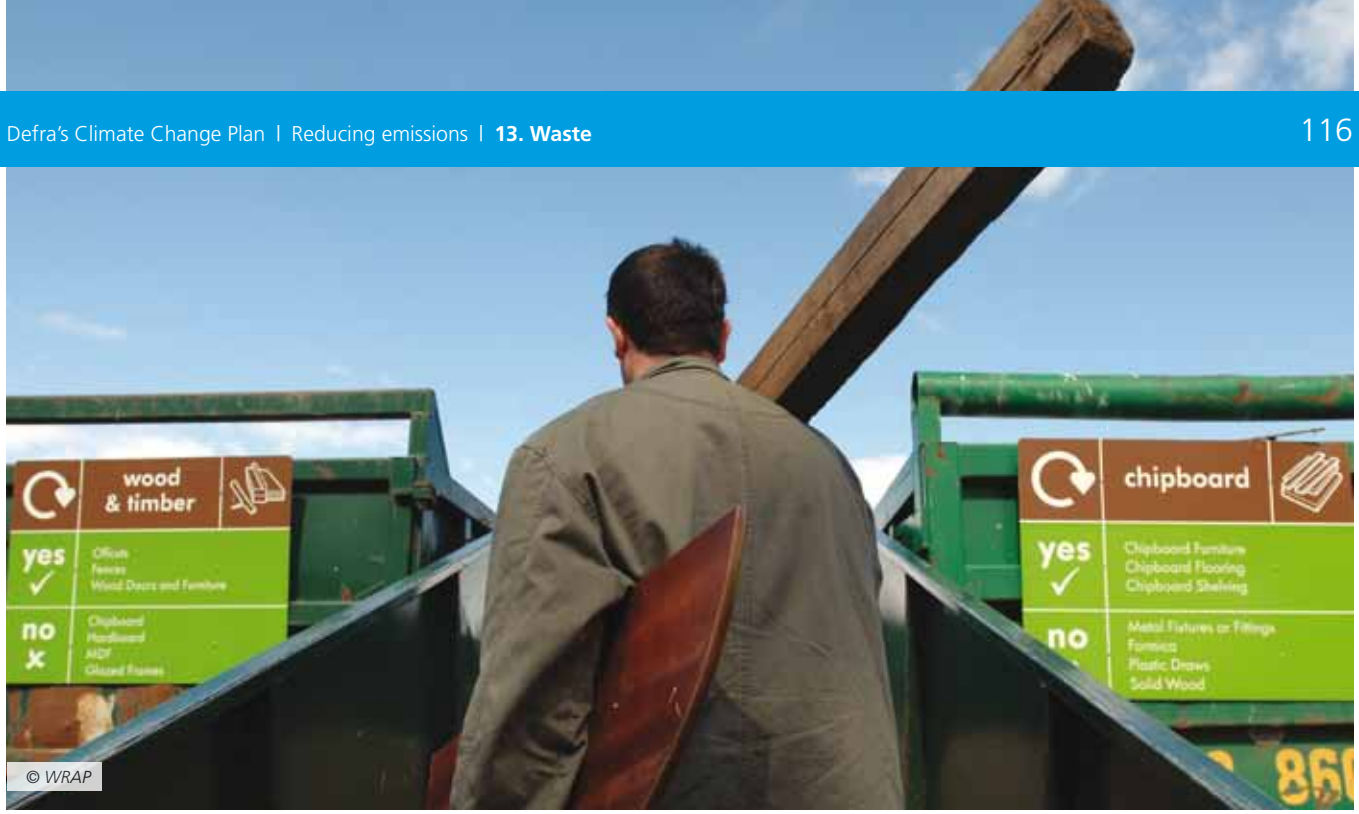
- Energy from waste facilities are exempt from the Climate Change Levy, and may also benefit from enhanced capital allowances.
- The Government has reopened the Bioenergy Capital Grants Scheme which promotes the early deployment of biomass energy plants.
- A fund of £10 million has been made available for a series of projects demonstrating innovative use of anaerobic digestion.
- Defra is providing substantial financial support to local authorities to invest in residual waste infrastructure, including energy from waste facilities, through Private Finance Initiative credits.

Creating markets for energy produced from waste

- Renewable electricity from waste receives Renewables Obligation Certificates (ROCs), which generators can sell to generate income in addition to the market price received for the electricity. The ROC system was recently extended to 2037 and the banding was reformed to provide greater support to anaerobic digestion, increase investor certainty, and remove barriers to the use of solid recovered fuel.
- The Feed-In Tariff scheme, to be introduced in April this year, will guarantee a minimum payment per unit of renewable electricity for small scale electricity generators. A specific 'farm-scale' anaerobic digestion Feed-In Tariff will be introduced.
- The Renewable Heat Incentive (RHI), to be introduced in April 2011, will guarantee a minimum payment per unit of heat from renewable sources, which will encourage the capture and use of heat from anaerobic digestion and waste combustion plants. It will also provide support for the injection into the gas grid of biomethane (biogas upgraded to pipeline quality).
- The Renewable Transport Fuel Obligation (RTFO) requires fossil fuel suppliers to ensure that 3.25% (rising to 3.5% in 2010/11) of their fuels for road transport comes from renewable sources, including those produced from waste (eg. used cooking oil and biomethane). The Department for Transport will be consulting later this year on changes to the RTFO required under the Renewable Energy Directive (RED). As part of these changes, the contribution made by biofuels produced from wastes is proposed to be considered twice as valuable as that made by other biofuels and so could receive double the support.

Addressing practical issues

- **Ensuring a secure supply of quality fuel.** Policy measures such as the landfill tax escalator provide a secure and accessible stream of waste for energy. If they were introduced, landfill restrictions could also have a role to play here.
- **Managing wastes generated during the energy recovery process.** For example, to help facilitate the development of the market for the digestate produced by anaerobic digestion plants, the Environment Agency published a *Quality Protocol* in 2009, setting out conditions for the production and use of quality digestate. Work is currently underway on an industry certification scheme to support the *Quality Protocol*.
- **Enabling Combined Heat and Power (CHP) plants to get the right support through ROCs and the RHI.** For example, by developing an online tool which enables the determination of the energy content from the biomass fraction of a mixed waste stream (e.g. solid recovered fuel).
- **Providing advice and information.** For example, in Spring 2010 Defra published an Implementation Plan of practical actions for anaerobic digestion, including the new web-based advice portal by the National Non Food Crops Centre, supported by Defra and DECC.



© WRAP

Helping people to choose the right waste management options

A wide range of individuals and organisations are involved in making decisions about how to manage waste at the local and regional level, such as local waste-collection and disposal authorities, Regional Development Agencies and Government Offices. A range of information tools are being developed to ensure they receive the correct direction and guidance from central Government on how best to manage waste, as it is not always clear how to implement the waste hierarchy (e.g. decisions on whether to recycle wood waste or burn it to produce heat and electricity depend upon the grade and quality of the waste wood).

Waste Management services

Waste management and recycling is an essential public service, and it is critical that local authorities offer an effective and efficient service. To help them do so, Defra is developing guidance which identifies the most sustainable waste management option or technology according to the type of waste material. This guidance is being informed by a number of research projects currently underway.

Planning

Developing better uses for waste is an essential part of the planning system's wider objectives for making preparations for low-carbon living. The planning system is key to the adequate and timely provision of the facilities and infrastructure needed to manage waste in a sustainable manner and to move waste up the waste hierarchy (see figure 10). Planning authorities are required by law to have regard to the waste hierarchy when undertaking many of their planning functions (e.g. when producing development plan documents) and CLG's *Planning Policy Statement 10: Planning for Sustainable Waste Management*[55] provides the overarching policy framework on how this should be done. CLG intends to update PPS10 by December 2010 to reflect the new waste hierarchy set out in the revised Waste Framework Directive.

The right energy from the right waste using the right technology

Within the overarching waste hierarchy, there is a hierarchy of different energy from waste technologies. For example, combined heat and power (CHP) plants are, in most cases, preferable to incinerating waste solely for electricity, because the heat produced in the process can be captured and used.

55 Available via http://www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/mineralsandwaste/wastemanagement/pps10

Defra has established a project, involving DECC, HM Treasury, BIS, DfT and CLG, to clarify the Government's stance on energy from waste, to encourage appropriate industry development and investment, and to ensure that the development of energy from waste is environmentally sustainable. This project is working to provide more detailed guidance for waste management operators, including local authorities, on recovering the right energy from the right waste with the right technology in the right place.

Waste collection and sorting

Dealing with different types of waste in different ways requires properly planned and co-ordinated collection and sorting. One of the options under consideration as part of the consultation on landfill restrictions is to introduce a requirement to sort. This will make it easier to divert specific waste materials from landfill and ensure they are directed towards the most appropriate treatment option.

The separate collection of food waste is crucial for anaerobic digestion. The Government has taken a number of steps to encourage separate collection, including the following:

- Defra has given WRAP £3.5 million to help local authorities pilot or improve food waste collections.
- WRAP, through its Recycling and Organics Technical Advisory Team (ROTATE), also undertake research and provide tailored advice to local authorities on developing recycling services with a priority area being food waste collections.
- *The Code for Sustainable Homes* encourages developers to provide facilities to compost household waste, reducing the amount sent to landfill. In December 2009, CLG launched a consultation on proposed improvements to the Code. CLG also plans to start an evaluation later in 2010 of a number of technical parts of the Building Regulations, including Part H6 and associated guidance on provision for the storage of solid waste, looking at what changes might be considered for the next revision of the Building Regulations in 2013.
- To make it easier for small businesses to recycle their commercial and industrial waste, Defra is funding pilot trade waste collection schemes.

Capturing more methane emissions from landfill

Landfills will continue to generate methane over the coming decades, both because some biodegradable waste will continue to be landfilled, and because waste that was landfilled in the past will continue to decompose for many years.

Defra is working to ensure that as much methane as possible is captured from landfill sites and then either used to produce energy or converted to CO_2 through flaring. Electricity produced in this way receives support through ROCs, and heat could qualify for the RHI, depending on the outcomes of the RHI consultation.

The Environment Agency has redrafted and re-issued its guidance on landfill engineering and landfill gas management, and the industry has developed a code of best practice. In 2008, the Environment Agency introduced a programme of technical assessments ('audits') of landfills to identify improvements that can be made to increase levels of methane capture.

Recycling food waste © WRAP

Reducing emissions

14. Fluorinated gases & industrial process emissions

The challenge

Fluorinated gases, or 'F-gases', are greenhouse gases that are used mainly as a refrigerant in commercial refrigeration and air-conditioning equipment (including in cars). F-gases have some more specialised uses as well, such as the Perfluorocarbons (PFCs) which are used in fire protection equipment, or in high voltage switchgear where they are used as an insulating gas (sulphur hexafluoride).

In the F-gas sector, total emissions for 2008 according to the Greenhouse Gas Inventory were 12.1 $MtCO_2e$. This was split into the following gases:

Type of F-gas Emissions 2008	
Hydrofluorocarbons (HFCs)	11.2 $MtCO_2e$
Perfluorocarbons (PFCs)	0.2 $MtCO_2e$
Sulphur Hexafluoride (SF6)	0.7 $MtCO_2e$

A Defra study from 2007 indicated that 27% of total HFC emissions related to air conditioning and commercial refrigeration, with the UK food retail sector accounting for 56% of this figure[56].

Summary

- There has been a significant fall in fluorinated gas (F-gas) emissions since the mid-1990s.
- Regulatory measures were introduced from 2008 to clamp down on leakage and reduce emissions.
- The Government is pushing for an international agreement to pave the way for major worldwide reductions in F-gas consumption and production.
- Nitrous oxide and methane emissions from industrial processes have fallen 90% since 1990. Defra is exploring the scope for further reductions.

56 http://www.defra.gov.uk/environment/quality/air/fgas/documents/fgas-report-1107.pdf

Considerable progress has been made to date in reducing F-gas emissions and there has been a decrease of 5.1 $MtCO_2e$ since 1990 (a 30% reduction). This reduction is shown in figure 11, alongside that for methane and nitrous oxide from industrial processes (see box on page 121).

Progress to date is a result of a comprehensive EU framework of controls, underpinned in the UK by the Fluorinated Greenhouse Gases Regulations 2009, which prescribe offences and penalties applicable to non-compliance with the EC provisions. The principal objective of these measures is to contain, prevent and reduce emissions of F-gases. For example the framework of controls establishes minimum personnel qualification and company certification requirements, in order to avoid unnecessary emissions and ensure proper recovery of F-gases.[57]

As stated in the *UK Low Carbon Transition Plan*, F-gas emissions are expected to decrease by some 1.9 $MtCO_2e$ between now and 2020, due largely to a continued reduction in leakage rates, increased efficiency as older units are replaced by more efficient ones, and market penetration of lower/no global warming potential (GWP) refrigerants such as hydrocarbons, CO_2 and low GWP HFCs.

Defra has commissioned a study looking at future HFC consumption and emissions, aimed at improving the quality of our data, which will inform the UK's negotiating position for an international HFC emissions reduction arrangement (see below).

Meeting the challenge

The Government wants to see continued progress towards the reduction of F-gas emissions and increasing use of alternatives where this makes commercial and environmental sense.

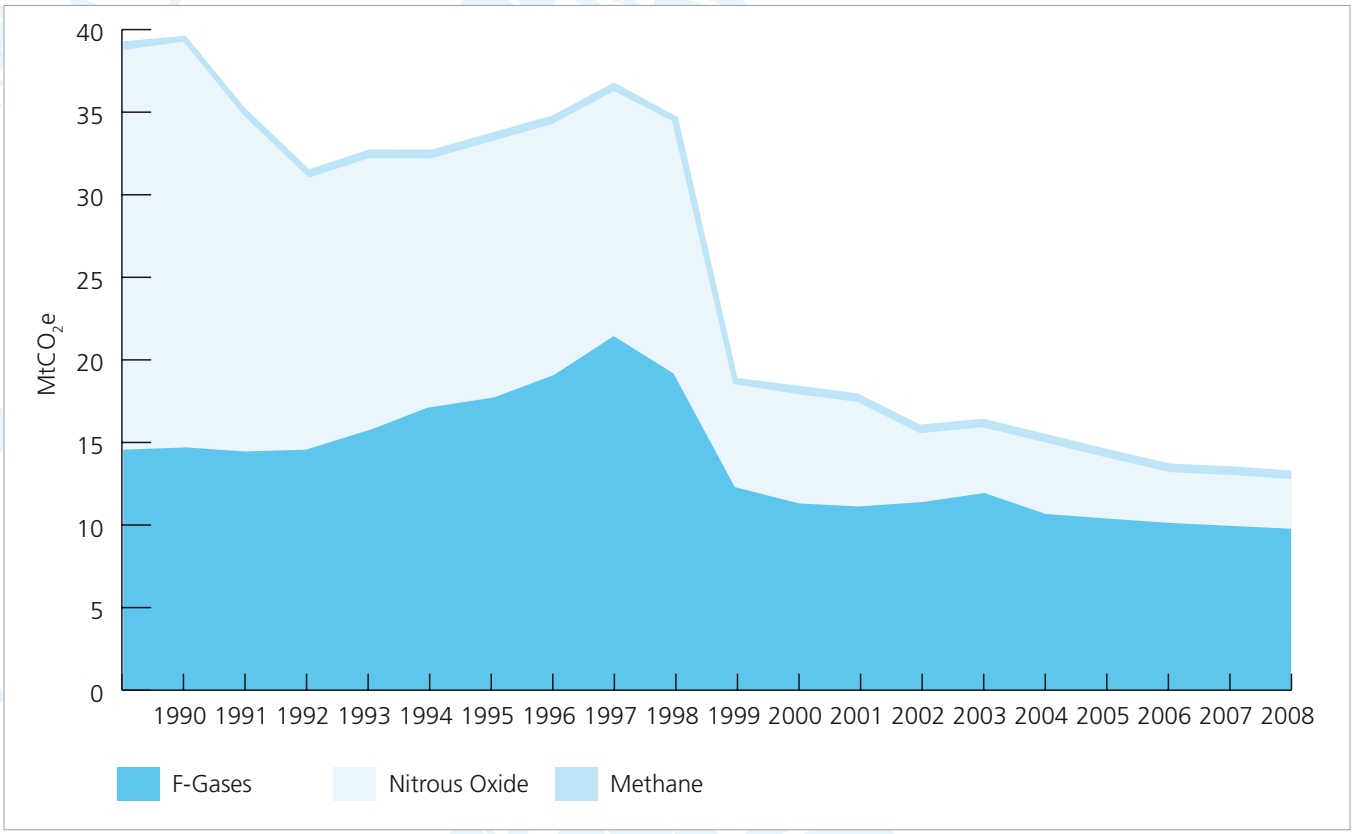


Figure 11: *Historical non-CO_2 greenhouse gas emissions from Industrial Processes and Fluorinated Gases*

57 Under the regulations only qualified personnel can carry out skilled tasks involving F gases, and only certified companies should provide work with F gases that involves breaking into circuits.

