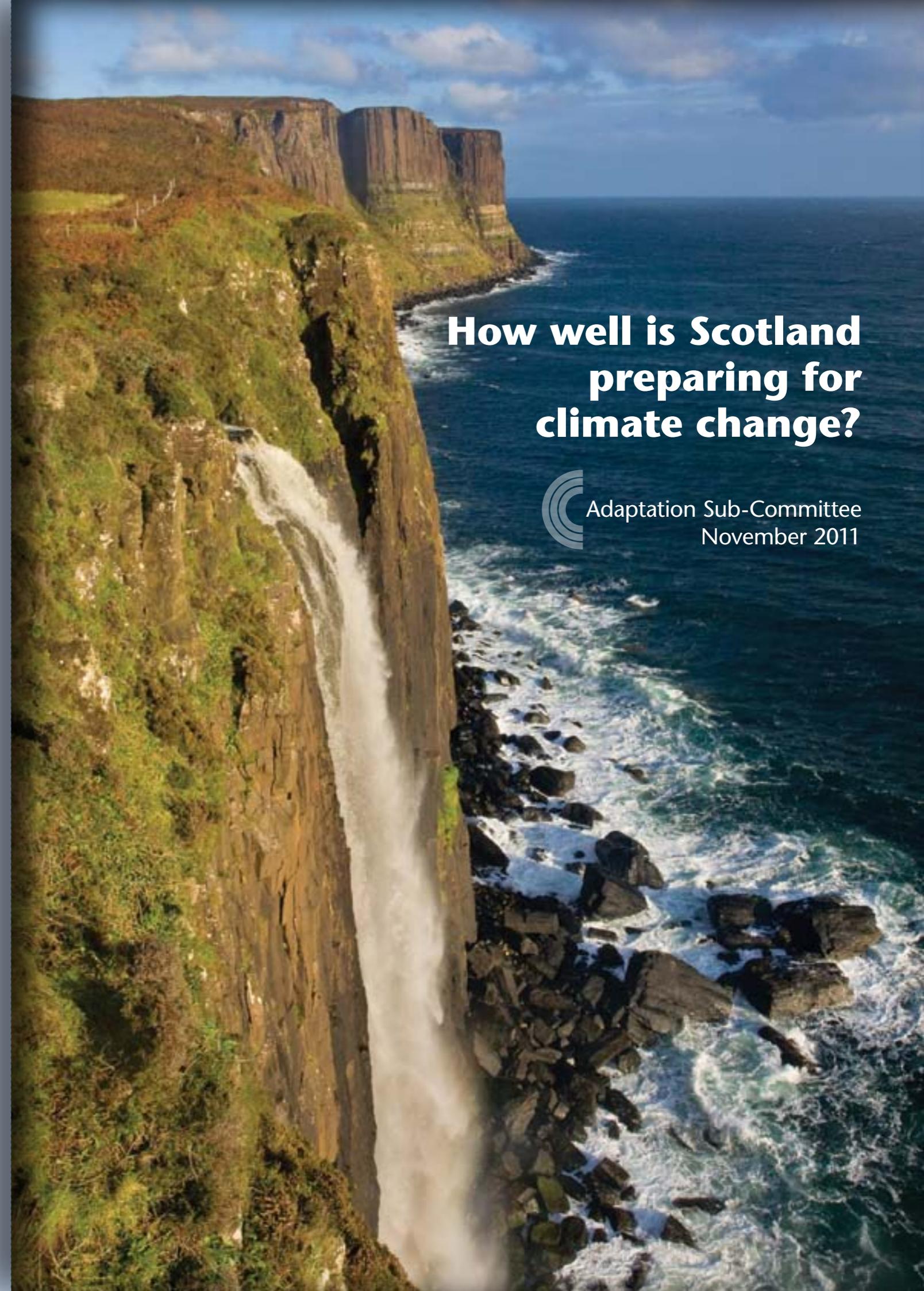


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then click.



Foreword



The Climate Change (Scotland) Act 2009 has established a legal requirement for Scotland to reduce greenhouse gas emissions by 42% by 2020, relative to 1990. The Act has also created the legal framework for a strategic and structured approach to adaptation.

The Scottish Government asked the Adaptation Sub-Committee to provide an initial assessment of how well Scotland is preparing for the effects of climate change, as a contribution to their statutory adaptation programme. While at first glance it may appear that Scotland will not be significantly affected by climate change and may even see some benefits, Scotland has a number of characteristics that will increase its vulnerability to a changing climate. Scotland can reduce the adverse effects of unavoidable climate change and take advantage of any opportunities by managing these vulnerabilities and increasing its resilience.

In this report we find that Scotland has made good progress in raising awareness about what climate change means for different organisations and embedding adaptation into some key policies, such as land use planning, building regulations, and emergency planning. The picture is more mixed on how this capacity-building is translating into tangible action on the ground. For example we find high deployment of sustainable drainage systems in new developments, but low uptake of property-level flood protection measures in existing buildings.

We advise that, in developing its adaptation programme, the Scottish Government should focus additional effort into understanding how its policies will address the risks from climate change. Key to this will be understanding the trends in Scotland's climate vulnerability and the uptake of adaptation actions, so that a robust and objective assessment of progress can be made. The Scottish Government should also consider where further development of adaptation policy may be warranted, including for example in preparing Scotland's national infrastructure for climate change and building the resilience of Scotland's peatlands.

Lord John Krebs Kt FRS
November 2011

Acknowledgements

The Adaptation Sub-Committee would like to thank:

The core team that prepared the analysis for this report. This was led by Sebastian Catovsky and included: Michael Dunkley, David Thompson and Laura McNaught.

Other members of the secretariat who contributed to the report: David Kennedy, Emily Beynon, Owen Bellamy, Emily Towers and Jo Wilson.

Those who provided information and feedback on the report:

Scottish Government: Jody Fleck, James Simpson, Fiona Page, Alastair Montgomery, Carole Stewart, Sally Thomas, Jim McGonigal, Heather McCabe, Martyn Cox, Colin Moffat, J MacDougall, Gareth Heaviside, J Whytock

Scottish Natural Heritage: Mary Christie, Phil Gaskell, Marion Mulholland and Sue Munro

Scottish Environment Protection Agency: Peter Singleton and Roy Richardson

Adaptation Scotland: Julian Holbrook

Scottish Water: Miranda Jacques-Turner and Mark Williams

Highland and Islands Enterprise: Diane Duncan

Historic Scotland: Ewan Hyslop

Visit Scotland: Claire Shepherd

Scottish Enterprise: Neil Kitching

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Sir Graham Wynne

Sir Graham Wynne CBE joined the RSPB in 1987, having spent 15 years as a city planner, principally concerned with inner city regeneration. He became Director of Conservation for the RSPB in 1989 and was appointed Chief Executive in 1998. He is currently a Special Adviser to the Prince of Wales' International Sustainability Unit and Chair of the Harapan Rainforest Foundation in Indonesia. He was a Member of the Policy Commission on the Future of Food and Farming 2001-2002, the Sustainable Development Commission 2000-2003 and England's Wildlife Network Review Panel 2009-2010.

Executive Summary

Adaptation is an important part of Scotland's approach to tackling climate change and complements its plans to reduce greenhouse gas emissions. The Climate Change (Scotland) Act 2009 created the legal framework for a strategic and structured approach to adaptation. This report analyses the Scottish Government's adaptation framework against the preparedness ladder of the Adaptation Sub-Committee (ASC) to provide an initial assessment of how well Scotland is preparing for climate change.

In the future, Scotland's climate is likely to be warmer and wetter in winter, and drier and hotter in summer than it is now. There may be some benefits and opportunities for economic growth and inward investment in Scotland from a changing climate, such as:

- Higher average winter temperatures could result in fewer winter deaths and lower demand for heating.
- Opportunities for expansion of tourism, and outdoor sport and leisure activities.
- New crops and expansion of suitable agricultural land.
- Melting of the Arctic ice sheet could result in new trade opportunities, although any associated increase in shipping may also have environmental risks for Scottish waters.

The first UK Climate Change Risk Assessment due to be published early next year will provide further refinement on the benefits and opportunities from climate change.

At the same time, Scotland has a number of social, economic and environmental characteristics that will increase its vulnerability to some of the damaging impacts of a changing climate, including the following:

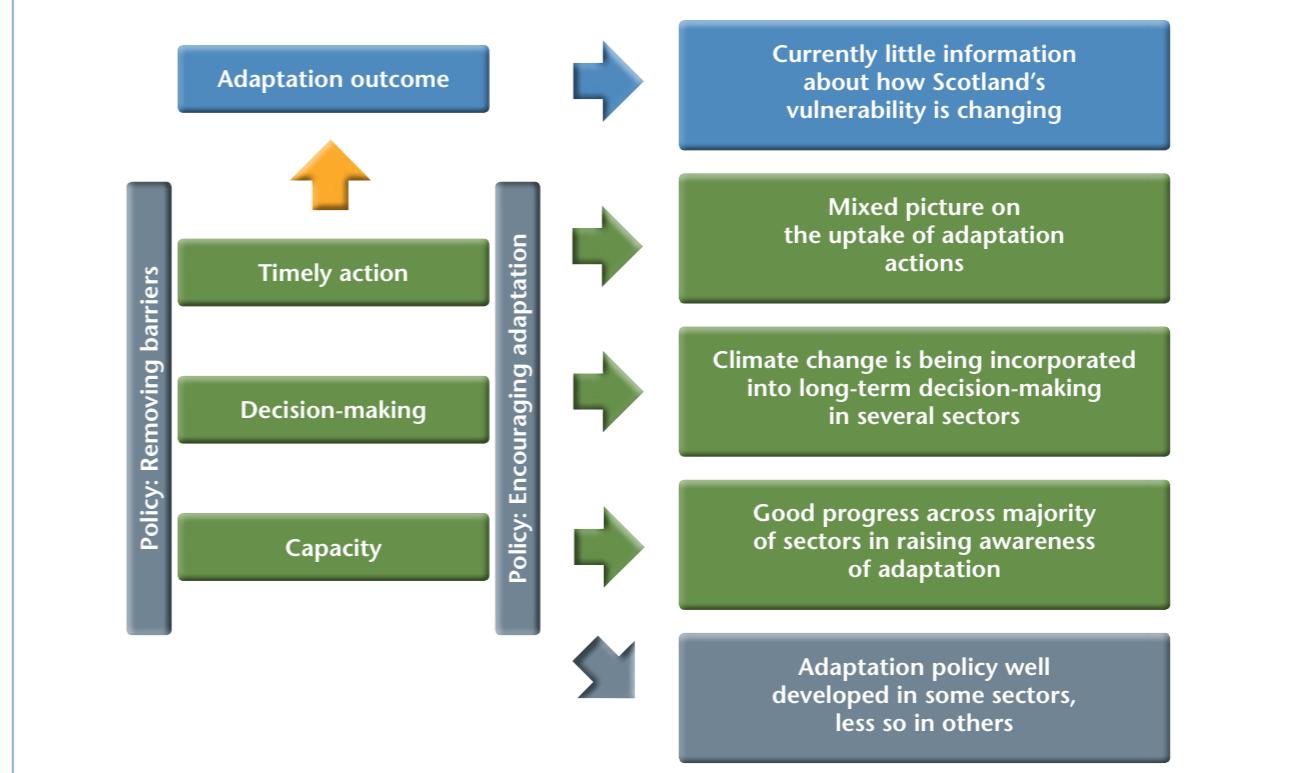
- Scotland's population is unevenly spread across the country. It has pockets of dense urban development that are particularly at risk of flooding and storms, alongside very remote communities that are vulnerable to transport disruption and interruption to critical services (such as water, power, and information and communication technologies) from extreme weather.
- Scotland's population is ageing and elderly people are more vulnerable to the impacts of extreme weather.
- There are a number of health challenges in Scotland, which are more pronounced in deprived areas. These will increase the vulnerability of certain communities to extreme weather.