Fluorinated gases are often used in commercial refrigeration.

Domestically, to back up the F-gas Regulations, the Government sponsors a business advice unit called F-Gas Support[58], which offers guidance to all organisations covered by the F-gas Regulations in order to help them comply with their obligations. F-Gas Support is encouraging the largest emitters and other major users of equipment containing F-gases to sign Compliance Assistance Agreements (CAAs). These voluntary agreements require organisations to provide data showing how they are complying with the F-gas Regulations. Reducing emissions from supermarkets is a key focus of this work (see box on Supermarket Actions on page 121).

Potentially very ambitious F-gas reductions are in the pipeline. Defra has been working with DECC to push for an international agreement to progressively reduce the production and consumption of HFCs. Such an agreement could pave the way for a significant reduction of production and consumption, perhaps as much as 90% by 2030/35.

The European Commission must review all the provisions of the EU F-gas Regulation and produce a report and proposals by July 2011 on whether further action should be taken to reduce F-gas emissions. Everything within the Regulation is open to review, including the possibility of introducing new use bans. An advisory group is to be set up to inform this process and the UK will play an active role in these discussions.

58 http://fgassupport.com/

Supermarket actions to reduce emissions

HFC emissions from the ten largest supermarket companies represent almost 60% of F-gas emissions from the food retail sector. There is potential for substantial emissions reductions in this area, through reducing leaks or using refrigerants with much lower, or no, global warming potential (GWP). Regulations relating to testing, automatic leak detection, and record-keeping ensure that supermarkets are working to avoid leakage. But some supermarket companies are going beyond regulatory requirements and adopting measures to make further emissions reductions, including:

- converting existing refrigeration plants to use HFC blends with half the GWP of more established refrigerants. This can lead to a 70% reduction in leakage emissions and a 10% reduction in energy related emissions. Some of the large supermarket companies already have major retrofit programmes in train;
- better system design, installation and commissioning improved HFC refrigeration equipment. One supermarket company has found that a strict approach to design and installation has reduced leakage from new systems by a factor of ten during the first year of plant operation;
- using alternative refrigerant systems. Several supermarket companies have voluntarily announced they will adopt CO_2 as the refrigerant of choice on all or most new installations.

Nitrous oxide & methane emissions from industrial processes

Certain industrial processes emit nitrous oxide or methane, as well as carbon dioxide. While carbon dioxide emissions from industrial installations are covered by the EU Emissions Trading System (EU ETS), Defra is responsible for the regulatory framework through which nitrous oxide and methane emissions are dealt with. In 2008, emissions of these two greenhouse gases from the industrial processes sector totalled 2.6 $MtCO_2e$. This was primarily made up of nitrous oxide emissions (2.5 $MtCO_2e$). These nitrous oxide emissions are now dominated by two chemical production installations in England, while the methane emissions are derived from fewer than ten installations in the steel and chemicals sector. The Environment Agency is responsible for regulating these installations.

Since 1990, emissions in this area have decreased dramatically, by 22 $MtCO_2e$ (90%). This is the result of contracting industrial activities and improvements in process control. Those improvements will have been driven largely by regulation, at first under the UK's integrated pollution control system and, since the middle of this decade, under the EU's integrated pollution prevention and control (IPPC) Directive.

Going forward, baseline emissions are expected to fall further to below 2.5 $MtCO_2e$ by 2020, as a result of further contraction in industrial activities and possibly further tightened IPPC requirements. Defra will shortly complete an assessment of the permit conditions on the major nitrous oxide emitting installations to establish if any further cuts in emissions would be viable and appropriate.

Reducing emissions

15. Water availability & quality

The challenge

Water usage contributes to greenhouse gas emissions in several different ways. First there are the essential – and energy-intensive – operational activities which supply us with clean water: pumping, treatment and distribution. Then there is the emissions impact of heating water once it has reached our homes and workplaces. Finally there are the emissions associated with the treating and handling of wastewater.

This is a challenging area in which to try to cut emissions. Clean water is essential to all our lives. Treating water is energy-intensive, and water quality standards (largely driven by European legislation) are likely to tighten over the next few years, increasing the carbon cost of water treatment. At the same time, demographic changes, such as population growth and a smaller average household size, are likely to require more drinking water to be supplied and wastewater to be treated.

As described in Chapter 3, the changing climate will make the challenge stiffer. The UK Climate Projections 2009 forecast a decline in overall levels of rainfall, but an increase in the number of severe storms likely to hit the UK. Both these changes would lead to upwards pressures on emissions. For example, an overall fall in water levels would reduce river flows and the ability of receiving waters to cope with sewage and pollution, increasing the need for further treatment. A rise in the number of violent storms would require more pumping of surface water with an associated increase in energy use.

Summary

- Water has a significant emissions impact: we need to be more efficient in the way we supply and use water.
- The Government's water strategy for England, *Future Water*, was published in 2009.
- The Government is working to reduce average daily individual water consumption from 150 litres to 130 litres, including through a £1m *Act on* CO_2 campaign.
- Significant progress has been made in reducing water leakage from supply. Defra is working with industry and Ofwat to increase operational efficiency.

Meeting the challenge

To reduce emissions associated with water, we need to make the way it is used and supplied more efficient. Using less water means reducing emissions at every stage in the process: pumping, treatment, distribution, heating, and wastewater handling. To that end, Defra, working closely with other key departments, has put in place a number of measures aimed at the public and at the water industry. Water efficiency is also vital to the adaptation agenda, so in many cases the actions Defra is taking are 'win-win's – policies that will help us adapt to climate change while also cutting emissions. The measures below, designed to make water usage more efficient, are covered in more detail in the adaptation section on pages 56 and 57:

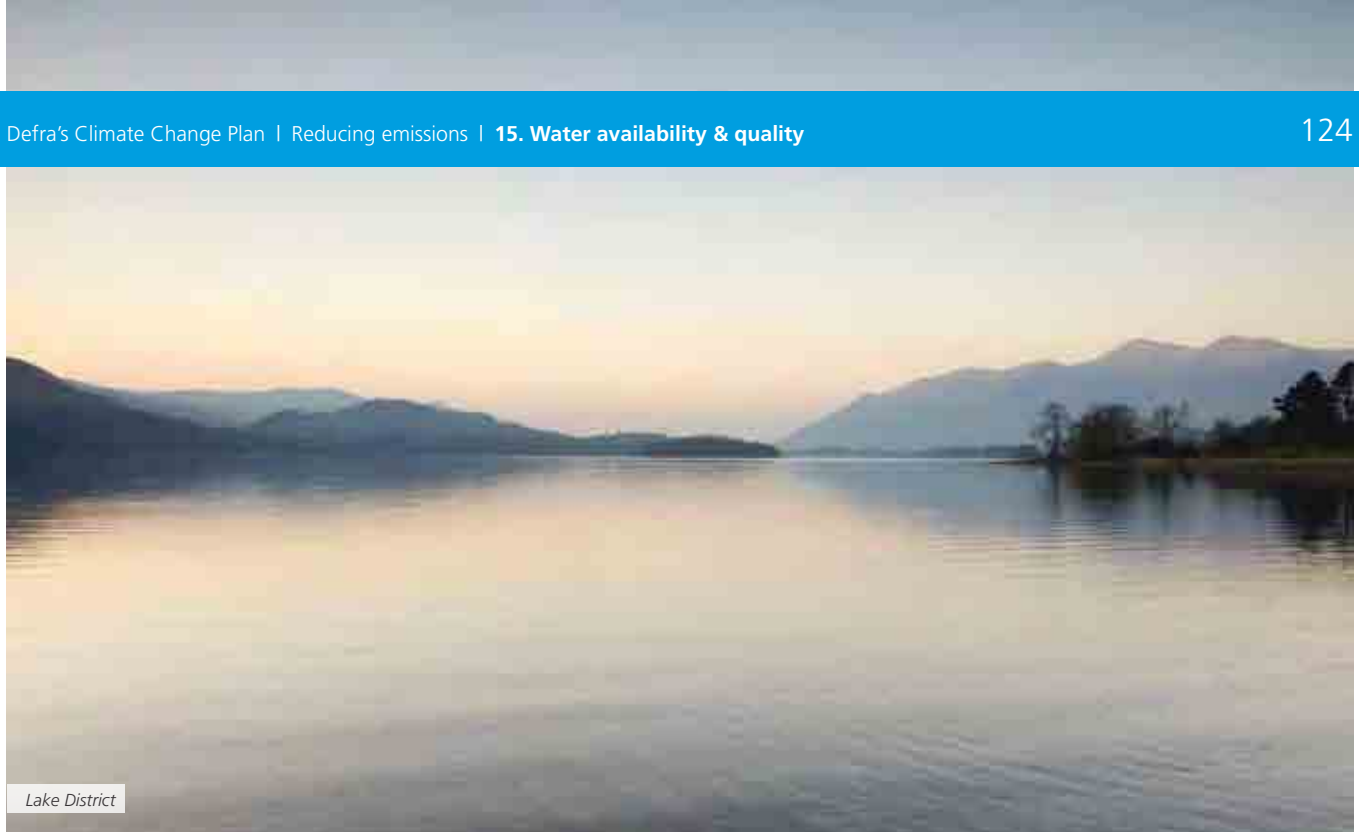
- The Government's water strategy for England, *Future Water*,[59] set an ambition to reduce a person's average daily water consumption from 150 litres to 130 litres.
- A £1 million *Act on CO_2* campaign, launched in September 2009, informs consumers of the energy and carbon implications of water use, and how they can help save water and emissions.
- As set out in Ofwat's 2009 Price Review, metering is to increase to 50% by 2014-15. The Government is considering metering policy in light of the Walker Review which was published in December 2009.

The Government also supports a number of programmes to encourage sustainable water consumption by businesses, such as the Enhanced Capital Allowance scheme for water efficient technologies.

As well as making demand more sustainable, we need to make systems of supply more efficient. Already, major efficiency gains have been made in operational activities. The water industry now uses around 10% less energy to deliver a unit of water and treat a unit of wastewater than it did five years ago. As noted earlier, since 1994-95, leakage from the supply network has fallen by about 37%, with enough water saved to supply the daily needs of over 12 million domestic customers. These are major improvements, but we need to go further. Ofwat has set new water efficiency targets for water companies for 2010-2014 to achieve water savings of 23 million litres per day. The Government has made it clear that it does not rule out taking forward a water efficiency commitment should water usage per head not fall sufficiently through other measures.

Ofwat's Price Review 2009 required companies to use the Shadow Price of Carbon in their cost-benefit appraisals of their capital programmes. This ensures companies put a value on carbon for both operational and embedded emissions.

59 http://www.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf



Lake District

Northumbrian Water and United Utilities – online carbon and water calculators

Most people don't consciously think about the water that they use in their everyday lives, let alone the energy used to pump, treat, clean and heat it. Water use in our homes accounts for about 5% of the UK's total greenhouse gas emissions, mostly due to the energy needed to heat it for washing, cooking, and cleaning. Reducing wastage of water, particularly hot water, is a simple and effective way of reducing greenhouse gas emissions and saving money on household bills.

Two water companies, Northumbrian Water and United Utilities, have each developed web-based carbon calculators to show the link between water and energy use. Customers can see how much water is being used at their home, and where, as they answer questions about their appliances and habits. They can also see how much carbon is being produced to meet their demand for water and where simple changes can reduce both their water use and carbon footprint.

http://www.nwl.co.uk/CarbonCalculator.aspx
http://www.unitedutilities.com/CalcCarbonWater.htm

Water companies are seeking to ensure that at least 20% of all energy used by the industry comes from renewable sources by 2020. Currently the water industry generates renewable energy from anaerobic digestion, wind and hydropower, representing around 750 GWh per year. Together with purchased accredited renewable energy, this totals about 17% energy use from renewable sources.

Tackling emissions from wastewater is very challenging, as the level of emissions is so contingent on population. One way to reduce the negative impact of wastewater is to capture the methane emissions and convert them into energy. Government provides an incentive for this process through a Renewables Obligation Certificate (ROC) (see page 115 for a description of ROCs). In 2008-2009 water companies beneficially recycled 84% of their sewage sludge, mainly by sending it for anaerobic digestion, to agriculture, and for land reclamation.[60]

60 Water UK sustainability indicators 2008-09

Reducing emissions

16. Marine and fisheries

The challenge

The marine environment plays a vital role in natural carbon storage and cycling. The world's oceans have absorbed about 25% of all the carbon dioxide emitted globally as a result of human activities over the last 200 years.[61] Ocean acidity has increased by 30% over the last 200 years, the fastest rate at any time in the last 65 million years.[62]

Ocean acidification, and other consequences of carbon dioxide emissions, pose a serious risk to global food webs, ecosystems, and biodiversity:

- the more carbon the upper ocean stores, the less it can absorb in the future – so the effect of the oceans in slowing climate change could diminish;
- increasing acidity and rising sea surface temperatures could damage marine carbon stores such as kelp forests. It is estimated that over half of the carbon captured each year by the world's biological systems is "blue carbon" in marine ecosystems, not only in the oceans but also in salt marshes and seagrasses.[63]

Summary

- Marine waters are vital carbon sinks: the world's oceans have absorbed 25% of all the carbon dioxide emitted from human activities over the past 200 years.
- Climate change and ocean acidification are affecting the oceans' ability to store carbon.
- Defra is co-funding (with the Natural Environment Research Council and the Department of Energy and Climate Change) the £12m UK Ocean Acidification Research Programme to understand better the implications of ocean acidification and its impacts on the whole earth system.

61 Sabine, C.L., Feely, R.A., Gruber, N., Key, R.M., Lee, K., Bullister, J.L., Wanninkhof, R., Wong, C.S., Wallace, D.W.R., Tilbrook, B., Millero, F.J., Peng, T.-H., Kozyr, A., Ono, T. and Rios, A.F., 2004. The Oceanic Sink for Anthropogenic CO_2, Science 305: 367-371.

62 MCCIP (2009), Marine Climate Change Ecosystem Linkages Report Card 2009. (Eds. Baxter JM, Buckley PJ and Frost MT), Summary Report, MCCIP, Lowestoft, 16pp. P.5

63 Nellemann, C., Corcoran, E., Duarte, C. M., Valdés, L., De Young, C., Fonseca, L., Grimsditch, G. (Eds). 2009. *Blue Carbon*. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal, www.grida.no, p.6

Waves crashing against Kynance Coves. These coves are protected by the National Trust.