- The global nature of Scotland's economy means that many businesses will be exposed to the international economic impacts of climate change.
- Scotland is rich in natural resources, has internationally important biodiversity, and stores globally significant amounts of carbon in its peatlands, all of which are sensitive to changes in climate.

The key findings from our analysis are summarised against the components of the ASC's "preparedness ladder" (Figure ES.1) that sets out the key steps that we would expect to see happening in a well-preparing society. In summary, we found:

- Scotland is making good progress in raising awareness of adaptation, building capacity and incorporating consideration of climate change into several aspects of long-term decision-making, for example in land use planning and building regulations, marine planning, health, and forestry.
- However, in some other critical sectors, it is not clear how long-term climate impacts are explicitly being taken into account, for example in planning and designing new national infrastructure, such as that required for delivering Scotland's renewable energy programme or the latest information technology (broadband).
- The adaptation framework does not give sufficient weight to Scotland's contribution to global efforts to safeguard the billions of tonnes of carbon stored in its peatlands, which are vulnerable to climate change, particularly when degraded.

Figure ES1: Summary of ASC's first assessment of Scotland's progress on adaptation



- There is a mixed picture on the uptake of low-regret adaptation actions, for example we found a reportedly high deployment of sustainable drainage systems in new development but a low uptake of property-level flood protection measures in existing buildings. This suggests that the policy framework is having varied success in encouraging adaptation by addressing some of the barriers to action by householders.
- To date there has been little work to assess the effectiveness of the Scottish Government's adaptation programme in reducing Scotland's vulnerability to a changing climate.

Based on these findings, we advise that, in developing its first statutory adaptation programme, the Scottish Government should:

- **Set clear adaptation outcomes and evaluate the effectiveness of policy** – the programme should establish clear policy priorities and outcomes for the most significant consequences facing Scotland from climate change, based on the findings of the first UK Climate Change Risk Assessment and associated economic appraisal. At the same time, the programme should put in place a process for evaluating the effectiveness of policies in delivering these adaptation outcomes by identifying key trends that affect vulnerability to current and future climate.
- **Enable the uptake of low-regret adaptation actions** – the programme should identify the types of low-regret adaptation actions that can be taken up in the short-term. In doing this, the programme should consider how to remove barriers to the uptake of such actions, for example through incentives or regulation.
- **Ensure key decision-makers explicitly consider adaptation in long-term plans** – the programme should ensure that key decision-makers are explicitly weighing up the long-term costs and benefits that can be expected as a result of climate change against other objectives and priorities.
- **Strengthen adaptation in some policy areas** – the programme should consider the case for strengthening policy in some critical priority areas, for example adapting Scotland's national infrastructure and improving the resilience of Scotland's peatlands.
- **Ensure effective working with the UK National Adaptation Programme** – the programme should ensure that it dovetails with the UK-wide programme in reserved matters to avoid any gaps in coverage in Scotland's preparedness for climate change.

Chapter 1: Introduction – purpose of study

The Climate Change (Scotland) Act 2009 requires Scottish ministers to lay a programme to adapt to climate change before the Scottish Parliament.¹ This programme will be published after the first UK Climate Change Risk Assessment is published in early 2012.

To help inform development of Scotland's statutory adaptation programme, the Scottish Government requested the Adaptation Sub-Committee (ASC) of the UK Committee on Climate Change² to undertake an initial assessment of Scotland's preparedness for climate change, based on reviewing published adaptation plans and strategies.

The ASC's assessment has been produced in advance of the publication of the UK's first Climate Change Risk Assessment (CCRA). While the broad climate risks for Scotland are already widely understood, subsequent assessments will be able to focus on Scotland's preparedness for the specific key risks and opportunities identified by the CCRA.

¹ Non-statutory forerunners to the Adaptation Programme – the Adaptation Framework and twelve Adaptation Sector Action Plans – have already been published.

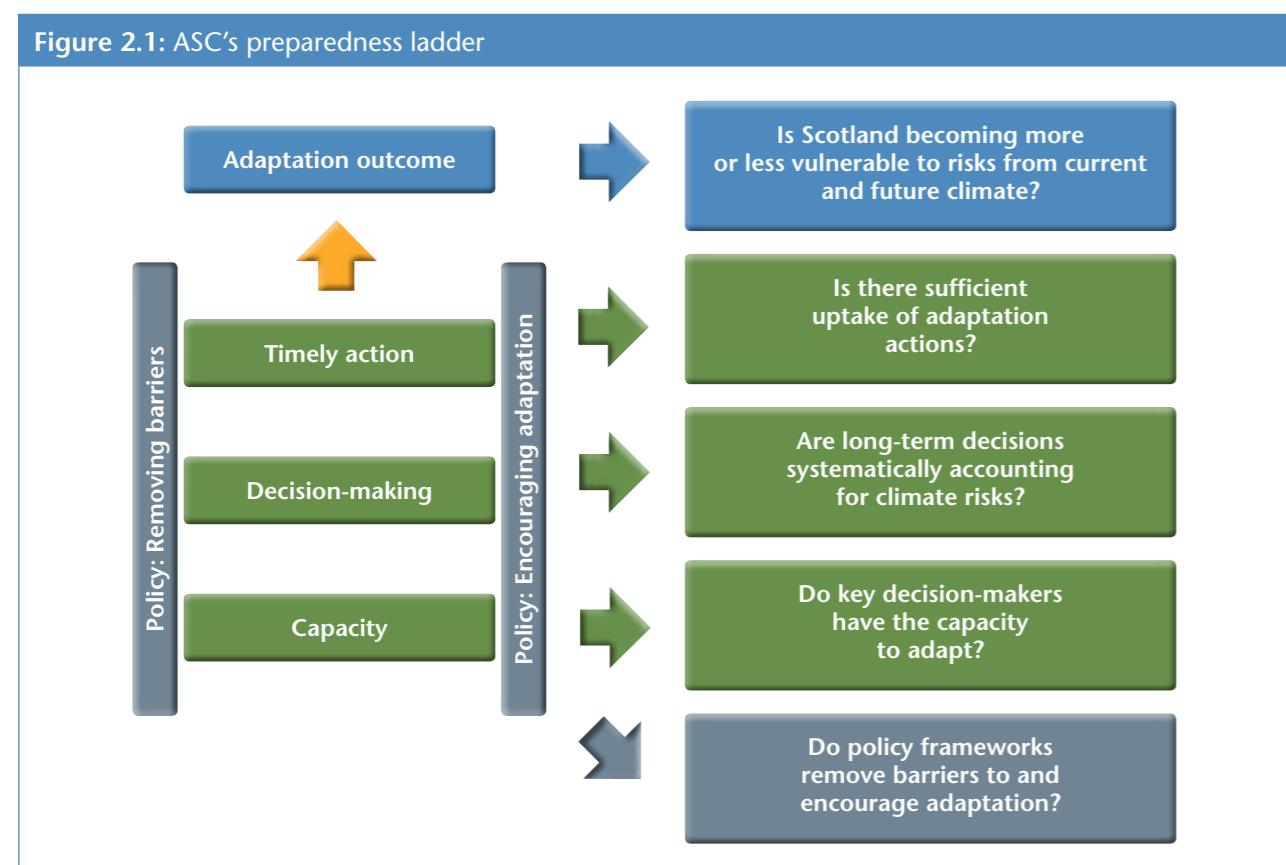
² The UK Climate Change Act (2008) established the Adaptation Sub-Committee (ASC) of the Committee on Climate Change to provide independent and expert advice to the UK Government and the devolved administrations on the impacts of climate change in the UK and assessing progress in implementing the UK national adaptation programme.

Chapter 2: Approach and methodology

2.1 ASC's preparedness ladder and priority areas for adaptation

The ASC's first report in September 2010 introduced a simple framework, "the preparedness ladder", which sets out the key steps that we would expect to see implemented if the UK were to be sufficiently preparing for climate change.³ The ladder characterises adaptation as progressing from building capacity, to embedding climate change into long-term decisions, and taking timely adaptation action to lead to an adaptation outcome.

This report uses the ladder to assess preparedness by asking the following questions based on the components of the ladder, as shown in Figure 2.1.



³ Adaptation Sub-Committee (2010).

The ASC has identified five generic priorities for early adaptation action based on decisions that are sensitive to today's climate and that have long-lasting or far-reaching consequences. The five priority themes are:

- **Land use planning** – determining where new housing and commercial premises should be located and overall urban form, including urban greenspace, so that places and their communities are resilient to a changing climate.
- **Designing and renovating buildings** – how new housing, commercial and public sector buildings are planned and built, and the methods and materials used to renovate the existing building stock, so that the health and well-being of their occupants is maintained.
- **Providing national infrastructure** – how critical infrastructure in the energy, transport, communication (ICT) and water sectors are designed and where they are located, so that they are able to continue to deliver services critical to the well-being and the prosperity of communities and business.
- **Managing natural resources** – management of ecosystems, habitats, agriculture, land, seas, fisheries and water in the face of a changing climate.
- **Emergency planning** – planning for weather-related hazards, such as flooding, storms, snow and heatwaves, to reduce costs and disruption to local communities and businesses and to minimise the impacts on health and well-being.

2.2 Indicators of preparedness

The ASC's second report started to develop the preparedness ladder into a set of indicators against which progress on adaptation can be assessed,⁴ focussing on the priority areas of land use planning, managing water resources, and the design and renovation of residential buildings.⁵

The ASC has undertaken an initial review of potential indicators for Scotland,⁶ which has informed this assessment.

2.3 Assessing progress in Scotland across ASC priority areas

This report first asks why adaptation is an important issue in Scotland (Chapter 3) and summarises Scotland's adaptation policy framework (Chapter 4), then looks at progress across the priority areas for early adaptation action, using the questions from the ASC's ladder (Chapter 5). Based on this analysis, it recommends what Scotland's forthcoming statutory adaptation programme can do to enable adaptation action by key organisations across the private and public sector, as well as by communities and individuals (Chapter 6).

⁴ Adaptation Sub-Committee (2011).

⁵ The scope of the report covered UK-wide issues for reserved matters and England only issues for those matters that are devolved.

⁶ AEA Technology (2011a).

The main source of evidence for the analysis has been the recently published sector action plans produced by the Scottish Government as part of the National Adaptation Framework.⁷ Table 2.1 shows how the twelve sector plans link with the ASC priority areas.

We also reviewed other adaptation plans relevant to each of the priority areas produced by statutory agencies (such as Scottish Natural Heritage and Scottish Environment Protection Agency), local authorities and businesses. We held a number of interviews and discussions⁸ with Scottish Government sector leads, two local authorities, representatives from Adaptation Scotland,⁹ two research bodies, six statutory agencies, Scottish Water, Scotland's 20/20 Climate Group and Scottish Environment Link. Wider engagement and consultation across the public, private and third sectors, particularly local authorities, community groups, and key infrastructure providers, will help refine future assessments.

Table 2.1: Link between ASC priority areas for early adaptation action and Scottish Government's sector action plans

Sector Action Plans	ASC Priority Areas				
	Land use planning	Providing national infrastructure	Designing and renovating buildings	Managing natural resources	Emergency planning
Spatial planning and land use	X	X		X	
Built environment	X		X		
Transport	X	X			
Energy	X	X		X	
Business and industry		X	X		X
Water environment and resources	X	X	X	X	X
Biodiversity and ecosystem resilience	X			X	
Forests and forestry	X			X	
Marine and fisheries				X	
Agriculture	X			X	
Health and well-being			X		X
Emergency and rescue services					X

⁷ <http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlandsaction/adaptation/AdaptationFramework>

⁸ Twenty-seven separate discussions were held in total.

⁹ Previously known as the Scottish Climate Change Impacts Partnership.

Chapter 3: Why adaptation is important – Scotland's key climate vulnerabilities

Adaptation is an important part of Scotland's approach to tackling climate change and complements efforts to reduce greenhouse gas emissions. The latest climate projections (UKCP09)¹⁰ indicate that under each global emission scenario modelled, Scotland's climate is likely to be warmer and wetter in winter, and drier and hotter in summer than it is now (Table 3.1). The frequency and magnitude of extreme weather events, such as storms and heavy rain, are also expected to increase, although these are harder to predict.

Relative sea level is projected to increase across Scotland, albeit more slowly than in other parts of the UK, even after accounting for geological land tilting.¹¹ Table 3.1 shows the estimates of relative sea level change for Edinburgh, accounting for vertical land movement.

Table 3.1: Central estimates (range in brackets)¹² for climate change in Scotland under medium emissions scenario for 2020 and 2050, compared to baseline (1961-1990)

Scotland	2020s			2050s		
	East	North	West	East	North	West
Change in mean winter temperature (°C)	+1.1 (+0.1 – +2.1)	+1.1 (+0.1 – +2.0)	+1.2 (+0.3 – +2.0)	+1.7 (+0.6 – +3.1)	+1.6 (+0.6 – +3.0)	+2.0 (+0.8 – +3.3)
Change in mean winter precipitation (%)	+4 (-4 – +12)	+6 (-5 – +14)	+7 (-5 – +16)	+10 (-2 – +20)	+13 (-1 – +26)	+15 (-1 – +31)
Change in mean summer temperature (°C)	+1.4 (+0.6 – +2.4)	+1.2 (+0.5 – +2.1)	+1.4 (+0.6 – +2.3)	+2.3 (+1.0 – +4.5)	+2.0 (+0.9 – +3.9)	+2.4 (+1.0 – +4.4)
Change in mean summer precipitation (%)	-6 (-17 – +8)	-4 (-15 – +18)	-6 (-17 – +8)	-13 (-28 – +6)	-11 (-24 – +6)	-13 (-28 – +6)
Sea level rise (cm) for Edinburgh relative to 1990	+5.7 (+4.3 – +7.5)	-	-	+13.9 (+10.5 – +18.0)	-	-

¹⁰ UK Climate Impacts Programme (2009).

¹¹ The vertical land movement associated with the melting of the ice sheets following the last ice age, which leads to an uplift in Scotland and subsidence in England, Wales, and the Shetlands.

¹² The figures in bold represent the central estimate, i.e. the 50% probability level where the value is as likely to be exceeded as not. The figures in brackets represent the wider range of uncertainty from the climate models.

Scotland has some specific social, economic and environmental characteristics that could increase its vulnerability to a changing climate. At the same time, Scotland is well placed to take advantage of some of the opportunities that climate change may bring. These are summarised in Table 3.2 below and then discussed in more detail in the following sections.

Table 3.2: Drivers affecting Scotland's vulnerability to and opportunities from climate change	
Demographics Vulnerabilities: <ul style="list-style-type: none"> • Ageing population • Densely populated urban areas and very dispersed remote areas • Health challenges, which are more pronounced in areas of higher deprivation Opportunities: <ul style="list-style-type: none"> • Potential health benefits from higher winter temperatures and increased outdoor activity 	Natural Resources Vulnerabilities: <ul style="list-style-type: none"> • Some species at the northern edge of their climatic range • Large proportion of UK natural resources concentrated in Scotland (peat, forests) • Over two-thirds of the UK's soil carbon stocks are in Scottish soils Opportunities: <ul style="list-style-type: none"> • New crops and fish species and expansion of suitable land for agriculture
Economy Vulnerabilities: <ul style="list-style-type: none"> • Some key growth sectors are intrinsically linked to climate and natural resources (food and drink, renewable energy, tourism) • Vulnerable to impacts of climate change abroad given global export markets and supply chains Opportunities: <ul style="list-style-type: none"> • Some potential opportunities for tourism, agriculture and inward investment 	Infrastructure Vulnerabilities: <ul style="list-style-type: none"> • Several of the major transport and energy infrastructure networks are concentrated along strategic corridors that are exposed to severe weather events

3.1 Climatic characteristics

Scotland's current climate is generally colder and wetter than the UK average,¹³ although it has milder winters and cooler wetter summers than countries on a similar latitude due to the North Atlantic drift.¹⁴ The west is generally warmer, wetter and windier than the east.

Scotland's average annual temperatures are lower on average than other regions of the UK, averaging 7.2°C, compared to England (9.4°C), Wales (8.9°C), and Northern Ireland (8.7°C). Annual average temperatures vary across Scotland, from 7°C in the Shetlands (which have the lowest annual average temperature for a low lying area in the UK) to almost 10°C in the Western Coastal areas, such as Ayrshire, Bute and Kintyre.

¹³ Met Office: <http://www.metoffice.gov.uk/climate/uk/actualmonthly/>

¹⁴ An extension of the gulf stream.

This warmer average temperature of 10°C is also reached in central Glasgow, due to the urban heat island effect.

Rainfall in Scotland is higher than the UK average (1540 mm per year compared to 1125 mm per year, respectively), but like temperature, also varies significantly across the country.

- The wettest place in the UK is near Fort William with 4000 mm per year. The west of Scotland has an average of 1700 mm per year compared with some areas of the east coast that have an average of 700 mm per year.
- The average number of days with extreme rainfall (over 10 mm) is highest in the west of Scotland (over 70 days a year) compared to 25 days or less on the east coast.
- Snow fall varies from less than five days on the west coast to over 100 days across the Grampians.

3.2 Socio-economic characteristics

3.2.1 Demographics

Scotland's population of 5.2 million people (8% of the UK) are unevenly spread across the country, with pockets of dense urban development together with some very remote communities. Each of these present different adaptation challenges.

- 82% of the population live on 6% of the land (Figure 3.1).¹⁵ The most populous cities are Glasgow and Edinburgh, which are the fourth and seventh largest cities in the UK respectively. One-third of Scotland's population live in the Glasgow City conurbation (1.75 million people) while almost 800,000 live in the urban area around Edinburgh. The main climate risks for Scotland's urban areas tend to be flooding and impacts from storm events.
- Around 7% of the population live in remote rural areas, including about 100,000 on the 118 inhabited islands. The Highlands and Islands region has the tenth lowest population density in the European Union.¹⁶ Such remote areas are vulnerable to transport disruption (road, rail, ship) and interruption to critical services, such as energy and water.

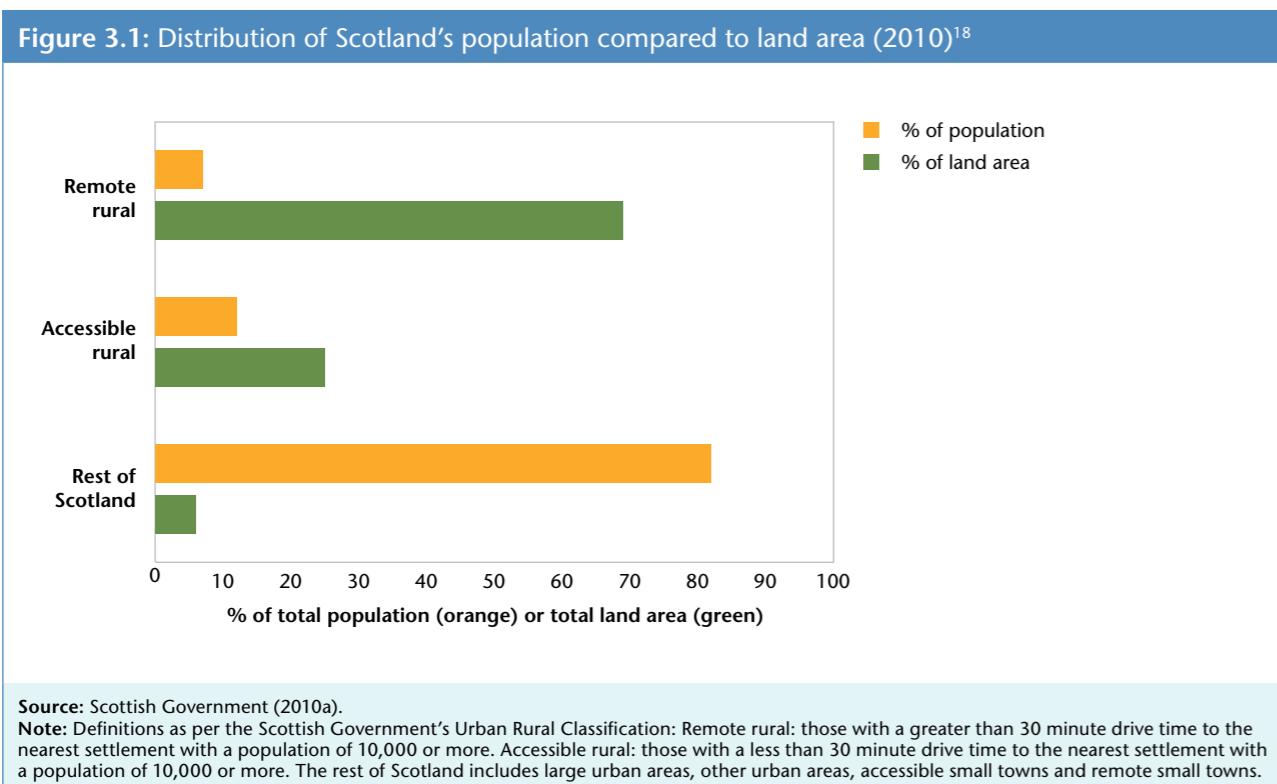
Scotland's population is ageing. This increases vulnerability to the health effects of heatwaves and cold snaps. In the last ten years the total population has grown by 2.4% but in the same period the over-75s increased by 14%. The proportion of Scotland's population at pensionable age is projected to increase from nearly one-fifth today to nearly one-quarter by 2033.¹⁷

¹⁵ In the UK as a whole 80% of the population live on 9% of the land.

¹⁶ Eurostat (2011).

¹⁷ Scottish Government (2010b).

Figure 3.1: Distribution of Scotland's population compared to land area (2010)¹⁸



There are a number of health challenges in Scotland, which also increase vulnerability to climate risks. These include a lower healthy life expectancy than in other parts of Europe, while mortality rates from certain cancers, heart disease and liver disease are among the highest in Western Europe.¹⁹ These factors increase vulnerability as populations that suffer ill health can be more vulnerable to the effects of flood events and increased temperatures.²⁰

Health inequalities can be more pronounced in areas of deprivation. For example, life expectancy in Scotland in 2008 was 68.0 for males and 70.5 for females, but this falls to 57.5 years and 61.9 years for males and females respectively in the most deprived 15% areas in Scotland.²¹ Research by the Joseph Rowntree Foundation²² found that Glasgow is the most highly vulnerable of all areas in Scotland to flooding and heat stress, in large part because of high levels of deprivation, which affect the ability of individuals and communities to prepare, respond and recover. Vulnerability was also found to be higher in the north and central highlands because of their remoteness.

3.2.2 Economy

Similar to the UK as a whole, the Scottish economy is dominated by the service sector, which accounts for 74% of output²³ and around 80% of jobs.²⁴ Within the service sector, financial and business services account for around 35% of Gross Value Added (GVA). Production sectors account for around 17% of GVA; construction around 8%; and agriculture, forestry and fishing around 2%.

All sectors of the economy are potentially sensitive to the risks and opportunities from the impacts of a changing climate.²⁵ The Scottish Government's recent Economic Strategy²⁶ adds a new Strategic Priority 'Transition to a low carbon economy', which sets out the need not only to reduce emissions but to take advantage of the current conditions for adaptation and investment. Some of Scotland's key growth sectors²⁷ could be directly affected by climate change, for example:

- **Food and drink** (which covers agriculture, fisheries and food and beverage manufacturing) – changes in temperature and rainfall, and in growing seasons, can affect crop yields, and present both opportunities for new products and some risks to existing products. The industry is also vulnerable to potential impacts along supply chains.
- **Tourism and leisure** – due to the influence of climate on the quality and length of seasons,²⁸ outdoor summer tourism and leisure could be positively affected by hotter, drier summers. Other sectors of the tourist industry in Scotland, such as ski and snow-related industries, have already had to adapt due to the trend for milder winters.²⁹
- **Energy** – renewable sources of energy, such as wind, solar and wave power, are particularly dependent on changing weather patterns, with the potential for both positive and negative impacts. Energy infrastructure is vulnerable to extreme weather events (floods, storms).³⁰

The global nature of Scotland's economy means that many businesses are exposed to the international economic impacts of climate change. Scotland exports goods and services all over the world, with international exports (excluding oil and gas) amounting to around £21 billion. The top exporting industries are food and beverages (17% – a large part of which is whisky exports); chemicals (13%); business services (13%); and electrical and instrument engineering (9%). In addition to the substantial export revenue that is at risk, many Scottish businesses rely heavily on extended global supply chains, including in countries that may experience significant climate impacts.