Reducing global emissions will help to protect the marine environment, but we need to better understand the impacts of climate change and ocean acidification on its ability to absorb carbon. Unlike changes in terrestrial carbon balances in trees, plants, and soils, changes in marine carbon balances are not currently included in international greenhouse gas emissions reporting or targets. But it is estimated that over the next 20 years, preserving and recovering blue carbon sinks could contribute to tackling global emissions on the same scale as reducing deforestation[64]

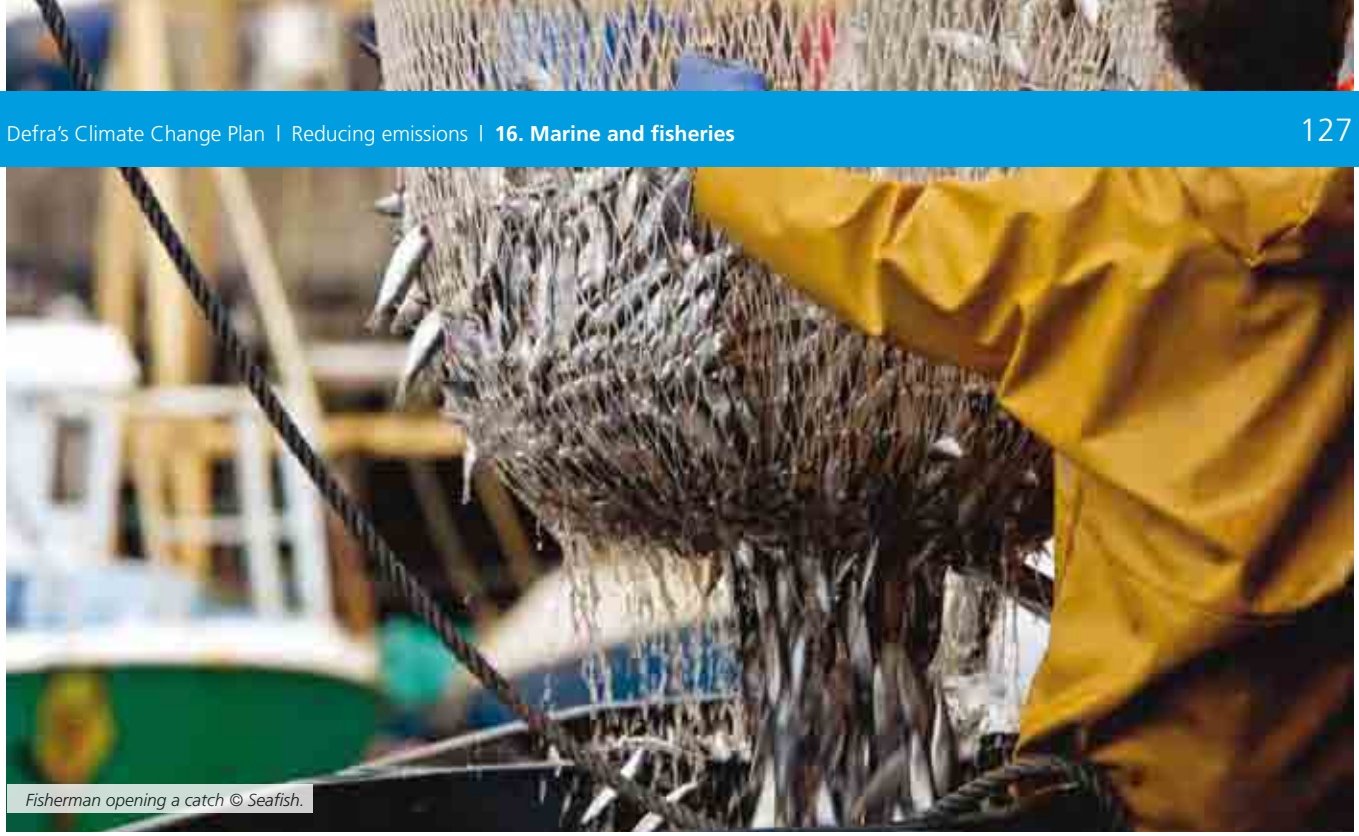
Meeting the challenge

Defra, together with DECC and the Natural Environment Research Council (NERC), recently launched the UK Ocean Acidification Research Programme. The Programme is providing £12 million over five years to drive forward research on the implications of ocean acidification, its risks to marine biogeochemistry and biodiversity, and its impacts on the whole Earth System.

Defra is also working with DECC to understand and manage the risks to the marine environment. This will enable the new Marine Management Organisation to ensure that any new energy development including wind, wave, tidal, oil and gas takes the marine environment into consideration, bearing in mind that offshore wind in particular is expected to play a substantial part in meeting our renewable energy targets.

Defra will also ensure that the storage of carbon dioxide in sub-seabed geological formations as part of the Carbon Capture and Storage process is taken forward in line with the environmental safeguards provided for by our international obligations, including those under the OSPAR Convention and the London Protocol.

64 Nellemann, C., Corcoran, E., Duarte, C. M., Valdés, L., De Young, C., Fonseca, L., Grimsditch, G. (Eds). 2009. *Blue Carbon*. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal, www.grida.no, p.6



Fisherman opening a catch © Seafish.

Reducing emissions from the fishing industry

Defra is also looking at some of the factors which affect greenhouse gas emissions from fisheries. Fisheries account for around 1.2% of global oil consumption.

For example, Defra ran the Environmentally Responsible Fishing Project, a pilot study which concluded in November last year, designed to measure the environmental and economic impact of commercial fishing vessels targeting quota species in inshore waters. The data collected includes information on the factors which affect emissions, including the gear type and engine efficiency of vessels and the distances travelled to reach different fishing grounds.

Defra will publish its findings from the project later this year.

Seagull on the Gweek Creek.

Defra's Climate Change Plan

Carbon Reduction Delivery Plan

This section sets out how Defra will deliver the actions to reduce emissions set out in chapters 9 to 16. It covers the following:

1. The carbon budget process and what Defra's carbon budget looks like;
2. The governance structures put in place to manage the carbon budgets process and the roles and responsibilities of different organisations, including the Devolved Administrations;
3. Delivery milestones over the next decade;
4. The indicators which will be used to track progress;
5. The work Defra is taking forward to improve the evidence base for climate change mitigation policy.

Carbon Reduction Delivery Plan

17. What is Defra's carbon budget?

The 2009 *UK Low Carbon Transition Plan* introduced the concept of "Departmental carbon budgets" as a way of providing Government Departments with accountability for reducing greenhouse gas emissions. This new approach is the first time any government has introduced such a mechanism, and it serves as a pilot that will be reviewed ahead of the second budget period (2013-2017).

Each Government Department holds a carbon budget covering the emissions from its own estate and operations, and several Departments, including Defra, hold a sectoral carbon budget made up of a proportion of the emissions in the sectors over which they hold a degree of influence. This chapter focuses on Defra's sectoral carbon budget. The emissions from its estates and operations are covered on pages 162 – 166.

Defra's sectoral carbon budget is made up of shares of six sectors of the economy. The largest of these are in the Agriculture, Forestry and Land Management (AFLM) sector and Waste sector where Defra holds the majority of policy levers (see Chapters 9 to 11 and 13) and is the lead Department (see roles and responsibilities, Chapter 18).

Defra has a substantial share of the Industrial Processes sector (led by DECC) which reflects the Department's leading role on fluorinated gas policy in the UK (see Chapter 14), and its regulatory role in relation to non carbon dioxide greenhouse gases from industrial processes (see page 121). Defra also has a relatively small share of emissions in the Heating Workplaces and Homes and Communities sectors (led by DECC and CLG respectively). This is because of the influence Defra has on sustainable consumption and production (see Chapter 12). Finally, Defra also has a small share of the Transport sector, as food freight is a considerable proportion of overall UK transport. Figure 12 illustrates how Defra's carbon budget is made up from the different sectors.

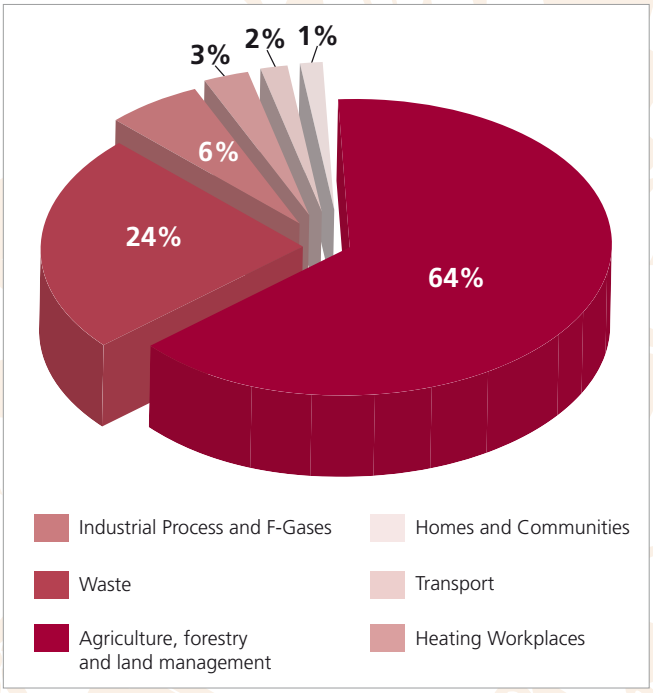


Figure 12: *Defra's Carbon Budget*

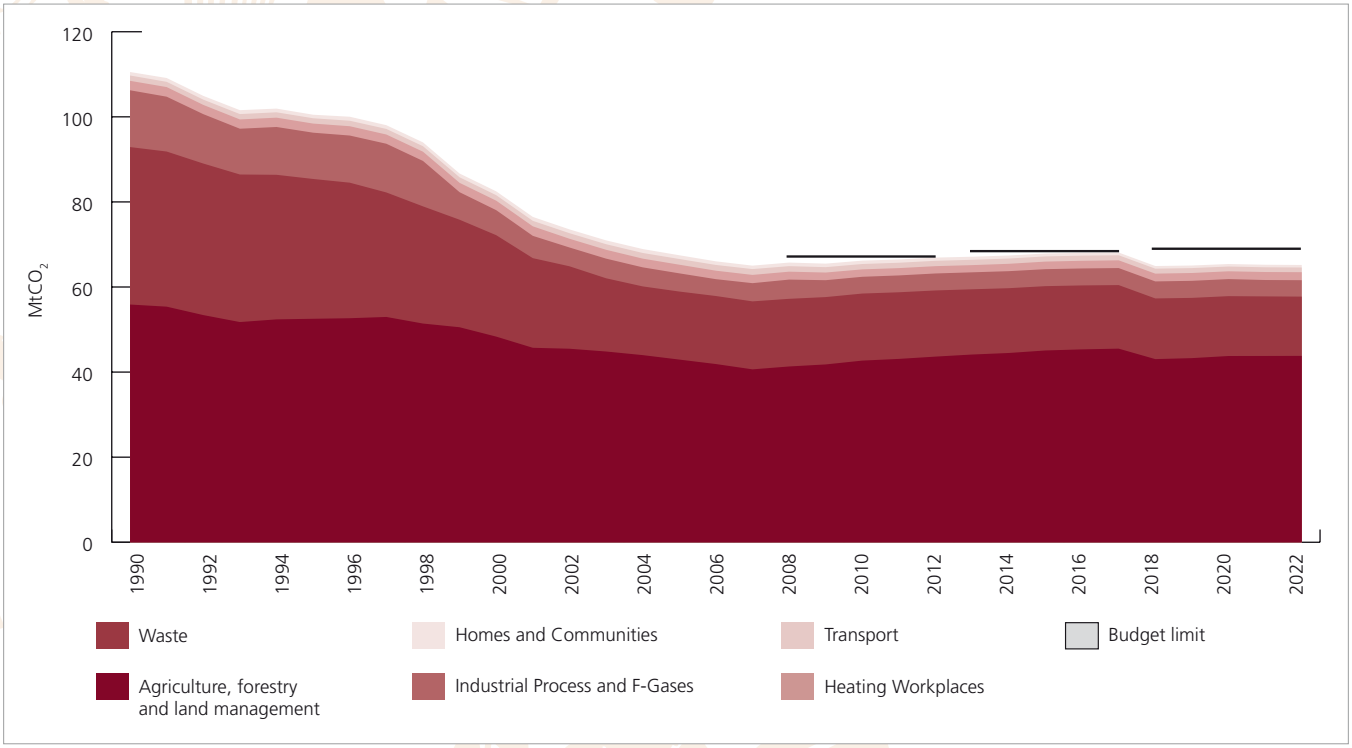


Figure 13: *Defra's first three carbon budgets (2008 – 2012, 2013 – 2017, 2018 – 2022), compared with projections of the related emissions over the same period. This clearly shows that Defra expects to keep emissions below the carbon budgets in all three periods.*

Carbon Reduction Delivery Plan

18. Governance, roles and responsibilities

How Defra is organised to deliver

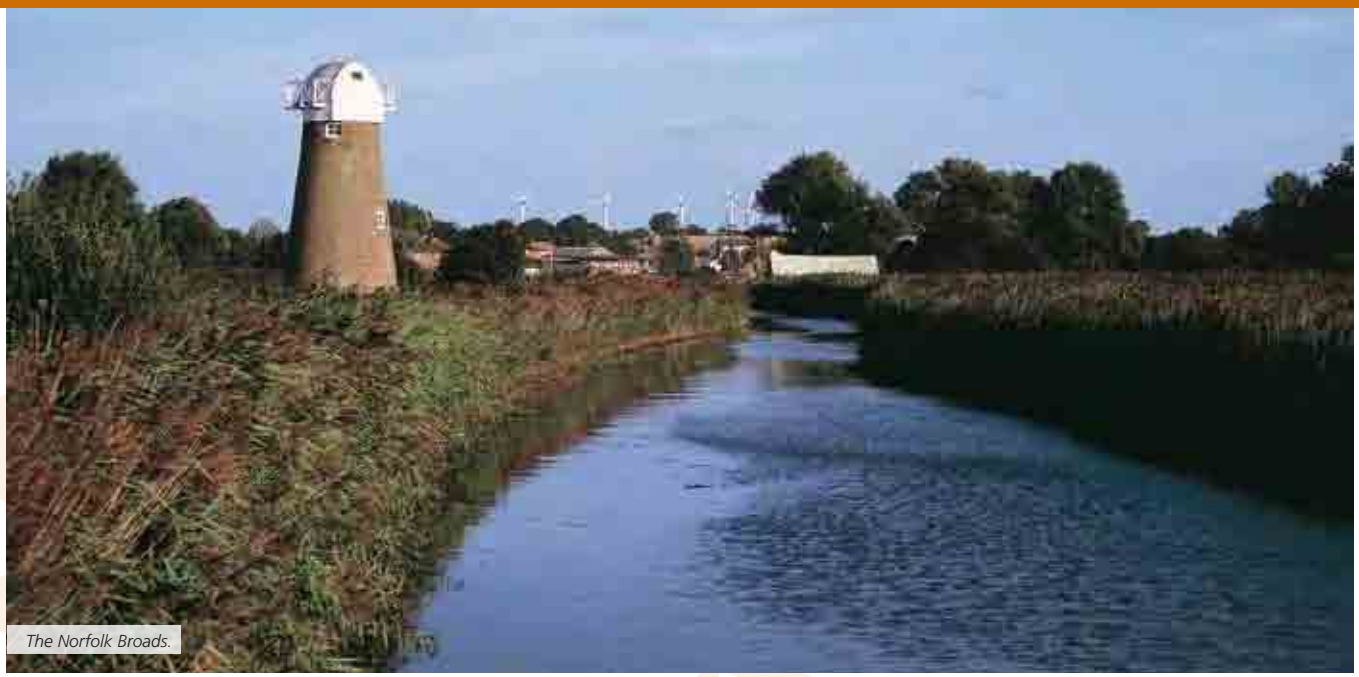
Defra has established a Climate Change Mitigation (CCM) Programme to ensure it meets its departmental carbon budget. Within Defra, the Director for Climate Change, Air Quality, Landscape, and Rural Affairs (CALR) is the Senior Responsible Owner (SRO) for the CCM programme. As SRO, he also sits on the cross-Whitehall Delivery and Strategy High-level (DASH) Board. Responsibility for management of the Defra Climate Change Mitigation Programme rests with the Head of Climate Change Mitigation.

Working level leads in each of Defra's relevant policy areas, report to the CCM Programme Manager. These reports are fed into the Defra Climate Change Mitigation Programme Board, which reports directly to the Defra Management Board.