¹⁸ Scottish Government (2010a).
¹⁹ NHS Scotland (2010).
²⁰ Lindley et al. (2011).
²¹ <http://www.scotland.gov.uk/Topics/Statistics/Browse/Health/TrendLifeExpectancy>

²² Lindley et al. (2011).

²³ Scottish Government: Quarterly GDP Index, 2007 weights: <http://www.scotland.gov.uk/Publications/2011/07/GDP2011Q1> Office for National Statistics (ONS) (2010) – GVA in Scotland (excluding North Sea Oil and Gas) amounted to £103 billion in 2009 (8% of UK total). GVA per head is in line with the UK average (at around £18,000 per person).

²⁴ There are a number of sources of employment figures in Scotland/UK. We have used the latest estimates from the Business Register Employment Survey which provides figures for 2009. Available (download from B10) from: <http://www.scotland.gov.uk/Topics/Statistics/Browse/Labour-Market/DatasetsEmployment>

²⁵ Scottish Government (2010c).

²⁶ Scottish Government (2011).

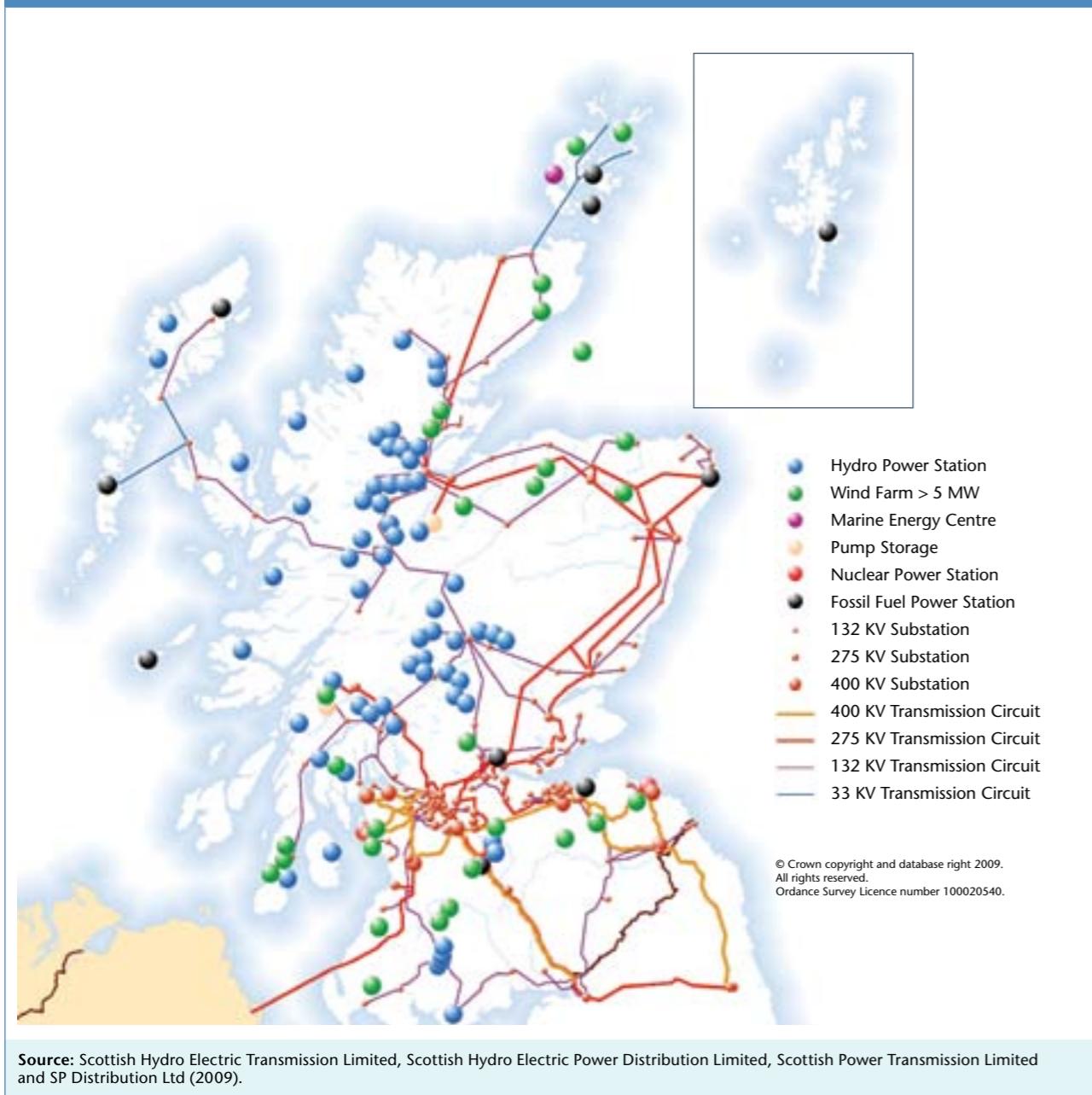
²⁷ The Scottish Government's Economic Strategy highlights a number of key sectors which have been identified as having high growth potential, the capacity to boost productivity, and have the potential to contribute to increasing sustainable economy growth, including the creative industries, energy, financial and business services, food and drink, life sciences, and tourism.

²⁸ The Scottish Government's Adaptation Framework highlights the risk that snow-related tourism may fall in Scotland as snowfall declines; on the other hand warmer temperatures may encourage more outdoor recreation.

²⁹ Scottish Government (2010c).

³⁰ AEA Technology (2011b).

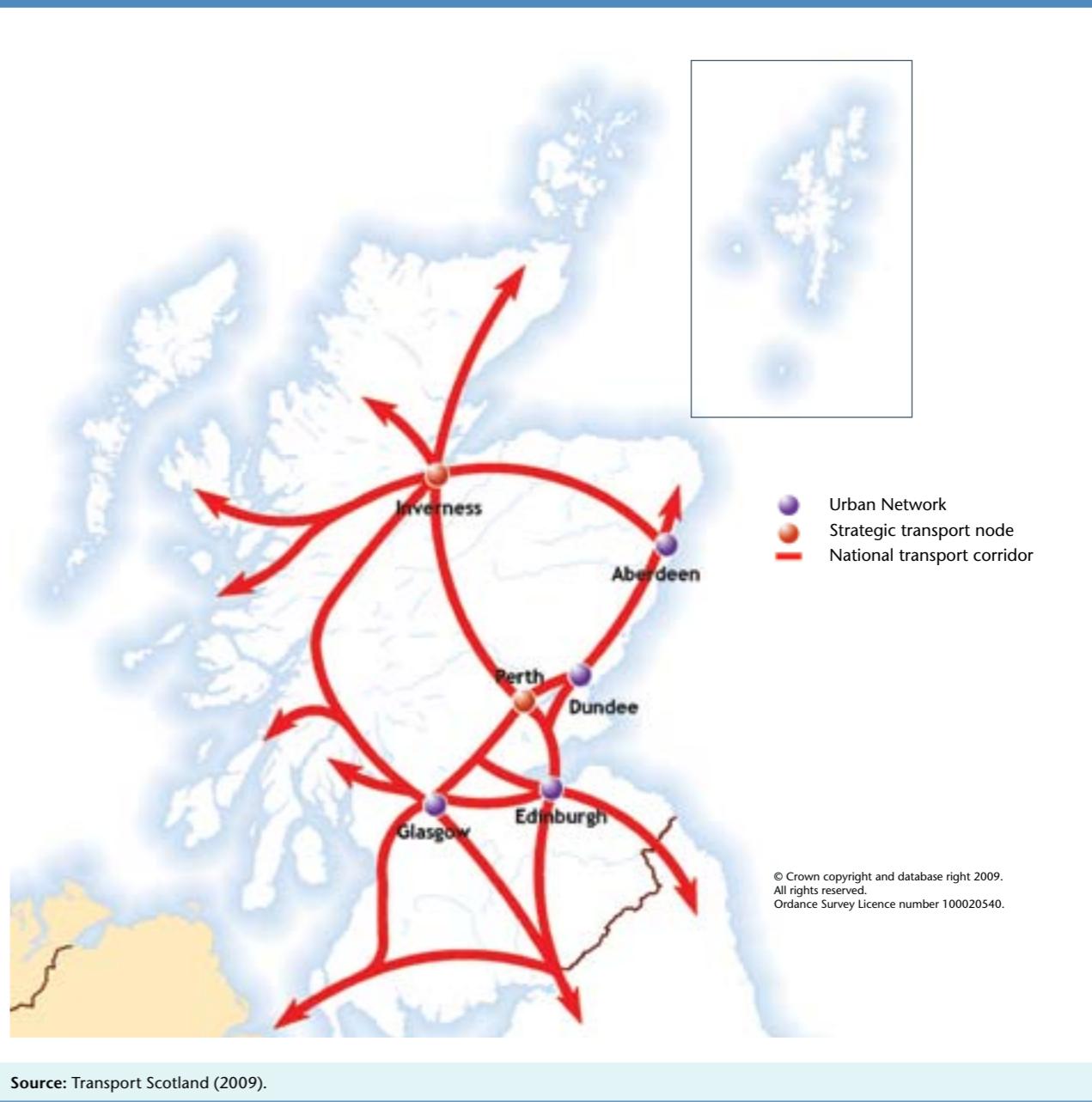
Figure 3.2: Electricity transmission system in Scotland



Many of Scotland's major transport, energy and communications infrastructure networks are concentrated in strategic corridors, and so are vulnerable to disruption from extreme weather events (Figures 3.2 and 3.3). In addition, there are 110 ports in Scotland, nine of which are defined as major. Several dozen ports currently provide vital 'lifeline' ferry services in the Highlands and Islands, while ports and related infrastructure will be of increasing importance as the supply chain for offshore renewable energy develops. Increases in the frequency and magnitude of storms, flooding and higher rates of coastal erosion could have significant economic impacts on port cities. A recent study estimated that currently Glasgow has \$2.6 billion (£1.6 billion) worth of assets exposed to sea level rise, storm surges and wind damage, which could increase to \$6.9 billion (£4.3 billion) by the 2070s.³¹

³¹ Nicholls et al. (2008).