Working with others to deliver

Successfully combating climate change will involve a huge range of actors, from other Government Departments, to individual consumers. Defra's extensive delivery chain is summarised in the chart below:

Frontline / operational	The agriculture, land management, food, waste, industrial process and water sectors; individual consumers, retailers, and businesses; supermarkets, industry, producers of products containing fluorinated gases; the fishing industry.
Intermediary bodies	Industry bodies including the National Farmers' Union, the Country, Land and Business Association, the Agricultural Industries Confederation, and Water UK; third sector bodies and non-governmental organisations such as the Waste and Resources Action Programme (WRAP) and REalliance.
Central government	Other Government Departments, including HM Treasury, DECC, CLG, BIS, DfT and the Forestry Commission; International bodies such as the European Commission, the European Union, the United Nations; Advisory bodies such as the Committee on Climate Change; Regulators including Ofwat and the Environment Agency; Defra delivery agencies and Non-Departmental Public Bodies including Natural England and the Forestry Commission; Sub-national governmental bodies, such as Government Offices, Regional Development Agencies, and Local Authorities.



The Norfolk Broads.

Climate change in National Parks and the Broads

The English National Parks and the Broads are spectacular landscapes, rich in wildlife and cultural heritage. Together they make up 8% of England's land area, are home to 210,000 people, and attract 75 million visitors each year. The English National Park Authorities (NPAs) and the Broads Authority work closely with many partners, including the farming community, to help to look after these areas.

Climate change will significantly affect the National Parks and the Broads. Higher temperatures, changes in rainfall patterns, and sea-level rise will all have an impact. It is vital that these areas are well-managed, so they can adapt to these changes and continue to thrive, not least because they have a major role to play in reducing emissions. Peatlands and woodlands, so prevalent in National Parks, are very important carbon sinks (see Chapter 10). 119 Mt carbon is held in the 449,000 ha of peat soils in National Parks – equivalent to England's entire CO_2 emissions for one year.

The National Park Authorities and the Broads Authority have set out four key areas for actions in relation to climate change:

- a sustainable approach to land management, whereby the Authorities champion and support work to maintain and restore peatlands, fens, moors and woodlands;
- the development of rural low carbon communities, particularly the promotion of appropriate renewable energy and energy efficiency measures for protected areas through initiatives such as the Sustainable Development Fund;
- adaptation to climate change on a landscape scale, through, for example, expanding woodland habitat networks and wildfire risk management;
- engagement with the public on issues and solutions relating to climate change, including the 61,000 young people who come to National Parks on school visits each year.

The climate change work that is already happening in National Parks and the Authorities' ambitions for the future are described in more detail in a 2009 document published by the Authorities: *Climate Change Mitigation and Adaptation in National Parks*. This document can be downloaded at:

http://www.enpaa.org.uk/enpaa/whatsnew/climate_change_statement.htm

Central Government

The carbon budgets system ensures that each Government Department has responsibility for a share of the emissions in every sector it has influence over. Cross-Government working groups have been established for each of the carbon budget sectors. Defra chairs the working groups for the AFLM and Waste sectors, as the Department with the largest influence over emissions in those areas. All the Departments with a carbon budget stake in the sector are represented on the relevant working group, along with key delivery agencies and the Devolved Administrations. The make-up of these working groups is shown in the tables below.

Carbon Budgets Working Group on Waste

Organisation	Responsibility within the sector
Defra (Chair)	Lead on waste policy across Government.
Department of Energy and Climate Change	Lead on renewable energy policy including on energy from waste, which can play an important role in diverting waste from landfill.
HM Treasury	Controls levels and types of taxation, including the landfill tax.
Department for Business, Innovation and Skills	Has the ability to influence a major waste stream through its broad sponsorship of, and close working with, the commercial and industrial sectors.
Department for Communities and Local Government	Lead on planning policy across Government so has key influence on waste infrastructure; also has influence over local authorities who collect municipal waste.
Department for Transport	Similarly to DECC, DfT leads on the renewable fuels so has policy levers to influence levels of energy from waste.
Environment Agency	Regulates waste management activities in England, and advises Government, regional bodies and local authorities on waste.
Scottish Executive	Waste management and strategy is a devolved issue.
Welsh Assembly Government	Waste management and strategy is a devolved issue.
Northern Ireland Executive	Waste management and strategy is a devolved issue.
Committee on Climate Change	Lead on independent advice to the Government on climate change.

Carbon Budgets Working Group on Agriculture, Food, Forestry, and Land Management (AFFLM)

Organisation	Responsibility within the sector
Defra (Chair)	Lead on AFLM policy across Government
Department of Energy and Climate Change	Lead on bioenergy. The production of feedstocks for bioenergy within the UK could impact on emissions from this sector.
Department for Transport	Lead on biofuels for transport. The production of feedstocks for biofuels within the UK could impact on emissions from this sector.
HM Treasury	Lead on public spending and economic instruments, and their role within the sector.
Department for Business, Innovation, and Skills	Lead on science and innovation, including in this sector.
Department for Communities and Local Government	Lead on planning policy. Emissions from this sector can be affected by planning decisions on land use change, and on planning permission for anaerobic digestion plants.
Department of Health	Lead on healthy eating policy, and significant public food procurement via the National Health Service.
Department for Children, Schools, and Families	Lead on food education in schools, and significant public food procurement via the school system.
Scottish Executive	Policy in this sector is largely devolved.
Welsh Assembly Government	Policy in this sector is largely devolved.
Northern Ireland Executive	Policy in this sector is largely devolved.
Forestry Commission England	Lead on delivery of forestry policy in England.
Natural England	The Government's statutory advisor on the natural environment. Delivery of Environmental Stewardship, and farm advice.
Environment Agency	Regulates farming in England and Wales, and advisor to industry and Government on environmental impacts
Committee on Climate Change	Lead on independent advice to the Government on climate change.

Defra sits on each of the other working groups where it has a stake in the sector: Industrial Processes, Transport, Homes and Communities, and Heating Workplaces. Defra is also represented on the interdepartmental Carbon Budgets Working Group, the National Climate Change and Energy Programme Board, and the National Inventory Steering Committee.

Defra works with a range of sub-national governmental bodies, such as Government Offices, Regional Development Agencies and Local Authorities. These bodies have a particularly important role to play in reducing emissions from the waste sector. For example:

- Regional Development Agencies work to improve resource efficiency in businesses and encourage them to consider more environmentally friendly technologies (e.g. the South East England Development Agency is leading on a Pathway To Zero Waste initiative focusing on the construction industry).
- Government Offices bring together key regional stakeholders, influencing what they do to meet the Government's waste strategy, and interpreting and explaining the Government's waste policies.
- Local Authorities have a wide range of responsibilities relating to waste management including to act as waste collection authorities, waste disposal authorities and waste planning authorities.

Defra also works with a number of Non-Departmental Public Bodies, delivery agencies, regulators and advisory bodies. The roles these bodies – such as the Environment Agency, Ofwat, and Natural England – play in work towards reducing emissions is highlighted throughout the policy area chapters (pages 89 – 127).

Intermediary bodies and the third sector

Intermediary bodies and the third sector have a vital role to play in the transition to a low-carbon economy. This Plan contains a number of actions which are being or will be implemented by third sector organisations. For example, the Waste & Resource Action Programme (WRAP), a not-for-profit company created in 2000 which is supported by funding from the UK Government, will work on a number of aspects within the Waste plan, including waste minimisation and the creation of new markets for recycled materials.[65]

Defra is working very closely with industry representatives, such as those who have written the agriculture industry's *Greenhouse Gas Action Plan*. These representatives have an important leadership role to play in helping their industries move to a lower-carbon future.

Frontline/Operational

To deliver emissions cuts on the scale necessary, frontline savings will be delivered at different levels of the economy in all sectors; from individual farmers to waste management companies making investment decisions. Defra is working closely with industry and individuals to give clear advice and a clear steer in each sector. For instance, Defra's sustainable consumption and production programme (see Chapter 12) aims to give consumers the information they need to make sustainable choices.

The Devolved Administrations

The *UK Low Carbon Transition Plan* assigned responsibility for delivering the UK carbon budget to Whitehall Departments, not the Devolved Administrations (DAs) (although this arrangement could be reviewed). But the actions taken by Scottish Government, Welsh Assembly Government and Northern Ireland Executive will all contribute to efforts to meet the UK carbon budget. The approaches of the Devolved Administrations to climate change mitigation in waste, agriculture and forestry, all of which are, to a significant degree, devolved policy areas, are summarised below.

65 See page 101 for further details on WRAP.

Highland cattle

Scotland

The Climate Change (Scotland) Act commits the Scottish Government to reduce emissions by at least 42% by 2020[66] and by at least 80% by 2050. Annual targets for the years 2010-22 must be set by 1 June 2010 and Scottish Ministers are required to set out proposals and policies for meeting these targets thereafter. The Act also requires Scotland's share of emissions from international aviation and international shipping to be included in the emissions reductions targets, and places a duty on Scottish public bodies to contribute to emissions reductions and statutory adaptation programmes.

In September 2009 the Scottish Government launched the '*Farming for a Better Climate*' initiative[67]. This initiative identifies and provides information on five key action areas where farmers are encouraged to reduce avoidable emissions while also improving and strengthening their businesses. The Scottish Rural Development Programme offers grants to improve the efficiency of farm business operations.

The Scottish Forestry Strategy (2006)[68] identifies climate change as one of its seven key themes, and its aims include increasing the amount of carbon locked up by Scottish forestry. Last year the Forestry Commission Scotland published a three year Climate Change Action Plan, which includes plans for protecting and managing existing forests, creating new woodland, promoting the use of sustainably produced wood for energy and construction, and reducing the forestry sector's carbon footprint.

The consultation paper *Scotland's Zero Waste Plan* was launched in 2009. This describes action to be taken to deliver Scotland's plans to improve waste management, reduce waste, and make resource use more efficient – all of which will help to mitigate climate change.

Wales

The Welsh Assembly Government has set a target to reduce greenhouse gas emissions by 3% annually from 2011 onwards. A Climate Change Strategy for delivering this target will be published in Spring 2010. The Welsh Assembly Government is developing land management schemes targeted on actions that will reduce greenhouse gas emissions. It provides advice and support for farmers on how to reduce emissions, and is developing red meat and dairy roadmaps to establish where further emissions savings could be found.

66 Subject to advice from the Committee of Climate Change.
67 http://www.scotland.gov.uk/Publications/2009/08/19141153/0
68 http://www.forestry.gov.uk/pdf/SFS2006fcfc101.pdf/$FILE/SFS2006fcfc101.pdf

Woodlands for Wales, the Welsh Assembly Government's strategy for woodlands and trees, focuses on striking a balance between carbon retention and sequestration, and using wood, for example in fuel, as a substitute for more carbon-intensive substances. The Strategy recognises the importance of creating new woodlands to maximise carbon storage.

A Land Use Climate Change Sub-Group of the Climate Change Commission for Wales has been set up to provide advice on longer-term emission reduction options. The report (due in 2010) will provide clear recommendations on how agriculture and land use can reduce its contribution to emissions while maintaining viable farm businesses.

The Welsh Assembly Government is seeking to develop a range of measures to increase waste prevention, divert waste from landfill by increasing recycling and composting, and increase research into methane capture and oxidation systems. The revised *National Waste Strategy* was launched for consultation on 29 April 2009. It focuses on cutting direct and indirect emissions of greenhouse gases as a result of resource use and waste. The *Strategy* proposes that by 2025, Wales should have a recycling rate of 70% across all sectors, and that residual waste should phased out of landfill towards high efficiency energy from waste plants.

Northern Ireland

In Northern Ireland the Department of Agriculture and Rural Development (DARDNI) is reviewing scientific evidence to underpin their development of mitigation measures based on local circumstances such as soil type and farming practices. Mitigation measures will encompass livestock management, nutrient management, land management and renewable energy. It is essential that the consequences of each mitigation measure are fully understood. The DARDNI-sponsored Renewable Energy Centre of Excellence, which opened in 2009, showcases renewable energy technologies that are applicable at farm level and will enable farmers to operate in a more carbon-efficient way.

In terms of waste policy, current actions, including the Northern Ireland Landfill Allowance Scheme (NILAS), which is designed to achieve the increasingly stringent Article 5 Waste Landfill targets for reductions in biodegradable municipal waste landfilled by 2010, 2013 and 2020, will deliver greenhouse gas reductions. Statistics indicate a steady decrease in the amount of biodegradable municipal waste landfilled over recent years, a decrease of 14.8% between 2005/06 and 2008/09. Other supportive actions include the progressive updating of licensed landfill site permits to require the measurement and collection of greenhouse gases.

Carbon Reduction Delivery Plan

19. Delivery and milestones

The chart on the next page sets out Defra's key actions and milestones over the next decade in relation to climate change mitigation. It summarises the policies set out in the individual policy area chapters.

Figure 14: *Defra policy and delivery milestones to 2020*

	2009	2010	2011	2012	2013	2014	2015	2016–2019	2020
Food and Farming		Industry's Greenhouse Gas Action Plan published Interest-free loans for energy-saving equipment available to farm businesses. Government reviewing voluntary approach and developing alternative options	Improved low-carbon advice for farmers launched. Consumer advice on food launched		Industry Action Plan implemented; Government keeps under review.	First stage of inventory improvement complete. New CAP Pillar 2 programming period begins.			Annual emissions reduced by at least 3 $MtCO_2e$ on projected 2020 levels.
Soils	Soils Strategy published.	Additional guidance on good agricultural practices. Consultation on Peat Framework for Action.							
Forestry		Consult on impact of Greenhouse Gas Reporting Guidelines. Woodland carbon Task Force established. Code of Good Practice for Forest Carbon Projects published.				Next round of RDPE begins.			

	2009	2010	2011	2012	2013	2014	2015	2016–2019	2020
Sustainable Consumption and Production	Agreed standards for energy-using products are introduced and take effect.	Sustainable behaviours framework refreshed and working group launched. Revised guidance on making green marketing claims. Review of PAS 2050 completed. Action Plans for 10 pilot product roadmaps underway.	New standards for another six energy-using products. Evaluation of Greener Living Fund complete. New ISO standard on carbon footprinting published. UK and EU minimum product procurement standards in place for 10 priority product groups.	Agree new standards for more energy-related products, and review existing standards.					

	2009	2010	2011	2012	2013	2014	2015	2016–2019	2020
Waste	Further landfill tax rises announced. £10 million for new composting and anaerobic digestion facilities. Renewables Obligation reformed.	Consultation on restrictions on landfilling certain types of waste. Phase 2 of the Courtauld Commitment launched. Consultation on establishing higher targets for the recycling and recovery of packaging waste. Review of voluntary agreements with the paper industry. Clean Energy Cashback Feed-In Tariffs Introduced. Consultation on draft Regulations implementing the revised Waste Framework Directive.	Food waste reduced by 250,000 tonnes through Love Food Hate Waste campaign. Renewable Heat Incentive introduced.	Phase 2 of the Courtauld Commitment reduces consumer food waste by 5% and supply chain food and packaging waste by 10%. Amount of construction waste going to landfill halved. Home improvement waste going to landfill halved.	Waste prevention strategy published. Final programmed increase in landfill tax.		Dependent on the outcomes of consultation, landfill restrictions could be introduced as early as 2015.		Annual emissions reduced by at least 1 $MtCO_2e$ on projected 2020 levels.
Fluorinated gases (F-gases) and industrial processes	New regulations on the use of F-gases introduced.	Permit conditions of the remaining nitrous oxide-emitting plants in the UK reviewed. Next round of UN negotiations in Mexico.	European F-gas regulations reviewed by European Commission						

	2009	2010	2011	2012	2013	2014	2015	2016–2019	2020
Water	Water efficiency Act on CO_2 campaign launched. Ofwat requires water companies to cost carbon in appraising capital programmes, and sets targets for water efficiency	Building Regulations amended to improve water efficiency in new homes. Consultation on national standards for sustainable drainage systems (SUDS). First set of Water Resources Management Plans (considering supply-demand balance over 25 years) published and implemented.				Ofwat sets price limits and targets for 2015 – 2020.	Level of household metering increased to 50%. Second set of Water Resources Management Plans		Voluntary water industry target that 20% of energy used in the industry should come from renewable sources by 2020.
Marine and fisheries	Ocean Acidification Research Programme launched. Oceans Day at Copenhagen Conference.								

Carbon Reduction Delivery Plan

20. Indicators

To help monitor Defra's performance in meeting its carbon budget, the Department has identified a number of indicators which can be used to measure progress. These indicators will serve a number of purposes:

- **they will help track progress towards meeting the carbon budget.** They will indicate what emissions are in each sector, and whether factors that affect those emissions are moving in the right direction.
- **they will provide an early indication of future changes in emissions.** Due to the complexity in measuring, compiling and quality assuring emissions data, these are not published for more than 12 months after the end of the year to which they refer (so, for example, 2008 data is published in 2010). Using indicators which are easier to measure will give a picture of what is happening to emissions before the official data are released.
- **they will enable better understanding of the drivers of changes in emissions in each sector.** The indicator pyramids described in this chapter have been constructed in a way which breaks down the sources of emissions into their constituent parts. Tracking these different sources will help in understanding which areas in particular are causing changes in overall emissions.
- **they will help to assess the effectiveness of the policies that have been put in place.** The indicators are a useful way of assessing how well policies are delivering expected emissions reductions, and how well they are performing in relation to each other.
- **they will help to target new policy where it is needed most.** The indicator pyramids will allow the Government to identify gaps in the policy landscape, and design policy which affects the key drivers of emissions in each sector.

For each of the sectors for which Defra is the lead Department (Agriculture, Forestry and Land Management and Waste), Defra has produced an indicator pyramid which sets out key indicators of emissions at different levels. These indicator pyramids are set out on pages 148 and 151, together with an explanation of why these particular indicators have been chosen.

The indicator pyramids have a common structure, as shown in Figure 15. At the top of the pyramid are total emissions from the sector, whilst Tier 2 breaks down these emissions into relevant sub-sectors. Tier 3 then categorises the drivers of emissions into two groups: drivers which relate to the emissions-causing activity itself (e.g. the amount of waste going to landfill), and drivers linked to the "emissions intensity" of that activity. Tier 4 sets out these drivers

– policy, technological, behavioural or other drivers – in more detail. Contextual factors which help to explain trends in other indicators are also included. The full indicator tables in the annex to this document provide detailed information on the indicators that Defra will use in each sector. These can be found at: http://www.defra.gov.uk/environment/climate/index.htm

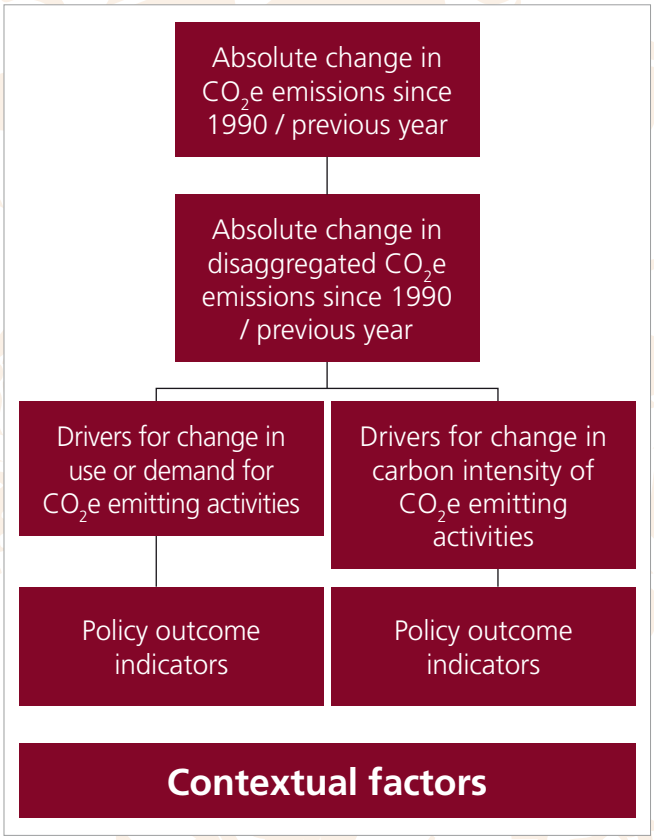


Figure 15: *Outline sector indicator pyramid*

For carbon budget sectors in which Defra has a share but is not the lead Department, Defra has identified indicators which reflect its influence in these areas. As well as being monitored by Defra, these indicators have been incorporated into the indicator pyramids produced by the relevant lead Departments.

Fluorinated gas (F-gas) and non-CO_2 industrial process indicators

Indicators for fluorinated gases and non-CO_2 emissions from industrial processes form part of the pyramid for the workplaces and jobs carbon budget sector. The relevant section of the pyramid and the associated indicators are set out in figure 15.[69] Defra has chosen a mixture of indicators covering policy delivery and international negotiations. In addition, DfT have a milestone relating to Mobile Air Conditioning (MAC) emissions.

69 For the full pyramid, see the DECC Departmental Climate Change Plan: http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/carbon_budgets/departments/departments.aspx

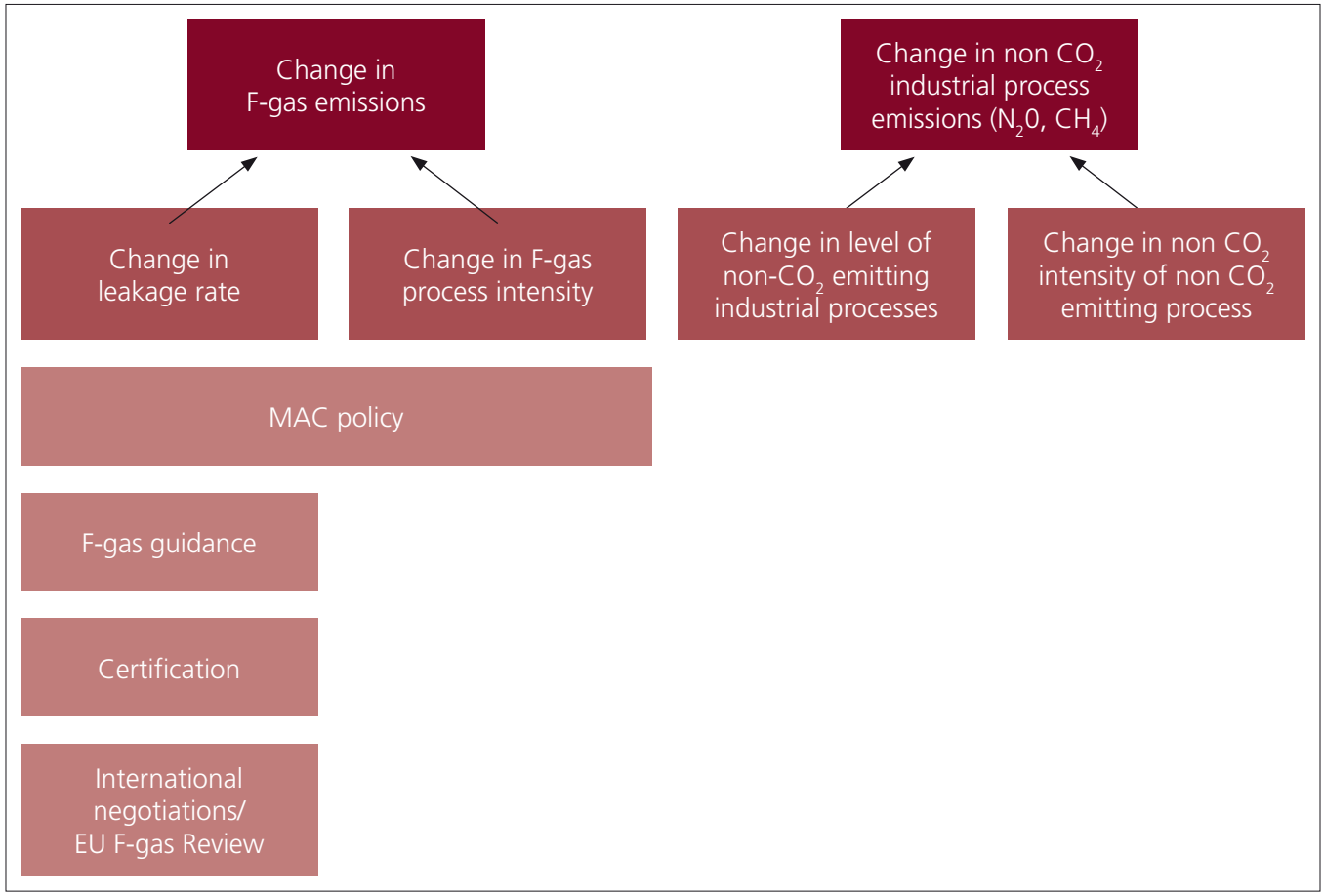


Figure 16: *F-gas and non-CO_2 industrial process indicators*

Sustainable Consumption and Production indicators

Sustainable Consumption and Production indicators feed into the pyramids for both the Homes and Communities and the Workplaces and Jobs sectors. Defra has chosen two indicators: one tracking cumulative savings from work to establish minimum standards and labelling for different energy-using products; the other, tracking changes in public attitudes towards low-carbon behaviours in the home.

Food Transport Indicators

Defra has two contextual indicators which feed into the transport sector pyramid, which help to explain the underlying demand for transport by the food and farming sectors. The indicators Defra has chosen are freight tonnages of certain agricultural products and foodstuffs, and total food transport carbon dioxide emissions.

AFLM indicator pyramid

The Agriculture, Forestry and Land Management (AFLM) sector is made up of three distinct elements: emissions from agriculture, CO_2 removals by forests, and the changing net balance of emissions from land use and land use change (LULUC), which can be either positive or negative. In terms of emissions, the sector is dominated by agriculture, but forestry and soils are vital carbon stores; if even a small fraction of this store were released into the atmosphere, this could have huge implications for overall emissions. The rationale for the choice of indicators in each sub-sector is set out below.

Emissions from agriculture

Whilst accounting for less than 1% of the UK's carbon dioxide, agriculture is a major source of methane (38%) and nitrous oxide (76%).

Livestock populations are a direct determinant of levels of both methane (from enteric fermentation) and nitrous oxide emissions (from organic fertilizer applications and deposits from grazing animals). Emissions can therefore be reduced either by reducing livestock populations or reducing the emissions per head of livestock. In relation to the former, improvements in **animal health**, reduced mortality and increased **fertility and longevity** of breeding animals will reduce the number of animals required to produce the same output of milk and meat. In terms of the latter, more efficient use of **feed** also has the potential to reduce emissions. **Livestock housing systems** can determine whether manure is stored in solid or liquid form and hence the quantity of methane produced. **Storage of livestock manures** (whether under cover or in the open) can influence the level of emissions. In addition, methane emissions can be reduced through the use of **anaerobic digestion**.

In terms of nitrous oxide emissions from agricultural soils, **soil nutrient balances**[70] are an important indicator. Whilst a shortage of nutrients can limit the productivity of agricultural soils, a surplus of these nutrients can cause nitrous oxide emissions. Therefore the nutrient balances, together with the **land area** to which they apply, are key determinants of nitrous oxide emissions from the sector. The use of fertiliser is an important determinant of soil nutrient balances. Appropriate application practices for manures and synthetic fertilisers and **testing the nutrient content of soils and manures** will help to ensure optimum applications. **Application rates** will also be monitored within the set of contextual indicators.

To complete the picture, **consumption** trends provide an indication of changes in the demand for food which will then be reflected in the level and mix of agricultural production (and net overseas trade) with a consequent impact on greenhouse gas emissions.

Tier 4 of the pyramid includes a number of key current and future policies that will influence future greenhouse gas emissions directly or indirectly through one or more of the routes described above, including the industry's Greenhouse Gas Action Plan and improved advice for low carbon farming.

Removals by forestry

Forestry is currently a net sink, drawing carbon dioxide out of the atmosphere. The strength of this sink depends on **woodland area**, and the **sequestration rate** of that woodland. This Plan focuses particularly on policies to increase woodland area through **afforestation**, as recommended by the Read Report. However, forest management is another important objective, and the **harvesting of wood products** represents an important carbon store. In addition, the use of **wood for fuel** can replace fossil fuels and achieve reductions in emissions from power and heating in various other sectors.

Emissions from land use and land use change

Emissions from land use are a function of the land use itself, and the emissions associated with each type of land use. The second of these does not lead to a meaningful indicator, so Defra will therefore monitor **land use change** itself, together with a measure of **soil carbon concentrations** (which result directly from changes in land use). For the UK Greenhouse Gas Inventory[71], Defra reports on **peat extraction** from horticulture and emissions from the historic **drainage of peatland**; indicators relating to these factors are included in Tier 4 of the pyramid.

Contextual indicators

Several contextual indicators have also been included within the framework to allow monitoring of factors which have a more indirect impact on emissions and which provide relevant background when interpreting trends in the main indicators. Agricultural **total factor productivity** measures the efficiency with which inputs are turned into outputs. More efficient use of many inputs (e.g. fertiliser, fuel) will reduce emissions from the agriculture sector per unit of output. Commodity and input **prices** will influence management

70 Further information on soil nutrient balances can be found at https://statistics.defra.gov.uk/esg/publications/monthly%20brief/July%202009%20Farming%20%20Food%20Brief.pdf

71 http://www.ghgi.org.uk/index.html

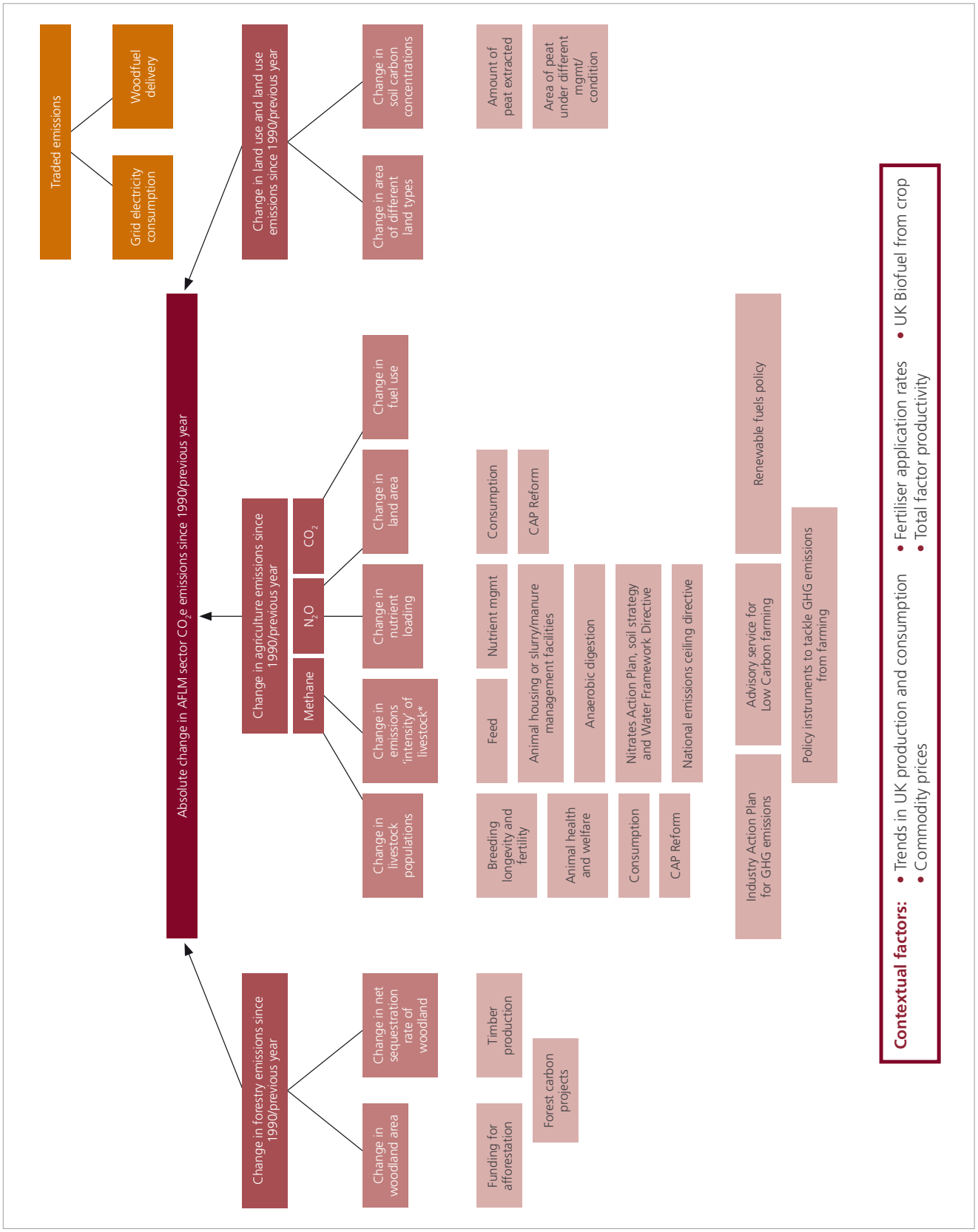


Figure 17: *Agriculture, Forestry, and Land Management indicator pyramid*

and business decisions taken by farmers. Monitoring **self sufficiency** allows an assessment as to whether we are seeing "leakage" of emissions through a greater reliance on imported foods.