Figure 3.3: Strategic transport corridors in Scotland

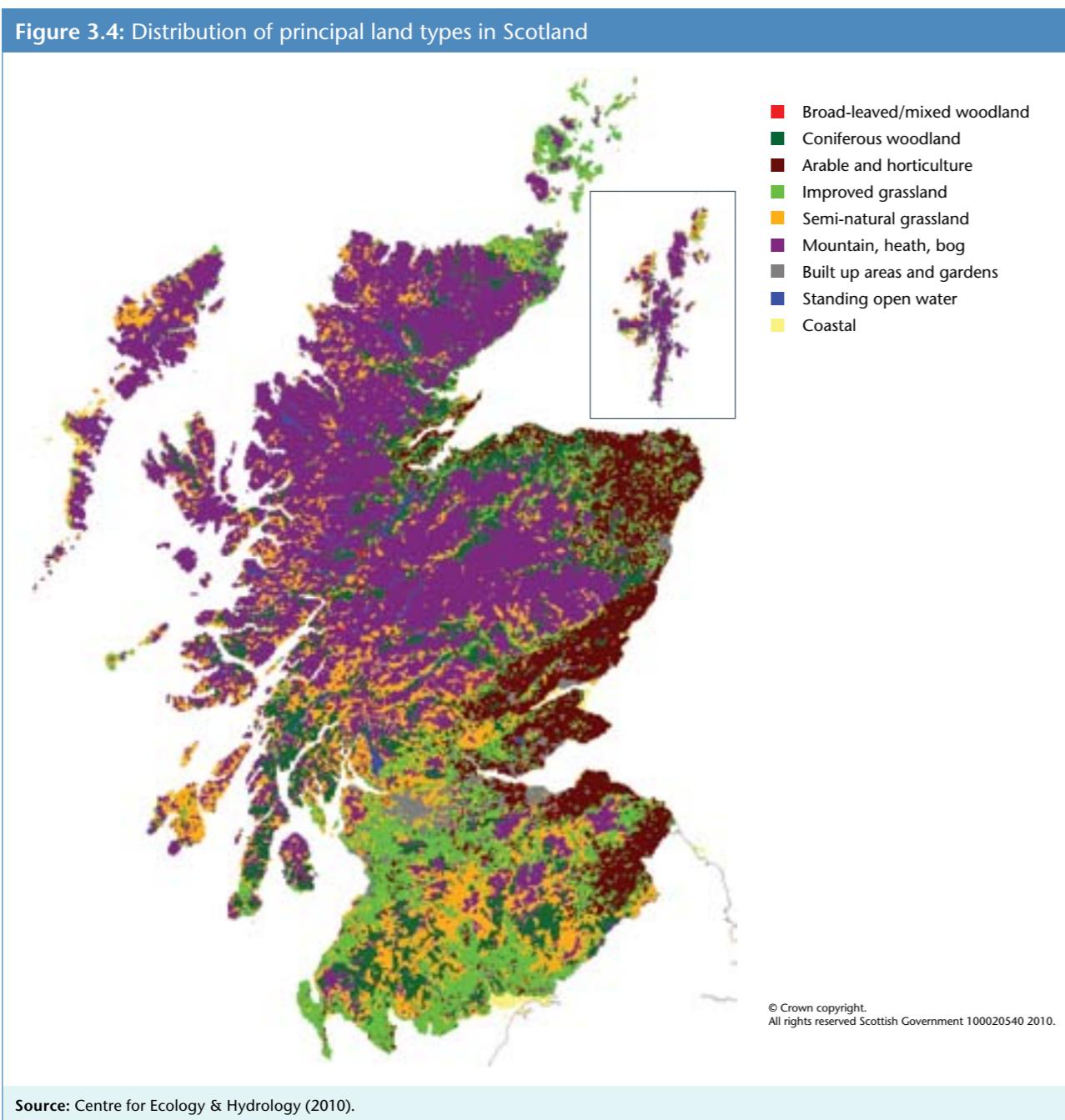


Natural resources, and the economic activity they underpin, are vulnerable to changes in climate, some of which may cause irreversible impacts on the natural environment. Natural resources play an important role in Scotland's economy. For example Scotland's forest and timber industries are estimated to be worth £1.7 billion each year to the Scottish economy,³² while the natural environment as a whole is estimated to support economic output of over £17 billion in Scotland and support around 250,000 jobs. Over one-fifth of industry sectors depend significantly on the environment.³³

³² Forestry Scotland and Scottish Enterprise (2011).

³³ Scottish Natural Heritage (2008). Note that output (GVA) and employment figures include the 'indirect' effects (i.e. the supply chain) and also the 'induced' economic impact (i.e. the spending by those directly and indirectly employed).

Figure 3.4: Distribution of principal land types in Scotland



Half of Scotland's total land area is forest and moorland, with over 1.3 million hectares of woodland (Figure 3.4). Scottish deep peat soils contain an estimated 1.8 billion tonnes of carbon³⁵ and make up around 4% of Europe's total peat carbon store.³⁶

Nearly 40% of Europe's most important habitats listed under the EU Habitats Directive are represented in Scotland.

Scotland has internationally significant nesting grounds for a variety of seabirds including Gannets and most of the UK population of Golden Eagles. 70% of the global resource of the rare coastal machair³⁷ habitat is in Scotland, as are all of the UK's ancient native pinewoods, which provide the habitat for the Scottish Crossbill, the UK's only endemic bird species. Just over one-quarter (26%) of Scotland's total land area is covered by a national or international natural heritage designation (Figure 3.5).

A number of Scotland's species are at the limit of their current climate space.

They could become extinct in Scotland as a result of being unable to adapt to a changing climate.³⁸

- Species already confined to high mountains, such as the Dotterel, may be lost as conditions become unsuitable or other species replace them.
- Scotland's currently fragmented habitats will also limit adaptation by reducing the ability of species to move through the landscape in response to the changing climate.
- There may also be physical effects on habitats, including loss of saltmarsh and machair due to coastal erosion, loss of salmon spawning beds to flash floods, and peat erosion from drying out of wetlands.
- New or enhanced risks from invasive non-native species including pests and diseases may also have implications for wildlife, and agricultural and forestry production.

3.3 Environmental characteristics

A significant amount of the UK's natural resources, many of which are sensitive to changes in climate, are located in Scotland, including:

- nearly two-thirds (59%) of the Great Britain coastline;
- 53% of the UK's inland water bodies;
- 47% of the UK's total forest land and 65% of the UK's pine forest; and
- around 60% of the UK's peatland.³⁴

³⁴ RSPB (2009).

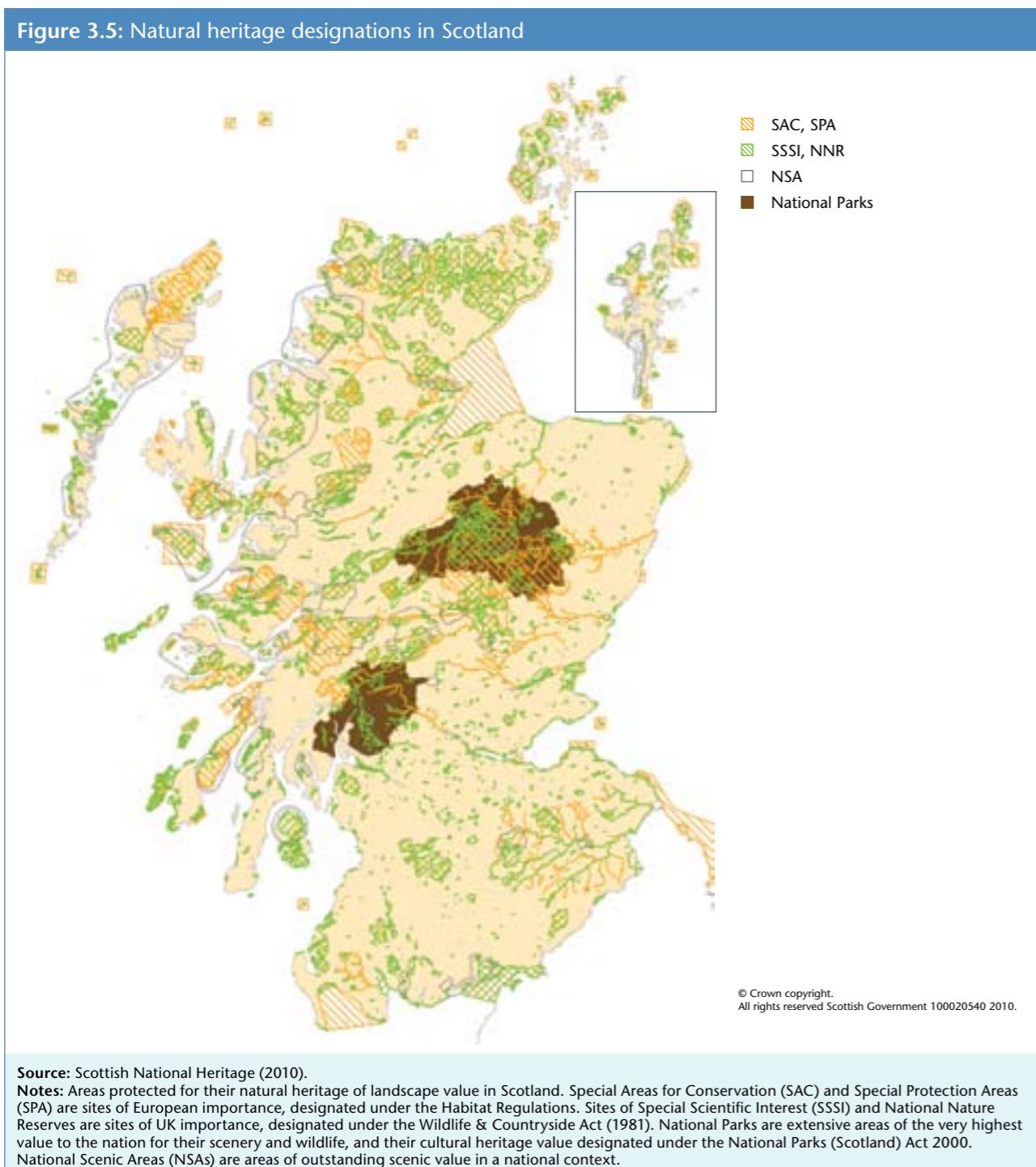
³⁵ Scottish Government (2007).

³⁶ Joosten (2009) estimates the total carbon stored in European peatlands to be in the region of 47.5 billion tonnes. Note that this definition of Europe includes European Russia which alone contains 21.3 billion tonnes.

³⁷ A sandy, grassy, often lime-rich fertile habitat above the high-water mark.

³⁸ Walmsley et al. (2007).

Figure 3.5: Natural heritage designations in Scotland



Chapter 4: Overview of adaptation policy in Scotland

The Climate Change (Scotland) Act 2009 introduced a statutory framework for adaptation policy in Scotland.³⁹ Scottish Ministers are required to lay an adaptation programme in the Scottish Parliament that sets out objectives in relation to adaptation, and policies and proposals for meeting those objectives. The programme is due to be laid following the first UK Climate Change Risk Assessment. Ministers must then report annually on progress towards implementing the adaptation programme. The Act also places a duty on public bodies to exercise their functions “in a way best calculated to deliver any statutory adaptation programme.”

Scotland’s Climate Change Adaptation Framework was published in December 2009 and aims to set the strategic direction for Scottish Government actions on adaptation. It is in effect the non-statutory forerunner of the statutory programme required by the Act. The overarching aim of the Adaptation Framework is to “increase the resilience of Scotland’s communities, and the natural and economic systems on which they depend, to the impacts of climate change.” It has established three pillars of action to achieve this:

- understand the consequences of a changing climate;
- equip decision makers with the skills and tools needed to adapt; and
- integrate adaptation into public policy and regulation.

The framework has been developed with a series of accompanying Sector Action Plans,⁴⁰ which outline the key issues and planned activity for adaptation. These look to existing sources of information and research to identify the key impacts of climate change on each sector and appropriate actions that can build resilience to these impacts. As shown in Table 2.1 earlier, the sector actions plans link with the ASC priority areas and similarly connect with the broad themes used by the UK Climate Change Risk Assessment.⁴¹

³⁹ <http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/climatechangeact>

⁴⁰ <http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/adaptation/AdaptationFramework/SAP>

⁴¹ Natural Environment, Agriculture and Forestry, Businesses and Services, Infrastructure and Buildings, Health and Well-Being.

In addition to the provisions of the Act there are a number of other support structures and policy commitments in place. For example, Adaptation Scotland provides free information, advice, tools and support “to help organisations and infrastructure in Scotland meet the challenges and opportunities presented by the impacts of climate change.”⁴² The Adaptation Scotland service is provided by the Scottish and Northern Ireland Forum for Environmental Research (SNIFFER), which also provides tailored research and information on adaptation.⁴³ The Centre of Expertise on Climate Change aims to create a world-renowned centre of expertise to deliver objective, independent, integrated and authoritative evidence to support the Scottish Government in relation to its activities on climate change mitigation, adaptation and transition to a low-carbon economy.⁴⁴

Scotland’s local authorities are responsible for delivering a wide range of services, many of which are directly relevant to adaptation, including land use planning, building control, transport, flood management, environmental services and social services. All of Scotland’s local authorities are signatories to Scotland’s ‘Climate Change Declaration’⁴⁵ which includes commitments to:

- assess the risks and opportunities of climate change scenarios and take action to adapt;
- encourage and work with others in local communities to take action to adapt to the impact of climate change;
- publish an annual statement on monitoring and progress of climate change response; and
- promote good practice on climate change mitigation and adaptation.

There are a number of reserved policy areas that are relevant to adaptation including foreign affairs, trade and industry, tax and fiscal matters, and insurance.

The UK National Adaptation Programme, which will set the wider adaptation policy context for reserved matters, will have an important bearing on Scotland’s overall approach to adaptation.

The Adaptation Reporting Power (ARP) in the UK Climate Change Act gives the UK Secretary of State the power to direct some public bodies in Scotland that operate in reserved matters to set out how they are accounting for climate change in their decision-making. The first round of the ARP process has focussed primarily on critical infrastructure providers, including:

- electricity generators, transmitters and distributors and gas transporters;
- strategic airport operators (including Glasgow and Edinburgh airports);
- lighthouse authorities;
- rail authorities; and
- electric communication operators.

⁴² <http://www.adaptationscotland.org.uk>

⁴³ <http://www.sniffer.org.uk>

⁴⁴ <http://www.scotland.gov.uk/Topics/Research/About/EBAR/StrategicResearch/future-research-strategy/CoEClimateChange>

⁴⁵ <http://climatechange.sustainable-scotland.net>

Chapter 5: Analysis of progress across priority areas for adaptation

This chapter summarises the analysis of progress in adaptation in Scotland using the main components of the ASC’s preparedness ladder for each priority area. For each priority area, we have identified the relevant sector action plans that were used for the basis of the analysis.

5.1 Land use planning

5.1.1 Importance to adaptation

The land use planning system is a priority area for adaptation action, because it is a primary mechanism for determining how vulnerability to climate change can be managed, particularly in towns and cities. Land use planning decisions can directly help to increase resilience to climate risks, but can also lock future generations into a development pathway that increases vulnerability or one that will be very costly to maintain or reverse.

The land use planning system is one of the most important adaptation functions delivered by local government. Local authorities are responsible for preparing the strategic policies in the ‘development plan’, on which decisions about individual planning applications are based. Policies set out what is expected of development in order for planning permission to be obtained. They identify specific locations or set criteria for types of locations that are suitable for particular land uses, and also stipulate particulars of the design of new development. Local authorities also make decisions on individual planning applications considering national and local planning policies to determine if a development proposal is acceptable.

Local authorities face difficult trade-offs when planning the future of their localities. The costs to the local economy of constraining development in areas at risk from climate impacts could be significant. The options that they have available will be determined in part by the availability and suitability of alternative sites for development.

5.1.2 Summary of findings

The relevant sector action plans reviewed to assess progress in this priority area were:

- Spatial planning and land use
- Built environment

From our analysis (Figure 5.1 and Table 5.1), national planning policy and strategic guidance look to be well developed on adaptation through the National Planning Framework.⁴⁶ Local decision-makers are being required by the policy framework to explicitly consider and account for the implications of climate change and adaptation responses when planning for their communities. The high uptake of sustainable drainage systems in new development suggests that the policy framework is having some success here.

However, we were not able to find much evidence on the effectiveness of national planning policy on influencing decisions on the location of new development. There is a lack of data on recent trends on the amount of development in areas of flood risk or behind eroding coastlines, which may be affecting the vulnerability of communities to climate risks. We could also not find data on changes to the area of hard surfacing and the amount of greenspace in urban areas.

The recently published Scotland Greenspace Map⁴⁷ will provide a baseline against which future changes in the amount and type of greenspace can be tracked (Box 5.1). Urban greenspace provides a number of important adaptation services, including reducing surface water run-off rates and the intensity of the urban heat island effect.⁴⁸ Monitoring changes to the extent and type of urban greenspace is therefore an important indicator of preparedness for climate change.

Figure 5.1: Summary of progress in adaptation in land use planning in Scotland

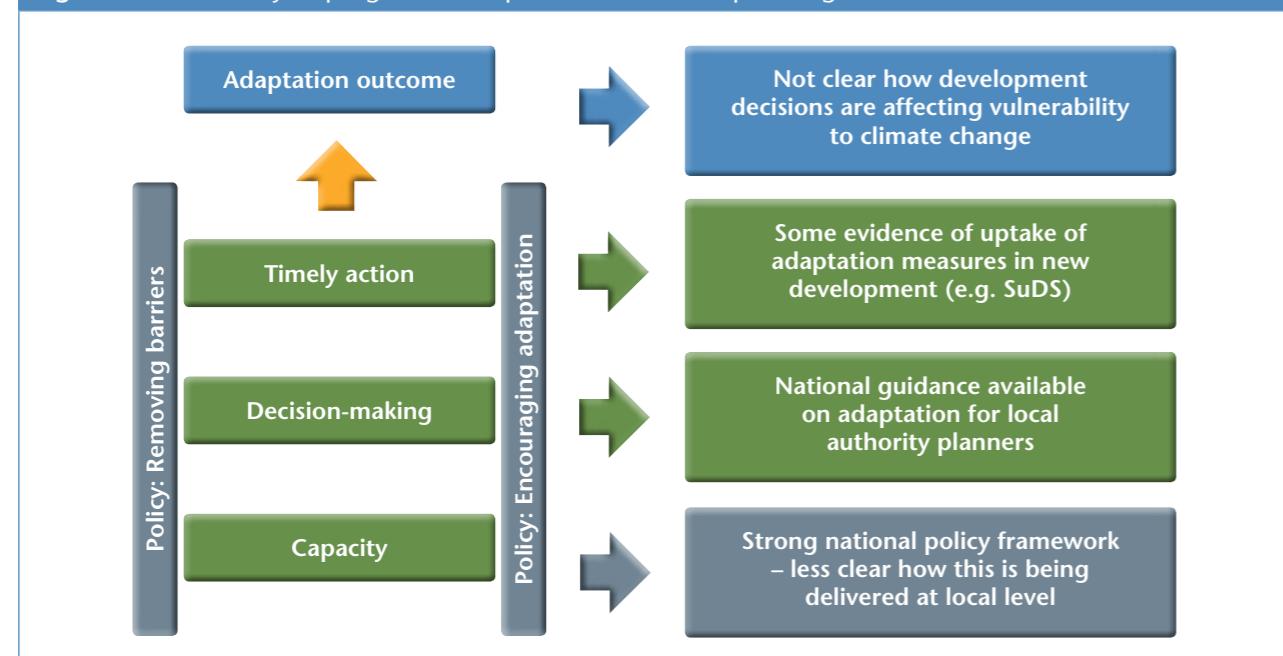


Table 5.1: Assessment of progress in adaptation in land use planning

Adaptation component	What we found
Adaptation outcomes – trends in climate impacts and vulnerability	<ul style="list-style-type: none"> Around 5% of existing properties in Scotland are currently at flood risk, of which the majority (4.5%) are residential.⁴⁹ Areas potentially vulnerable to flooding have been mapped by the Scottish Environmental Protection Agency (SEPA) (Figure 5.2).
Timely actions	<ul style="list-style-type: none"> Since 2001, national planning guidance has stipulated that all new developments should incorporate drainage strategies and designs to reduce water run-off rates in new development, including proposals for sustainable drainage systems (SuDS). As a result, the use of SuDS has become standard practice, although we were not able to find data on the proportion of actual new developments that include SuDS or trends in uptake since 2001.⁵⁰
Decision-making and capacity	<ul style="list-style-type: none"> The Spatial Planning and Land Use sector plan includes an action to integrate adaptation into local authority development plans and highlights the importance of cross-boundary working. However, the policy mechanism for how this would be achieved was not clear.
Policy enabling adaptation	<ul style="list-style-type: none"> The National Planning Framework identifies adapting to climate change as one of the key challenges facing Scotland. Planning authorities are required to develop strategies for more sustainable patterns of development that take account of climate projections and to understand changing development capacity due to factors such as long-term flood risk and the increased frequency of extreme weather. There are also more detailed Planning Notes that provide guidance to planning authorities on flood risk. Flood Risk Management Act (Scotland) (2009) places duties to map risk and create local flood risk plans. Water Environment Regulations (2005) require that surface water discharges must be by means of a sustainable urban drainage system authorised by SEPA.

Box 5.1: Mapping Scotland's Urban Greenspace

Scotland's Greenspace Map is an innovative Geographical Information System (GIS) based map that provides comprehensive information on the location, extent and type of greenspace across all of Scotland's urban settlements (towns and cities with a population of 3,000 or more).

The map (Figure 5.3) was compiled in 2011 from greenspace data provided by all 32 Scottish Councils. The local datasets were produced using GIS maps and aerial photography to categorise greenspaces into 23 different open space types, including public parks, play areas, allotments, amenity greenspace, private gardens.

The map provides valuable baseline data by which to track future changes in the extent and type of urban greenspace, including:

- 30% of greenspace is private gardens;
- 28% is natural and semi-natural land;
- 15% amenity greenspace;
- 13% sports areas; and
- 9% public parks and gardens.

⁴⁶ Scottish Government (2009b).

⁴⁷ <http://www.greenspacescotland.org.uk/scotlandsgreenspacemap/>

⁴⁸ Greenspace Scotland (2011).

⁴⁹ SEPA (2011).

⁵⁰ SNIFFER (2002). SuDS database for Scotland records over 700 SuDS sites, incorporating nearly 4000 individual systems, in 2001.

Figure 5.2: Potentially vulnerable areas to flooding in Scotland

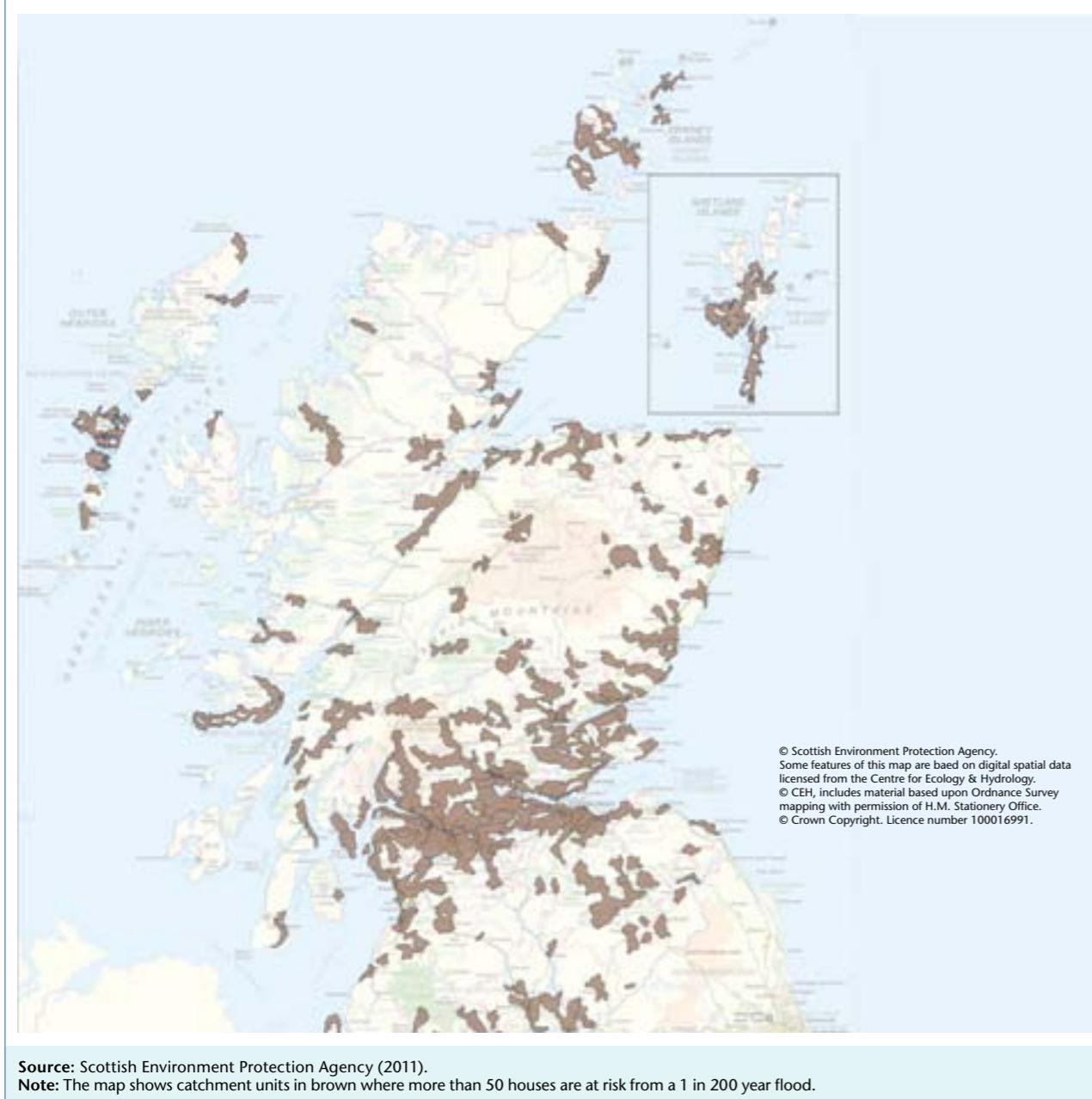


Figure 5.3: Scotland's Greenspace map



These risks are a concern both for new buildings and the existing housing stock. Around 70% of UK homes that will exist in 2050 have already been built.⁵¹ These homes are susceptible to both current and future risks. Future climate should therefore be considered both in the design and renovation of buildings.