Waste management indicator pyramid

The Waste sector is made up of three elements: emissions from landfill; emissions from wastewater; and emissions from incineration. The sector is overwhelmingly made up of methane emissions from landfill (90%), hence the primary focus of the pyramid is on this element. However, it is important to track what is happening in the other two elements because – whilst they are small in comparison – significant changes in their emissions could cause the sector as a whole to miss its targets.

The waste sector indicator pyramid is on page 151. Once again, total sector emissions are shown at the top of the pyramid, with the three sub-sector sources' emissions detailed at the next level down. The rationale for the choice of indicators in each sub-sector is set out below.

Emissions from landfill

When biodegradable waste materials are put into landfill they decompose to produce landfill gas which is typically comprised of roughly 60 percent methane and 40 percent carbon dioxide. A proportion of this gas is captured for energy recovery/flaring, however a significant amount does escape into the atmosphere. Emissions from landfill are therefore determined by the **amount of biodegradable waste materials landfilled** and the **methane capture rate** achieved by landfill site operators – the pyramid contains an indicator for each of these drivers for change.

The Government has a wide range of current and planned policies, as described earlier in Chapter 13, which aim to reduce the amount of biodegradable waste landfilled and improve the methane capture rate – the pyramid contains indicators for each of the key policy outcomes that the Government is trying to achieve.

In relation to reducing the landfilling of biodegradable waste, the policies principally act to either:

- prevent waste arising in the first instance or encourage its reuse (e.g. by changing **consumer and SME attitudes** or by encouraging industry to enter into **voluntary agreements** such as the Courtauld Commitment), or
- divert waste away from landfill (e.g. by encouraging higher recycling rates or by increasing **energy recovery** from waste through market support measures such as the Renewables Obligation).

The main policy in place to improve the methane capture rate is the programme of **audits of landfill sites undertaken by the Environment Agency**.

Aside from the impact of the policies in the waste management sector, there are also significant impacts in other inventory sectors including emissions covered by the EU ETS. As well as being users of energy (for transport, running plant/recycling processes), the waste sector is a supplier of renewable energy via **energy from waste** facilities.

Emissions from wastewater

Similarly to landfill methane, emissions from wastewater are determined by the **volume of waste** produced (in this case sewage sludge) and the **method used** to treat that waste. The volume of sewage sludge produced is in turn dictated by population growth and diet (in simple terms what we eat determines the nutrient content of what we flush down the toilet and ultimately has to be treated at the sewage works). A number of policies are designed to encourage recycling of sewage sludge, including the availability of Renewables Obligation Certificates (ROCs) to incentivise capture and conversion to energy of methane emissions from waste water.

Emissions from incineration

Emissions from incineration are determined by the **volumes of waste that are incinerated**. However, not all incinerated wastes contribute to the emissions from this sub-sector. The incineration of wastes at

Composting more food waste will help to reduce landfill methane emissions

energy-from-waste facilities[72] and the in-situ burning of agricultural waste (e.g. crop residues) are excluded as they count towards emissions in other inventory sectors. The incineration of chemical wastes, clinical wastes, sewage sludge and animal carcasses is included here, and emissions from crematoria are also included. The Government does not have any current or planned policies that directly affect the volumes of these waste-types that are incinerated.

Contextual factors

The pyramid also highlights key contextual factors for the waste sector which can help explain changes in emissions/drivers that are not necessarily the result of policy actions. For example:

- the 'volume of waste' (a key driver under each of the three sub-sectors), whilst influenced by our current and planned policies, is also dependent on other factors such as changes in **population** and **Gross Domestic Product** (in simple terms more people with more money will produce greater volumes of waste, all other things being equal).
- the **composition of waste** is a key contextual factor which will influence the size of the emissions from each of the three sub-sectors. For example, different types of biodegradable waste decompose at different rates when put into landfill and contain varying amounts of carbon (i.e. have different **emissions factors**).

72 see Chapter 13

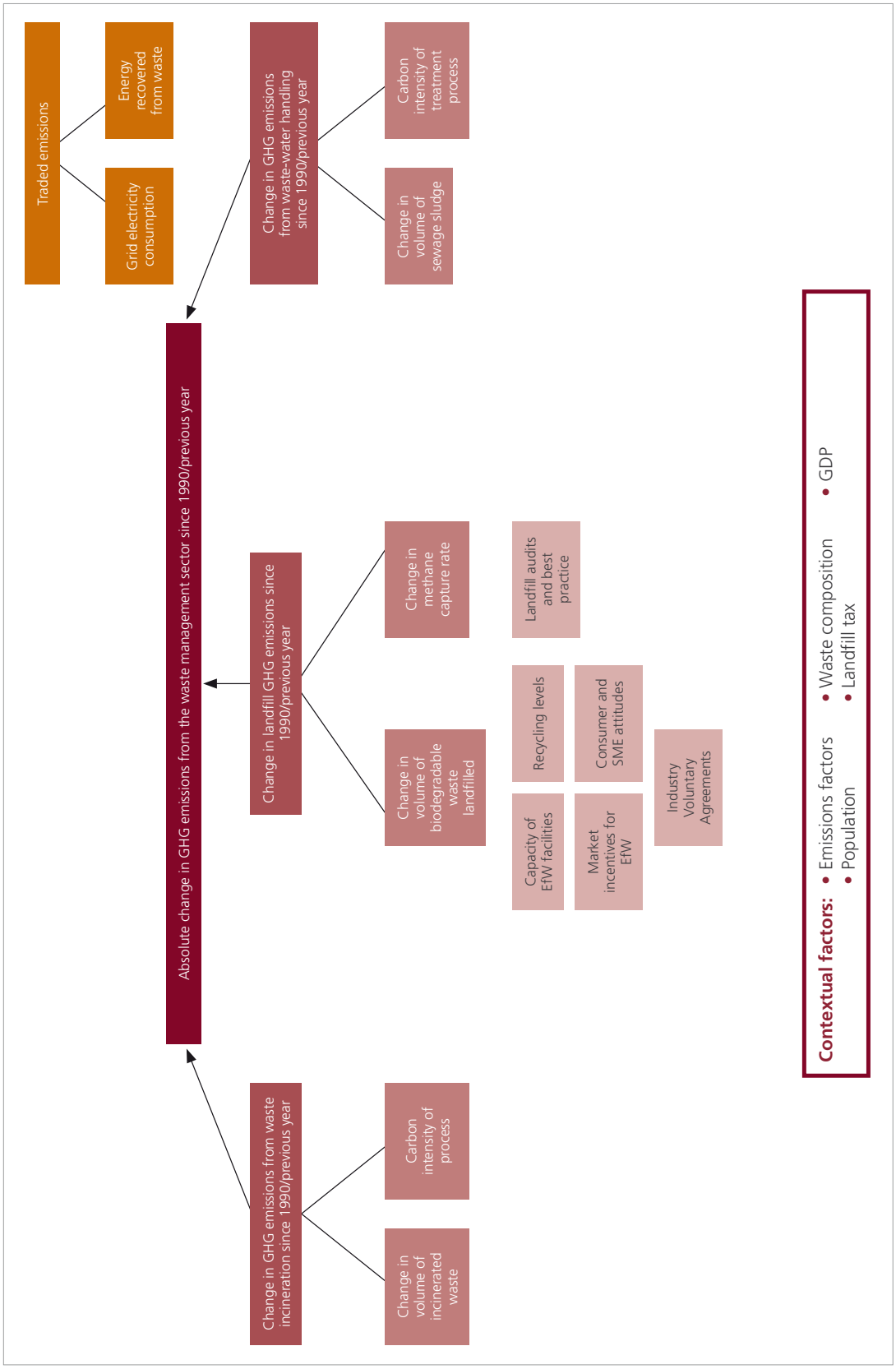


Figure 18: *Waste indicator pyramid*

Carbon Reduction Delivery Plan

21. Evidence plans

The actions Defra is committing to in this Climate Change Plan are based upon the best available evidence, much of it available due to work undertaken or commissioned by Defra. As the Department takes forward work across its policy areas, it will develop the evidence base in a number of areas, including:

- reducing measurement and reporting uncertainty.
- assessing the potential to reduce emissions further.
- assessing the potential contribution of specific policy instruments.

Reducing measurement and reporting uncertainty

The bulk of emissions targeted in this Plan are of non-carbon dioxide greenhouse gases. Estimates of non-carbon dioxide emissions are subject to considerable uncertainty, and are inherently more difficult to calculate than those in other sectors. This is due to the current state of knowledge around emission sources and their measurement. Calculating carbon dioxide emissions from, for example, burning a tonne of coal in a power station is relatively straightforward. Burning a tonne of coal releases the same quantity of carbon dioxide regardless of where and when it happens. In contrast, the quantity of nitrous oxide released following fertiliser application on a hectare of agricultural land is affected by a range of factors, including weather, soil type and farm management practices. Another example is methane emissions from landfill, where actual emissions are heavily influenced by temporal factors which cannot be picked up by a model producing annual estimations (e.g. a wet summer will have a big impact on actual emissions).

Agricultural Greenhouse Gas Research and Development

For the agriculture sector, Defra is establishing a Greenhouse Gas Research and Development platform, in collaboration with the Scottish Government, Northern Ireland Executive and Welsh Assembly Government, to develop a more sophisticated methodology for measuring, reporting and verifying emissions for inventory purposes (introducing what is known by international convention as a Tier 2 or Tier 3 methodology). The objective is to develop country specific emission factors which can be used with national statistics in order to better characterise and allocate emissions from agriculture. Specific objectives of the research are:

- to improve the spatial and temporal resolutions of the agricultural greenhouse gas inventory and reduce its uncertainties.
- to improve the understanding of emissions from UK agricultural systems.
- to better understand management options for reducing emissions of greenhouse gases from the agricultural sector and the food chain.
- to identify productivity benefits for the agricultural sector and the food chain.

Developing the agricultural inventory presents a significant scientific challenge, which requires long term investment. Defra is commissioning work in this area to be delivered through a collaborative research model encompassing academics, consultants and industry. This approach will facilitate information sharing and draw together state of the art techniques and knowledge to bring about rapid improvements in our understanding of agricultural emissions. The first phase of investment (ending in 2014) will deliver major changes that will reduce the uncertainty in, and enable the Government to record, the impact of improved farm management practices on national emissions. When fully developed the inventory will replace (wholly or in part) the need for proxy indicators and will be capable of measuring the extent to which the targeted annual reduction in emissions from English farming is being achieved.

The emissions figures quoted in this Plan, which replicate those in the UK's Greenhouse Gas Inventory (from which the carbon budgets are derived), are therefore often based on simplified methodologies. While generally providing a strong sense of the overall magnitude of emissions, they do not reflect the intricacies of the real world, such as those described above. As this variability cannot be picked up, many potential mitigation measures cannot be accurately accounted for in the overall emissions figures.

A key part of the Defra's evidence plan therefore revolves around increasing understanding of emissions under different conditions and practices, and making improvements to the way they are measured and reported in Defra's sectors. In the Agricultural sector this work will be developed under the Greenhouse Gas Research and Development Platform (see box above).

Defra is also working with international partners to improve the evidence base both in the UK and internationally. The UK will join other countries in participating in the Global Research Alliance initiated by New Zealand which seeks to increase international cooperation, collaboration and investment in both public and private research into agricultural emissions. This will enable the sharing of research findings and best practice to develop a stronger evidence base.

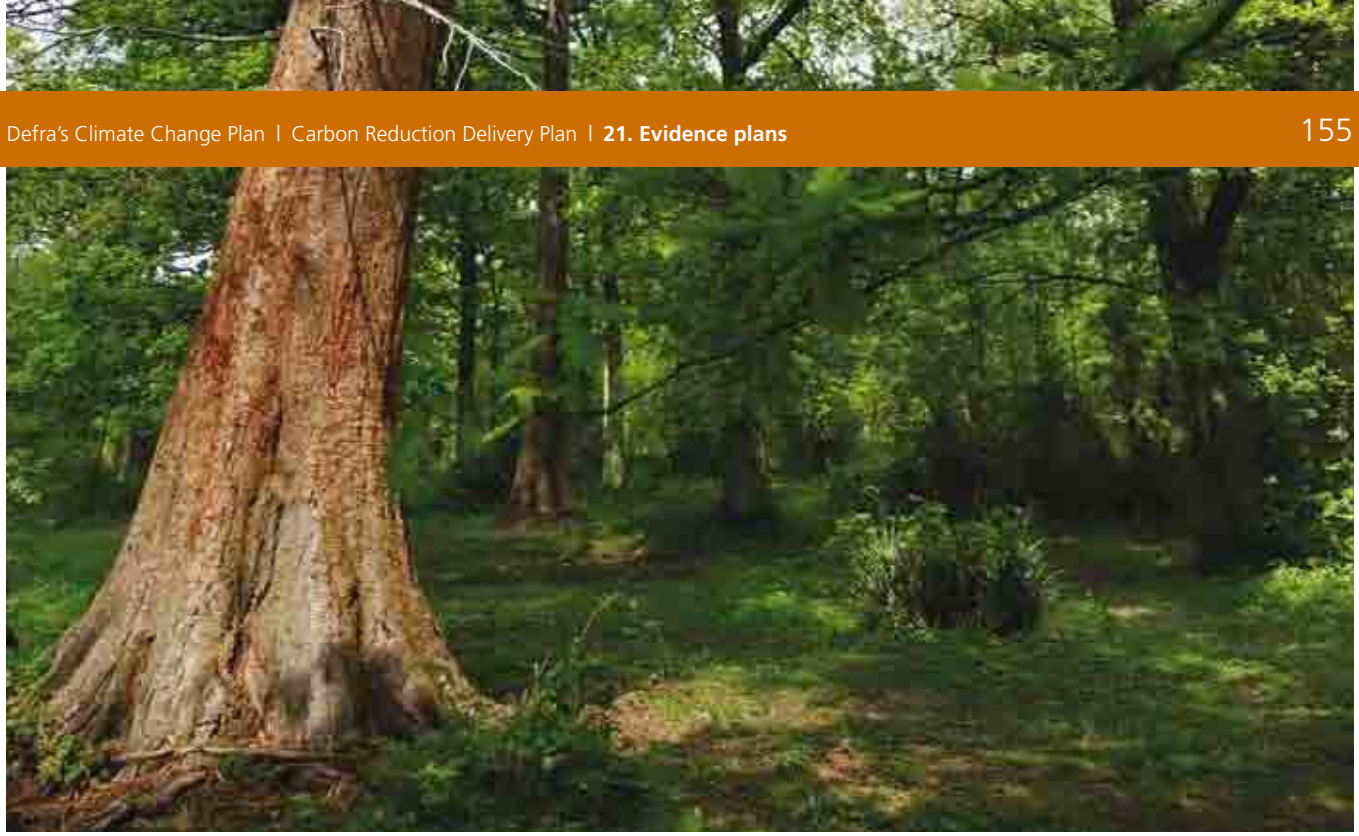
Water Waste Treatment Works.

In the Waste sector, the measurement of landfill methane emissions is currently a priority area for development within the UK inventory improvement plan. Work is underway to address uncertainties around both the science and data. In relation to the science, there are considerations around the emissions factors associated with different waste components, as well as uncertainty around oxidation rates. On data, one example is information on commercial and industrial (C&I) waste sent to landfill. In recent years, this has begun to decrease as a result of the impact of the landfill tax and other policy measures. Given the escalation of the landfill tax and the impact of other policy measures since the projections were last changed in the inventory model, the model's assumption of unchanged commercial and industrial waste to landfill is particularly inaccurate, and will be revised as part of the improvements.

A further important area of uncertainty surrounds the rate of methane capture at landfill sites (currently believed to be 75%). This is a combination of science and data. Defra and the Environment Agency have recently considered this issue, and given the evidence available, there is not a strong case to move to a new figure at present. However, both organisations will continue to investigate and are putting in place work to improve confidence in the ongoing use of this figure. For example, knowledge is being improved of:

- the amount of methane produced. The model used to estimate methane emissions will be upgraded. The quality of the input data, relating to the quantity and composition of waste entering landfill, has improved greatly in recent years and is continuing to improve due to changes in waste recording and reporting.
- the amount of methane captured. All landfill sites that were operational at the time the Landfill Directive was introduced in 2001 have a permit which includes an obligation to report the measured amount of methane being flared and put through the gas engines.
- the amount of fugitive emissions. The Environment Agency are currently carrying out scoping work for a possible joint Defra-EA-DECC survey to measure fugitive emissions from a range of landfill sites across the UK. The results of this survey could be used to provide a better picture of actual emissions from landfill sites and ground-truth model outputs.

Work is also being taken forward on the Land Use Land Use Change and Forestry (LULUCF) inventory. This is managed by DECC, although Defra plays a key role in shaping the project. In addition, Defra will



soon be commissioning a project which will in the long term lead to an improvement in the inventory by addressing evidence gaps in relation to emissions and removals from UK peatlands.

Improvements are also planned for the forestry part of the LULUCF inventory. The National Forest Inventory will include an assessment of standing biomass for 15,000 forest sites, providing a direct measure of biomass carbon stocks of British woodlands when field measurements for the first cycle are completed in 2014. Subsequent cycles will provide a measure of carbon stock changes while integration with the Forestry Commission's production forecast system will provide improved projections of changes in forest carbon stocks.

For fluorinated gases (F-gases), Defra is taking forward work to revalidate and update current UK models for historic consumption and resulting emissions by sector, application and substance.

Assessing the potential to reduce emissions further

Uncertainty regarding the measurement and reporting of emissions affects our understanding of the extent to which emissions can be reduced through different measures. However, given the challenge of emissions targets, waiting until the Government has a complete understanding of all the uncertainties is not an option. Defra's evidence plans therefore include work to refine estimates of abatement potential in a number of sectors where baseline emissions are not yet fully understood.

In terms of the technical abatement potential, Defra will undertake work to improve understanding of the most effective way to deliver the reductions committed to in this plan, as well as looking forward to the fourth carbon budget period (2023 to 2027) and beyond.

In the agricultural sector, Defra is working jointly with the Committee on Climate Change (CCC) to review and update the UK's marginal abatement cost curve (MACC) for agriculture, in light of the latest evidence. This work will increase our understanding of the uncertainties around current estimates of abatement potential and costs, and provide greater confidence of the overall abatement potential from the agricultural sector for the fourth carbon budget (2023-2027).

It also seeks to understand the barriers to greater up-take of abatement measures by the industry, and enforcement costs of various mitigation options.

Ongoing and future Defra research will also focus on refining and developing cost-effective mitigation options (e.g. ruminant nutrition, livestock breeding, nitrification inhibitors and optimum fertiliser application) as well as investigating the feasibility of on-farm mitigation activities. To inform this work and to develop a consistent long-term trajectory across farming sectors, Defra will develop a framework for exploring mitigation opportunities to 2050 through scenario analysis. This framework will be developed in collaboration with stakeholders to ensure a full range of options is explored.

The outputs from the above work, and work discussed below, will be used to support the industry, through advisory services and direct discussions with the Industry Climate Change Task Force, to deliver the emissions reduction target for the third carbon budget (2018 to 2022).

In the Waste sector, Defra will assess how current policy measures will contribute to emissions reductions in the fourth carbon budget period. In addition, Defra will consult on further restrictions on the landfilling of waste, which has the potential to reduce landfill methane emissions. As Defra builds up a better picture of the methane capture rate at landfill sites, it will also be able to consider the extent to which increases in methane capture (beyond the 75% currently assumed) are a possible means of reducing methane emissions.

In the forestry sector the Government has a good sense of what abatement is available through the recent publication of the Read report *Combating Climate Change: a Role for UK Forests*; the issue is around identifying potential policy instruments to deliver this. Evidence needs in relation to these are discussed below. Likewise in the F-gases sector, the evidence being taken forward relates to the impacts of policies rather than technical abatement potential.

In the land use and land use change sector, emissions are still too uncertain to be able to identify specific mitigation measures.

In relation to Sustainable Consumption and Production, Defra already has a broad evidence base relating to the potential for emissions reductions through, for example, greater resource efficiency, and the focus of the evidence work is now on assessing the potential impacts of specific policies in this area.

Assessing the potential contribution of policy instruments

In a number of sectors where understanding is already more advanced Defra will undertake work to assess the potential role of different policy instruments in delivering our emissions targets.

In agriculture, for example, evidence examining the socio-economic barriers and costs of different abatement opportunities by farm types will feed into the policy development process to ensure policies effectively tackle the barriers to action. As part of its evaluation of the industry's *Greenhouse Gas Action Plan*, Defra will carry out an impact assessment of policy options that may be required if industry-led action is judged insufficient to guarantee delivery of the annual abatement target.

In the Waste sector, the aforementioned consultation on restricting waste to landfill will assess different options to achieve emissions reductions.

In the forestry sector Defra and the Forestry Commission will continue to explore financial instruments, changes to reporting procedures and market mechanisms that could deliver increased levels of private funding for woodland creation, as outlined in the UK Low Carbon Transition Plan.

In the F-gases sector, a number of projects are being taken forward to assess the impacts of current and forthcoming policy on emissions, including:

- an assessment of how the further adoption of existing low global warming potential technologies is likely to affect consumption of F-Gases in the UK over the next 10 years.
- how these trends will be affected by the emerging new group of low-global warming potential HFCs and HFOs and in which areas of application.
- when these new alternatives will be available in the UK market and what the implications will be of that timing.
- what the likely cost barriers are to their introduction.

In relation to Sustainable Consumption and Production, Defra's Market Transformation Programme team conducts analysis on the impact of Government policies that contribute to improving the efficiency of energy using products. A current consultation on this analysis asks for views on the assumptions feeding into the analysis as well as the overall results. Revisions will then take place, and a more detailed breakdown of emissions impacts provided, before publication of the Final Report in summer 2010. In addition, work is on-going to assess the impacts of wider policies, for example to establish the relationship between emissions reporting and behaviour change, to see if there is scope for further emissions reductions.

Defra's Climate Change Plan

Defra Estates and Operations

22. Defra estates and operations

Defra continues to strive to operate more sustainably to make its own contribution to the national effort, to learn from its experiences, and to set an example for others. This chapter sets out what Defra is doing to reduce emissions, and to ensure the Department's estates and operations are resilient to climate change.

Adapting Defra for a changing climate

Defra estates and operations: risks, opportunities and impacts of climate change	
Increased risk of flooding	A number of Defra's properties have been identified as being at risk from coastal flooding, surface water flooding and water ingress from extreme or heavy rainfall due to ineffective drainage systems.
Extreme summer and winter temperatures; urban heat island effect	May affect comfort levels for staff and the operation of ICT infrastructure.
Reduced summer water availability	May impact on our ability to provide cooling for offices and ICT equipment.
Increased frequency of extreme weather events	May cause damage to properties and infrastructure, present health and safety risks to staff, and disrupt business continuity, availability of workspace and capability of ICT networks. Impact on transport networks may affect staff access to offices.
Disruption to supply chains	May disrupt supply of goods and materials, and access to offsite utilities (e.g. communications, waste treatment).

Policy and practical responses

Estates management

In 2009, Defra carried out a comprehensive initial survey of its properties both to understand the current resilience of the Defra estate to climate impacts and to assess how our grounds and buildings might be affected in future. The results are already being used to inform our departmental estates strategy.

The survey looked at 172 sites across the Defra estate. It used the UKCP09 projections to support a broad assessment of current and future risk, and looked at flooding, the urban heat island effect, solar gain, subsidence, increased wind speeds, higher rainfall, and summer drought conditions. It also considered the impacts of climate change on local transport networks and the accessibility of buildings to staff. The survey highlighted a number of areas where the Defra estate could be affected by the changing climate, for example 26% of Defra buildings are potentially at risk from the urban heat island effect and 23% from flooding.

Results from the survey have been checked for consistency with the Department's latest energy and

Dragonfly House

Dragonfly House.

Dragonfly House, which has been leased by Defra, is the greenest office in the East of England, with an Excellent rating on the Building Research Establishment's BREEAM scale which measures the environmental performance of buildings.

The state of the art office houses the Broads Authority, the Environment Agency and Natural England. It means that three of the main environmental bodies working together on issues such as climate change can now be located in the same place.

Some of the key features of the new building that give it an excellent rating are:

- environmentally friendly building materials. The office is clad in sustainably sourced timber, with brise soleil sunshades to reduce solar gain and provide natural cooling of the building.
- air drawn through an earth duct: a large pipe buried three metres underground, helps to warm the building in winter and cool it in summer.
- propane powered chillers are being used to cool the temperature in the computer room and maintain performance of the building's key ICT infrastructure. As well as being an effective risk management measure, propane has virtually no global warming impact and due to the clever design of the building the cooling requirement is much smaller than for a conventional office building.
- rooftop solar panels are expected to heat 35% of the water used in the building.
- water efficiency will be increased by collecting rainwater that falls on the building roof and filtering and storing it in an underground tank for use in flushing toilets. The storage tank can hold 30,000 litres of water.
- a sustainable urban drainage system (SUDS) will reduce the risk of flooding and protect water quality.

water surveys and the Defra estate strategy. They have been taken into account in the latest round of investment planning and prioritisation, and now provide an effective baseline for future strategy on the Defra estate. The review process will be refined and updated as part of formal business planning on an annual basis. It will help to achieve the progressive improvements needed in terms of identifying and managing climate risks which will be introduced under the proposed new framework for sustainable development in Government for adaption from 2010-11 onwards.

Information and Communications Technology

Work is being carried out to ensure that the Department's key IT and communications infrastructure is well-adapting to the risks of climate change. For example:

- Defra has introduced a range of remote and mobile communications services, which allow staff to work remotely in the event of fire or flood, transport or utilities disruption. In the recent cold and snowy weather some 3,000 staff were able to work at home or away from their main offices, reducing disruption to Defra's business;
- Defra's main IT partner has confirmed that its key servers and equipment are now capable of operating within a wider range of temperatures (18 to 270C instead of the previously accepted range of 20 to 250C). This will improve resilience to external temperature change at local Defra sites as well as the two main off-site data centres used to support Defra's IT services.

Procurement

Defra's Procurement and Contracts Division is taking forward a range of actions to build climate change adaptation into Defra's procurement strategy and contractual arrangements.

A formal commitment to adaptation is now set out in Defra's sustainable procurement policy statement. We have also developed a "condition of contract" which requires suppliers to identify the risks arising from climate change and variable weather that have the potential to disrupt the supply of goods to the Department, and improve their resilience by putting appropriate preventive, recovery and support systems in place.

➜ THE DEFRA ESTATE ACTIONS

72. Defra is planning a number of major new build and significant refurbishment projects over the next five years. These projects will each incorporate a formal adaptation assessment at the design stage.

73. We are working with our suppliers to raise their awareness of the need to implement adaptation measures, through:

- Defra's Supplier Engagement Programme – through which we are encouraging suppliers to carry out reviews of their business models, check that their processes are 'fit for purpose' and climate-proof;
- provision of adaptation advice via our suppliers web site which contains advice to suppliers on what they can do to adapt, and links to tools such as Defra's "adaptation wizard", a "business assessment tool" and a risk framework.

74. We will be implementing the joint Defra/OGC guidance on how to embed adaptation within the public procurement process (due to be published in 2010). Defra will look to be an exemplar organisation in its adoption and use of the new guidance.

75. Defra is supporting the introduction of a process for sharing best procurement practice on adaptation at the corporate level across Defra.

76. The Government is currently finalising the review of the SOGE targets. The new framework is expected to include a new adaptation target to improve the preparedness of departmental estates to the impacts of climate change by 2015 and ensure that progress is reviewed on an annual basis. In 2010, Defra will set out a plan of action to deliver early progress for our own estate.

Reducing Defra's carbon footprint

In the last ten years Defra has made significant progress in reducing the size of its own carbon footprint. Emissions from Defra's office estates are down 18% on 1999/2000 levels. This section describes what Defra is doing to drive emissions down still further. These actions are part of a wider programme of work, described in Defra's *Sustainable Development Action Plan*[73] which sets out the principles of sustainable development that run through the Department's operations.

Under the Sustainable Operations on the Government Estate (SOGE) framework, Defra has a set of carbon emissions reduction targets which apply to its office estates and operations, and across those of its executive agencies[74]. These targets have been converted into a carbon budget for Defra's estates and operations. Defra's carbon budget comprises: i. Emissions from Defra's office estate (incorporating core Defra offices and office based Executive Agencies, but not its laboratory based Agencies); ii. Emissions from all operational travel undertaken by core Defra, it's executive agencies and also the Environment Agency.

Budget period 1 (tCO_2e)	Budget Period 2 (tCO_2e)	Budget Period 3 (tCO_2e)
2008 – 2012	2013 – 2017	2018 – 2022
187,097	168,652	150,874

Figure 19: *The carbon budget for Defra's estates and operations*

In 2008/09 the CO_2 footprint of Defra's office estate and operations (including those of its office based executive agencies) was 34.8 tCO_2. Of this 14.6 tCO_2e came from offices primarily arising from energy use for heating, lighting and electrical/ICT equipment. An exercise carried out by Defra's ICT supplier, IBM, in 2009 estimated the emissions from ICT usage to be approximately 4.9 tCO_2e per year. The rest came from business and administrative travel, split between motor vehicles (15.4 tCO_2e), rail (1.7 tCO_2e), and air travel (3.2 tCO_2e).

The Defra network and carbon budgets

The Defra delivery network is complex, because of the wide range of responsibilities and activities it undertakes. Beyond the core Department are seven **executive agencies**[74], which deliver specific outputs and are accountable to ministers. The SOGE framework includes emissions from office based, Executive Agency operations.

Non-Departmental public bodies (NDPBs) operate at arm's length from the Government and ministers. NDPBs can be executive – such as Natural England – or advisory – like the Royal Commission on Environmental Pollution. Currently NDPBs are not incorporated into the SOGE framework. Defra voluntarily reports the Environment Agency's emissions. The Forestry Commission, as a **non-ministerial Department**, completes a separate SOGE return.