Buildings and the urban form also strongly influence how people experience climate impacts. For example, during heatwaves night-time temperatures can be significantly higher than those recorded for surrounding rural locations, because of the urban heat island effect. Similarly, building occupants use the majority of water and energy supplied by utility companies.

5.2 Design and renovation of buildings

5.2.1 Importance to adaptation

Buildings are a priority area for adaptation because decisions concerning their design, construction and renovation are long-term and may be costly to reverse.

Buildings are already vulnerable to current climate risks, such as flooding, storms, overheating and subsidence. The location, design and fabric of new buildings will influence their vulnerability to future climate change. Rising temperatures may make buildings uncomfortable for occupants, and more frequent and severe weather events, such as flooding, may expose occupants to greater risk unless action is taken.

⁵¹ Based on a replacement rate of around 1% per year.

5.2.2 Summary of findings

The relevant sector action plans reviewed to assess progress in this priority area were:

- Built environment
- Spatial planning and land use

From our analysis (summarised in Figure 5.4 and Table 5.2), it appears that the policy framework for adaptation of new buildings is well developed. Building regulations include some specific adaptation measures, particularly in relation to flood resilience and urban drainage. In general roofing structures are required to be stronger than is the case in England, reflecting greater average wind speeds in Scotland. This demonstrates how policy mechanisms can be tailored to reflect current weather conditions. These regulations could act as important mechanisms for enabling the uptake of resilience measures, although they primarily influence new development and have less effect on existing buildings.

We found less evidence on the uptake of adaptation measures in the retrofit or repair of existing properties. The ASC's second UK progress report⁵² identified a number of reasonably low-cost measures for existing buildings (£500 to £2,500 per property) that avoid significant damages from modest flood levels. These include airbrick covers, door-guards, re-pointing external walls, main sewer non-return valves, drainage bungs and toilet pan seals.

Householders and developers require the right incentives to take action. The ASC's second progress report found instances where there is either a lack of or misaligned incentives, both of which lead to an inefficient adaptation outcome. Levers other than regulation, such as insurance incentives and better information, may be more important for existing homes. However, we did not find evidence of any specific programmes in Scotland to support the retrofitting of existing buildings to improve their resilience to future climate risks.

Figure 5.4: Summary of progress in adaptation in designing and renovating buildings

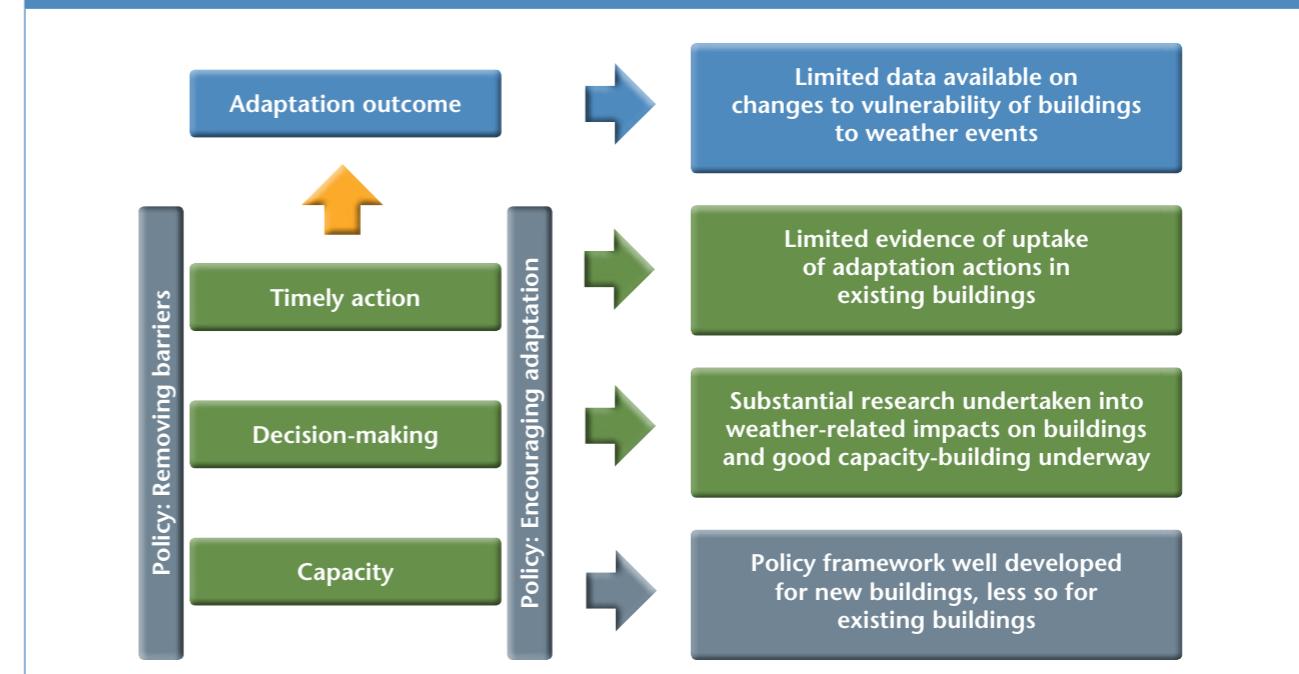


Table 5.2: Assessment of progress in adaptation in designing and renovating buildings

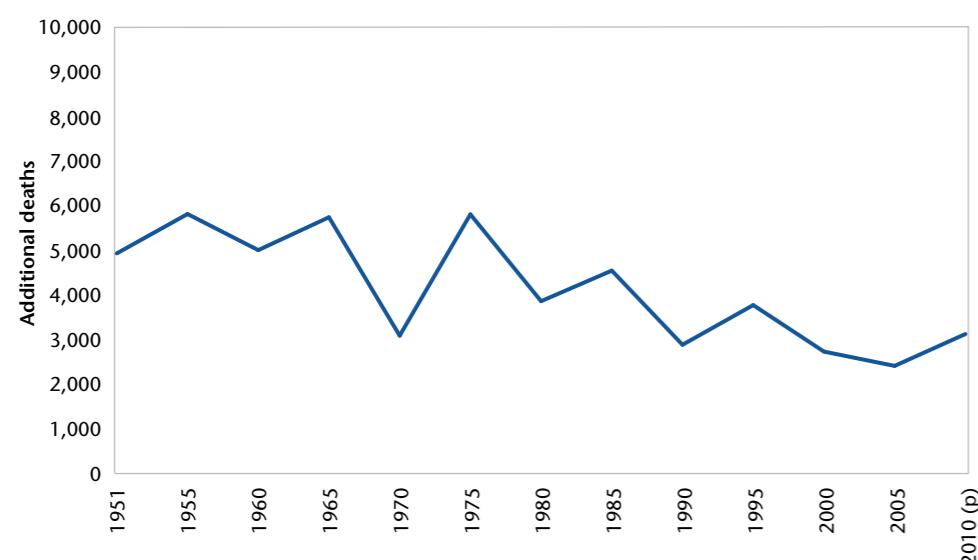
Adaptation component	What we found
Adaptation outcomes – trends in climate impacts and vulnerability	<ul style="list-style-type: none"> SEPA have estimated average annual losses of between £720 million to £850 million from flooding of buildings and agricultural land.⁵³ Data on insured losses are only available at a UK wide basis. Winter mortality data point to a general decline since the 1950s (Figure 5.5). This could be due to a combination of improved health care provision, improved building stock and milder winters.
Timely actions	<ul style="list-style-type: none"> Around 1% of properties are water-metered and this has not increased since 2006.⁵⁴ This may be proportionate to the lower risk from water stress in Scotland.
Decision-making and capacity	<ul style="list-style-type: none"> The Scottish Government has carried out research into effects of wind-driven rain on external walls. The Sector Skills Councils and the appropriate professional bodies are working with industry and skills providers to ensure that new entrants and existing professionals have developed the required skills to respond to climate change. Local authorities are considering climate change and energy efficiency as they prepare their Local Housing Strategies, although it is not clear if adaptation measures are included.

⁵² Adaptation Sub-Committee (2011).

⁵³ Figure from SEPA's submission to Scottish Ministers on Flood Risk Management, Potentially Vulnerable Areas and Local Plan Districts (September 2011). http://www.sepa.org.uk/flooding/flood_risk_management/consultations/national_flood_risk_assessment.aspx

⁵⁴ AEA Technology (2011a).

Figure 5.5: Trends in winter mortality, Scotland (1951-2010)



Source: GROS (2010)
Note: 2010 figures are provisional.

Table 5.2: Assessment of progress in adaptation in designing and renovating buildings

Adaptation component	What we found
Policy enabling adaptation	<ul style="list-style-type: none"> The National Planning Framework (2009) requires planning authorities to recognise the need to reduce and better manage demand for energy and water in new development. It recognises that modifying Scotland's existing built environment will be a "much greater challenge". Building Regulations include a number of standards relevant to adaptation: <ul style="list-style-type: none"> flood resilience measures for new properties at risk;⁵⁵ any constructed hard surface greater than 50 m² needs to use sustainable drainage systems or other appropriate techniques for managing surface water run-off; and preventing damp/water ingress from wind driven rain.

⁵⁵ Based on industry design guidance (CIRIA 2007).

5.3 Provision of infrastructure

5.3.1 Importance to adaptation

The provision of national infrastructure is a priority area for adaptation action as decisions are long-term and often irreversible, with the potential for costly retrofitting and/or reduced returns on investments in the future if climate impacts result in existing and newly provided infrastructure no longer being fit for purpose. Examples of adaptation measures include:

- ensuring infrastructure is resilient to potential increases in extreme weather events, such as storms, floods and high temperatures;
- ensuring investment decisions take account of changing patterns of consumer demand, as a result of climate change, in areas such as energy and water use, travel, and consumption; and
- building in flexibility so that infrastructure systems can be modified in the future without incurring excessive cost.