This Plan is based on the current scope of the SOGE targets and Defra's carbon budget. As the new SOGE framework is built into the carbon budget allocation from budget period two onwards, Defra will work across its estates and wider family to ensure that it reports against and meets the broader and more challenging targets. These emissions reductions will also deliver financial savings, contributing to the Government's aim of releasing £300 million in energy bill savings by 2012/13. Defra's Plan to reduce emissions from estates and operations is expected to be updated in the next 18 months to present Defra's new share of the public sector, and the revised set of measures being planned to secure both carbon and financial savings.

73 http://www.defra.gov.uk/sustainable/defra/pdf/sd-action-plan-2009-2011.pdf

74 Defra's office-based executive agencies are the Rural Payments Agency (RPA), Animal Health, and the Marine & Fisheries Agency. Defras laboratory-based executive agencies are the Veterinary Laboratories Agency (VLA), the Veterinary Medicines Directorate, the Food & Environment Research Agency (FERA), and the Centre for Environment, Fisheries, and Aquaculture Science (CEFAS).

Nobel House interior.

Defra Estates

Defra is performing well against its SOGE targets. The 2008/09 Sustainable Development in Government (SDiG) report showed Defra had already met and exceeded the 2010 targets for emissions from offices and travel. Defra has also achieved five stars for performance against the mandated mechanisms and scored 100% in this area.[75]

In 2006 Defra began benchmarking energy and water usage to identify potential savings. The projects implemented as a result of this exercise resulted in Defra achieving Energy Efficiency Accreditation Scheme (EEAS) certification in August 2007 for its whole estate and The Carbon Trust Standard for its office estate in May 2008. Projects undertaken during this phase were mainly quick win initiatives, including voltage reduction technologies, energy efficient lighting, boiler sequencing and latest technology applications for building insulation.

A *Defra Estates Climate Change Delivery Plan* has been developed, based on evidence from portfolio wide surveys, along with Forward Maintenance and Repair (FMR) requirements and the high-level Estate Strategy. This plan will deliver the Department's ongoing sustainability requirements, supported by a comprehensive Behavioural Change Programme, designed to embed sustainable behaviour in the day to day activities of Defra employees.

Nobel House

Defra's headquarters are at Nobel House, a ten storey listed building in Westminster. Over the past decade the building has been drastically refurbished and improved. Open plan office areas, conference facilities, a central atrium, a new restaurant and staff facilities were created. When completed, the project achieved the then highest ever BREEAM rating for a project of its type and was awarded the RICS London Regional Award for Sustainable Building.

The delivery plan includes the following actions:

- Upgrade of building infrastructure and fabric (including Insulation, double glazing, and lighting systems);
- Upgrade of heating and ventilation systems (boilers, radiators and air conditioning systems);
- Improved monitoring and management of Building Management Systems;
- Installation of energy efficiency technologies (voltage reduction and gas boiler sequencing);
- Improved monitoring of energy and water use through smart metering;
- Installation of renewable technologies (e.g. photovoltaics, wind turbines, rainwater harvesting, CHP and biomass boilers).

75 More information on the SOGE targets can be found at: http://www.defra.gov.uk/sustainable/government/gov/estates/targets.htm

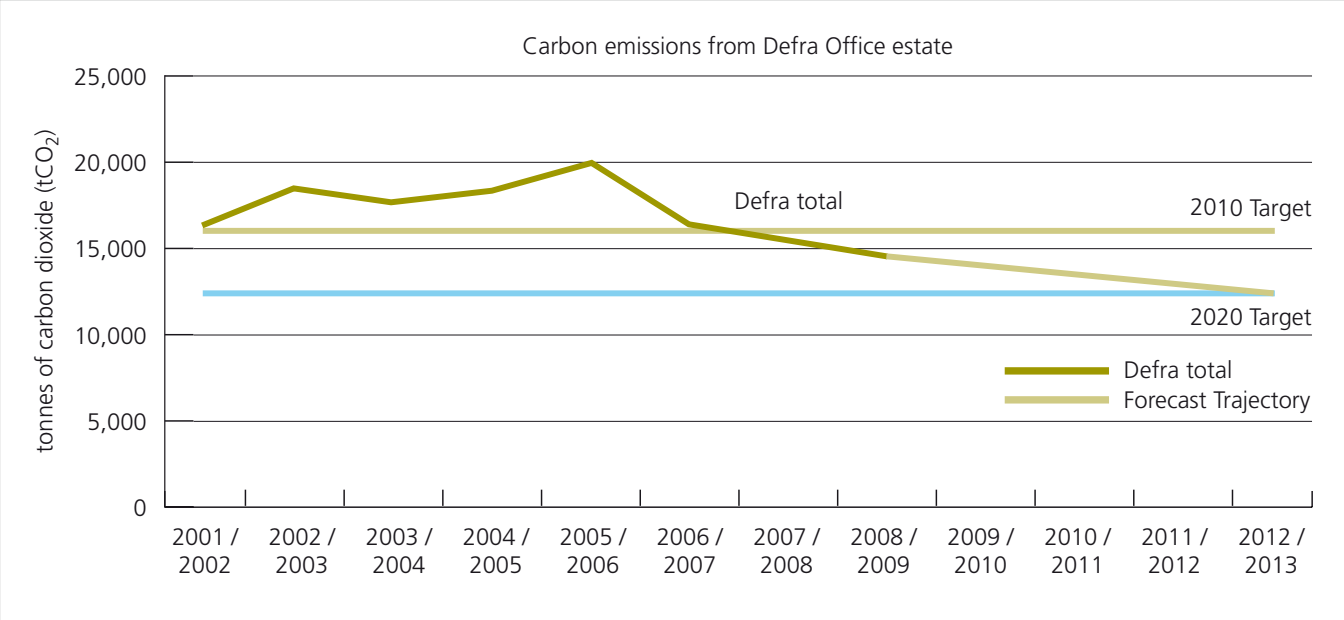


Figure 20: *Historic and projected emissions from Defra Office estate*

These measures are expected to deliver at least a 12% reduction in emissions over the next three years. This means that by 2013 Defra should have reduced its emissions by 30% on 1999/2000 levels, hitting its 2020 target seven years early. The Department is working to identify further gains across the estate. Figure 20 shows Defra's year on year performance against the SOGE carbon emissions from offices target and the projected trajectory to 2013.

A programme of property development and refurbishment will run in parallel to the delivery plan which will improve the quality and sustainability of the Defra estate, incorporating measures which reduce emissions and minimise the use of natural resources.

Since April 2004 Defra has reduced the size of its estate by 19%, disposing of some 83,000m^2. Efficiency gains have been achieved through the introduction of hot desks, 80:20 desk ratios, geographic co-location of agencies within single buildings and by actively challenging expansion where space exists elsewhere on the estate. All new build and major refurbishment projects within the Defra estate aspire to the BREEAM Excellent standard and use the latest cutting edge sustainable technologies where appropriate. These standards and other prestigious awards have been gained by several new properties in Weybridge, York, and Norwich. Further to these achievements, in January 2010, Defra's new ultra-low-carbon office at Alnwick was the first building in the UK to be awarded the BREEAM Outstanding standard.

Biomass Boilers

Biomass boiler.

Installing biomass-fuelled boilers, to provide space and water heating, offers significant on-site carbon savings and increased security of energy supply.

To date, Defra has installed six biomass-fuelled boilers at properties in Alnwick, Crewe, Penrith, Preston, Thirsk, and Worcester. These installations are currently saving the department 450 tCO_2 a year and approximately £25,000 in annual fuel costs. A further seven installations are planned for 2010, with anticipated savings of a further 300 tCO_2 per year. Fuel has been sourced from sustainably managed forests or waste wood sources and where possible, from within a 50 mile radius of the site, thereby minimising emissions from transportation.

Travel

Later this year, Defra will publish a new *Departmental Travel Plan*, setting out a sustainable and low carbon approach to staff travel. Already, there are a number of actions in place to reduce emissions from travel:

- Audio and video conferencing is being promoted across the Defra Network as an alternative to travel.
- Defra has met its 2010 target to reduce its fleet's emissions average to 130 gCO_2/km (the current average is 126 gCO_2/km). The Department only procures vehicles which support and develop low-carbon technologies.
- Staff are encouraged to use rail travel within the UK and, where possible, for journeys to Europe.

All of these commitments are supported by mechanisms to influence and change staff choices and attitudes towards travel. Many of these are embedded in the systems used by staff to book travel, for example Travel Decision Trees which steer staff towards the most sustainable options.

The *Travel Plan* published later this year will set out an approach to behavioural change, as well as how Defra will work with its Network Agencies and suppliers to ensure appropriate travel solutions are delivered.

Information and Communications Technology (ICT)

Defra's Green ICT programme has two work streams: the first to improve the energy efficiency of its ICT services; the second to extend the use of ICT services to enable smarter and lower-carbon working for staff. The second strand includes remote and mobile networking, e-conferencing and mobile telephony services. In undertaking this work Defra is taking on board the best practices set out in the Government's Green ICT strategy.

The cornerstone of work to increase ICT efficiency is the refresh of Defra's IT contract with IBM. This includes a comprehensive server virtualisation and consolidation workstream which will result in a 25% reduction (some 2,500 tCO_2) in the overall ICT energy footprint for Defra and its executive agencies by October 2011. The remaining servers, and the IBM data centres, will be run according to the best practice set out in the EU Code of Conduct for energy efficient data centres.

The refresh programme will further rationalise print services, reducing the cost and carbon footprint of printing. It will also see a move from a three year to a four year refresh cycle for ICT assets. Defra is now consistently achieving 97% or better recycling/re-use rates by weight for IT equipment.

To enable more flexible working that will reduce travel and accommodation, new laptop and communication services have been deployed to some 8,000 staff in

Defra and its executive agencies. The Department will improve the provision of electronic conferencing services, including web and video conferencing, and promote their uptake in support of the Travel and Estates programme of emissions reductions.

Procurement

Defra is revising its Sustainable Procurement Policy Statement to reflect the three priority areas to be delivered through public procurement agreed by the Government in the 2009 Pre-Budget Report, one of which is to use procurement to achieve resource efficiency focusing on greenhouse gas emissions. Defra is continuing to embed these policies into procurement to help the Department reduce its emissions and improve its sustainable performance generally. Defra has looked beyond its own activities to those of the suppliers that provide its goods and services and through its supplier engagement programme is working with them to improve performance and drive down emissions in the supply chain. Defra's Procurement and Contracts Division is working to reduce emissions firstly, by ensuring the Department purchases eco-efficient goods and services such as low-energy IT systems and green vehicles for business travel; and secondly by seeking to promote best practice in the supply chain, by, for example, encouraging suppliers to participate in the Carbon Disclosure Project.

To embed sustainability in its contracts, Defra has committed to:

- achieve the Government's new SOGE target for procurement by 2012, three years ahead of the 2015 deadline.[76]
- exceed the EU target for 50% of public procurement tenders across a range of priority product groups to comply with the core criteria of the EU's Green Public Procurement (GPP) by 2010. Defra is working towards aligning the UK Government Buying Specifications (previously known as the Quick Wins standards) with the GPP.
- strengthen the Department's supplier engagement programme, including using the apportionment methodology once developed under the Carbon Disclosure Project[77] to calculate the carbon emissions specific to Defra contracts and use that information to help reduce emissions.
- continue to promote the UK Government's sustainable timber procurement policy across Government, the wider public sector and internationally where other EU member states are adopting similar approaches to that of the UK.

Defra's suppliers website explains Government procurement policy and practice and directs suppliers to guidance, tools and available support: http://www.defra.gov.uk/corporate/about/how/procurement/sell-sustainably/index.htm

76 The SOGE target for procurement designates requires departments to reach the lead level (#5) of the refreshed Flexible Framework by 2015.
77 https://www.cdproject.net/en-US/Pages/HomePage.aspx

23. Abbreviations and Acronyms

ACC	Adaptation to Climate Change
AD	Anaerobic Digestion
AFFLM	Agriculture, Food, Forestry and Land Management
AFLM	Agriculture, Forestry and Land Management
BAP	Biodiversity Action Plan
BIS	Department for Business, Innovation and Skills
BREEAM	Building Research Establishment Environmental Assessment Method
BSI	British Standards Institute
CAAs	Compliance Assistance Agreements
CALR	Climate Change Adaptation, Air Quality, Landscape and Rural Affairs
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CC	Countryside Commission
CCC	Committee on Climate Change
CCM	Climate Change Mitigation
CFE	Campaign for the Farmed Environment
CFMP	Catchment Flood Management Plan
CHP	Combined heat and power
C&I	Commercial and Industrial
CLA	Country Land and Business Association
CLG	Communities and Local Government

CO_2e	Carbon Dioxide emissions
CQuEL	Character and Quality of England's Landscapes (a Natural England monitoring programme)
CRWP	Construction & Resources Waste Programme
CSP	Code for Sustainable Homes
CSS	Countryside Stewardship Scheme
DAP	Departmental Action Plan
DARDNI	Department of Agriculture and Rural Development Northern Ireland
DASH	Delivery and Strategy High-level
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
Dfes	Department for Education and Skills
DfID	Department for International Development
DSO	Departmental Strategic Objective
EA	Environment Agency
EEAS	Energy Efficiency Accreditation Scheme
ELS	Entry Level Stewardship
ENPAA	English National Parks Authorities Association
ESS	Environmental Stewardship Scheme
ETIP	Entry Level Stewardship Training and Information Programme
EU	European Union
ETS `	Emissions Trading Scheme
Fera	Food and Environment Research Agency
F-gases	Fluorinated gases
FMD	Foot and Mouth Disease
FRM	Forward Maintenance and Repair
GOs	Government Offices
GWh	Gigawatt-hours of electricity
GPP	Green Public Procurement
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HLS	Higher Level Stewardship (part of Environmental Stewardship scheme)
ICT	Information and Communications Technology

IEA	International Energy Agency
IPPC	Integrated Pollution Prevention and Control Directive
JNCC	Joint Nature Conservation Committee
LATS	Landfill Allowance Trading Scheme
LULUC	Land Use and Land Use Change
MAC	Mobile Air Conditioning
MACC	Marginal Abatement Cost Curve
MCCIP	Marine Climate Change Impacts Partnership
MCZ	Marine Conservation Zone
MDG	Millennium Development Goals
MONARCH	Modelling Natural Resources Responses to Climate Change
$MtCO_2e$	Mega tons of Carbon Dioxide emissions
MWe	Megawatts of electricity
NAO	National Audit Office
NE	Natural England
NERC	Natural Environment Research Council
NFU	National Farmers Union
NGO	Non-Government Organisation
NILAS	Northern Ireland Landfill Allowance Scheme
NPAs	National Park Authority
OECD	Organisation for Economic Co-operation and Development
OELS	Organic Entry Level Stewardship
OGD	Other Government Department
OSPAR Convention	The Oslo and Paris Convention for the Protection of Marine Environment of the North-East Atlantic
PAS	Publicly Available Specification
PFCs	Perfluorocarbons)
PiP	Projections in Practice
PPS	Planning Policy Statement
PSA	Public Service Agreement
RCCF	Rural Climate Change Forum
RDAS	Regional Development Agencies
RDPE	Rural Development Programme for England

RED	Renewable Energy Directive
RHI	Renewable Heat Incentive
ROCs	Renewables Obligation Certificates
ROTATE	Recycling and Organics Technical Advisory Team
RPA	Rural Payments Agency
RSPB	Royal Society for the Protection of Birds
SCPP	Sustainable Consumption and Production Programme
SDAP	Sustainable Development Action Plan
SDiG	Sustainable Development in Government
SFP	Single Farm Payments
SLA	Service Level Agreement
SMP	Shoreline Management Plan
SOGE	Sustainable Operations on the Government Estate
SRO	Senior Responsible Owner
SSSI	Site of Special Scientific Interest
SUDS	Sustainable Drainage System
tCO_2e	Tonnes of CO2 equivalent
UKCIP	United Kingdom Climate Impacts Programme 2002
UKCP09	UK Climate Projections 2009
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VLA	Veterinary Laboratory Agency
WFD	Water Framework Directive
WRAP	The Waste and Resources Action Programme

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