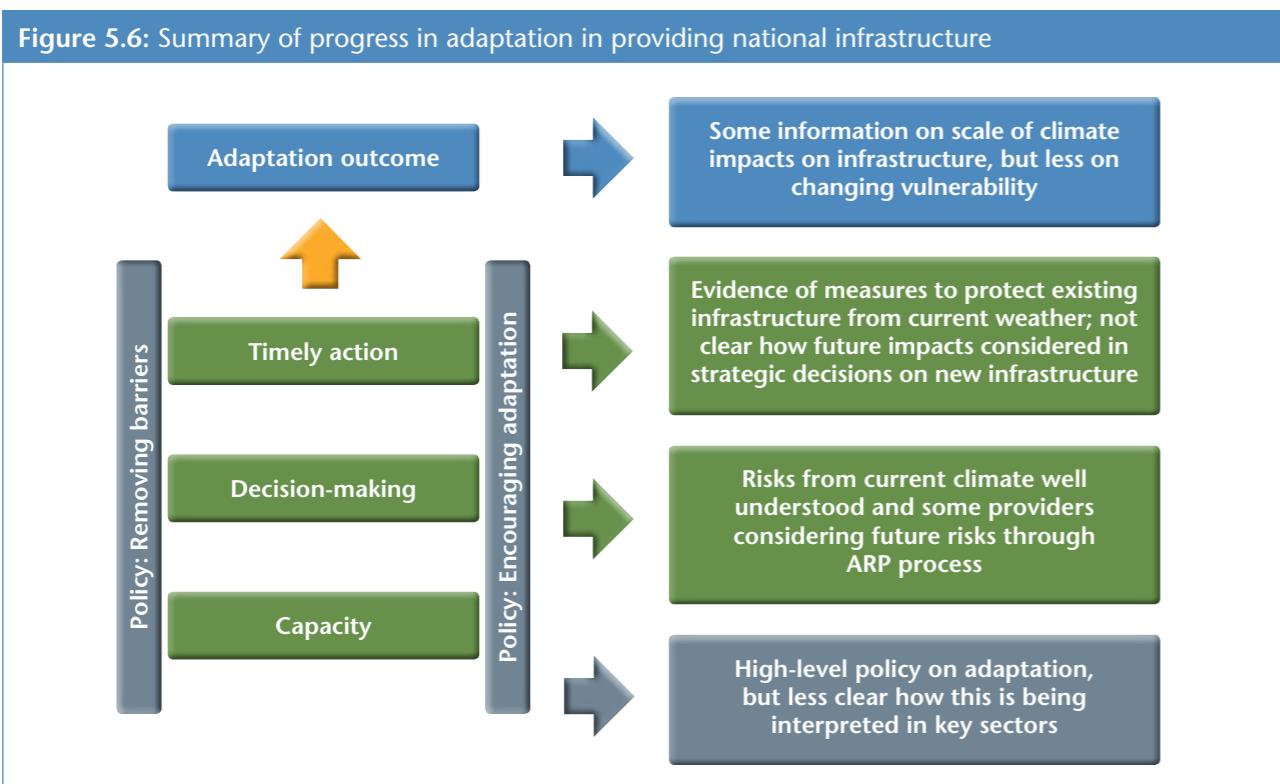
The location and design of new infrastructure is a particular priority in Scotland because of the remoteness of some communities and the concentration of many of Scotland's major transport, energy and ICT infrastructure networks in strategic corridors exposed to extreme weather events. Furthermore, a significant amount of investment in new infrastructure is being delivered or is planned over the decade, particularly renewable energy and the associated distribution and transmission network, new transport links, and flood defence and drainage schemes. Much of this new development will be in place until at least the middle of the century and in some cases longer.

5.3.2 Summary of findings

The relevant sector action plans reviewed to assess progress in this priority area were:

- Transport
- Energy
- Water environment and resources
- Land use and spatial planning

Figure 5.6: Summary of progress in adaptation in providing national infrastructure



From our analysis (Figure 5.6 and Table 5.3) we found that national policy requires consideration of climate risks in planning new infrastructure. The National Planning Framework contains a number of detailed policies for each sector that require consideration of climate risks on the location and design of new infrastructure.⁵⁶

We found evidence of work to improve the resilience of existing transport and energy infrastructure to extreme weather events, but less work assessing the implications of climate change for the strategic deployment of new infrastructure. We found minimal focus on how to make ICT infrastructure more resilient to future climate.

Infrastructure providers appear to have a good understanding of how extreme weather today can affect their operations and what steps to take to improve their resilience. Adaptation appears to be incorporated into the business planning of key delivery bodies (for example Transport Scotland and Scottish Water). Some providers have undertaken assessments of climate risks to their operations through Adaptation Reporting Power (ARP) process under the provisions of the UK Climate Change Act.⁵⁷ Operational guidance on adaptation has also been prepared in some sectors, for example standards for energy networks. A substantial amount of research is in progress to better understand the implications of climate change for critical services, particularly on transport.

Uncertainty in climate predictions for wind speeds/direction and waves poses challenges for the planning Scotland's renewable energy programme. The Committee on Climate Change recently reviewed the risks posed by a changing climate to the UK's mitigation strategy and their implications for delivering the UK's carbon budgets, which offers a potentially useful approach (Box 5.2).

We found limited data on trends in climate-related impacts on the provision of critical services or on the vulnerability of existing infrastructure assets to climate risks. The lack of such data will make it difficult to assess the effectiveness of the numerous strategies and guidance on adapting infrastructure.

Table 5.3: Assessment of progress in adaptation in providing national infrastructure

Adaptation component	What we found
Adaptation outcomes – trends in climate impacts and vulnerability	<ul style="list-style-type: none"> The only relevant data on climate impacts on the provision of infrastructure are Drought Order trends. There have been a total of five since 1976 in Scotland (compared to 518 in England). Four of these have occurred since 2000.⁵⁸ We have not been able to identify data on interruptions to other critical services (energy, transport, etc) caused by extreme weather. Data on the location of infrastructure assets that are vulnerable to flood risk will be available when SEPA publish their national flood risk assessment later in 2011.
Timely actions	<ul style="list-style-type: none"> Anecdotal evidence that flood resilience measures are being incorporated into the design of new roads and rail infrastructure, such as use of sustainable drainage systems. Scottish Water undertook a £2.5 billion investment programme to renew water and drainage infrastructure between 2005-2010. Between 2010-15 they aim to carry out flood risk assessments on 292 assets. These take account of the impact of climate change on flooding frequency and magnitude. From this, they will identify capital investment priorities. Scottish Water are also undertaking analysis on water resource zones vulnerable to climate change, which will be reported in the next revision of their Water Resource Plan due in 2013.

⁵⁶ The NPF designated 14 infrastructure projects that are deemed to be in the national interest. They are mostly transport and energy related, although also include green infrastructure (the Central Scotland Green Network) and a drainage scheme (the Metropolitan Glasgow Strategic Drainage Scheme).

⁵⁷ Network Rail and National Grid.

⁵⁸ AEA Technology (2011a).

Table 5.3: Assessment of progress in adaptation in providing national infrastructure

Adaptation component	What we found
Decision-making and capacity	<ul style="list-style-type: none"> Infrastructure providers that operate in reserved areas of policy, such as Network Rail and National Grid, have undertaken assessments of climate risks to their GB-wide operations through the Adaptation Reporting Power (ARP) process. According to the National Grid, electricity and gas construction and operation standards are fit for a 2080 high climate scenario. Scottish Government and SEPA have carried out a Flood Risk Assessment for Critical National Infrastructure. From this, flood risk mitigation plans will be prepared by end of 2011 where appropriate. The Scottish Government are also working with the UK Government (Cabinet Office) to complete Energy Sector Resilience Assessments which factor in future climate projections. Transport Scotland is undertaking work to understand the consequences of climate change, including: <ul style="list-style-type: none"> Scottish Road Network Climate Change Study (2005) assessed future climate risks on transport network and identified a number of actions. A detailed study of the future risks from landslides is being used by Transport Scotland to prioritise resilience measures, including developing rainfall-monitoring systems to enable early warning. An assessment of potential sea level rise in specific Scottish ports in reference to historic data, to assess implications for operations. Considering the suitability of existing transport routes to support lifeline services (e.g. ferries) when accounting for effects of high winds and storms Assessing vulnerability of coastal transport infrastructure. At a GB-scale, a comprehensive review of the vulnerability of the rail network by the Rail Safety Standards Board (RSSB)⁵⁹ has identified Scotland specific issues and actions.
Policy enabling adaptation	<ul style="list-style-type: none"> National Planning Framework sets strategic policy for all infrastructure provision including the Central Scotland Green network and the Metropolitan Glasgow Strategic Drainage Scheme. The NPF requires that the implications of a changing climate must be considered "to ensure the sustainability of these investments". Consideration of the implications of climate change on renewable energy is being incorporated into key strategic plans, including the Renewables Action Plan and Renewable Heat Action Plan. Transport Scotland's Corporate Plan takes explicit account of implications of climate change and include commitments to deliver adaptation actions in their process and procedures. The 'public bodies' duty in the Climate Change Act (Scotland) will require all infrastructure providers in Scotland to exercise their functions in ways that contribute to the national adaptation programme once it has been published.

⁵⁹ Rail Safety Standards Board (2010).

Box 5.2: Climate risks to the UK's carbon budgets

Recognising the importance of considering the implications of a changing climate for emissions reductions (such as the supply of wind power and bioenergy, and the demand for heating and cooling), the Committee on Climate Change commissioned an initial analysis of climate risks to UK carbon budgets over the next 20 years.⁶⁰

The work included specific case studies for a subset of major risks spanning the range of uncertainty. The key findings from the analysis are:

- In wind power, there is considerable uncertainty about future wind patterns from current climate model projections. The effect of a given change in wind on power output is however well known. Based on the lowest wind-speed months of the last decade, sustained lulls could lead to an additional 3-4 MtCO₂/yr in 2030 through use of increased fossil fuel backup generation.⁶¹ Currently, uncertainties in future costs of wind power due to projected climate change do not appear greater than uncertainties from non-climate factors such as the rate of wind technology improvement.
- In heating/cooling demand, climate projections are that average UK temperatures will increase, leading to a likely seasonal shift in demand from winter heating towards summer cooling. Uncertainty in how this will affect emissions comes primarily from non-climate trends in building properties (e.g. insulation) and behaviour (e.g. uptake of air conditioning units). But current evidence suggests that, out to 2030, decreases in winter demand may more than offset increases in summer demand.
- Analysis of the power sector as a whole highlights potential system-wide vulnerability to some weather events. In particular, a prolonged heatwave and drought will have negative impacts on all thermal power generation (e.g. coal and nuclear) while simultaneously reducing efficiency of transmission lines and increasing demand for cooling in buildings.

The study shows that there are many interactions between mitigating and adapting to climate change. It represents a start in identifying climate risks to meeting emissions targets, and serves as a useful example of how organisations can approach adaptation risk assessment.

5.4 Managing natural resources

5.4.1 Importance to adaptation

The management of ecosystems, habitats, land, seas and natural resources (such as water) is a priority for early adaptation action. Natural resources are highly sensitive to changes in climate, in terms of both changes to current averages (such as temperature, rainfall, ocean acidity) and changes in the frequency and magnitude of extreme weather events. Climate change can result in irreversible changes to many aspects of the natural environment such as loss of certain species and habitats, changes to landscape character and implications for the viability of some crop and timber types. However, there may also be some benefits and opportunities, such as new markets for crops and timber currently not economically viable.

⁶⁰ AEA Technology (2011).

⁶¹ Poyry (2011).

The sustainable management of natural resources can make an important contribution to both adaptation and mitigation. For example, restoring degraded peatlands can reduce losses of carbon dioxide to the atmosphere (a mitigation benefit) as well as helping to deliver adaptation benefits such as managing water flow at a catchment scale and building biodiversity resilience (see Box 5.3). Another example is woodland and tree planting, which as well as sequestering carbon dioxide can also help reduce flood risk, improve habitat connectivity so that biodiversity is more able to respond to changes in climate, and contribute to mitigating the urban heat island effect.⁶²

Box 5.3: Importance of peatland restoration for climate change adaptation and mitigation

Peatlands are vulnerable to climate change

Warmer average summer temperatures could dry out this wetland habitat, with possible increased peat cracking and erosion. This in turn will increase vulnerability to wildfire, which can result in significant localised vegetation loss. High rainfall events may further erode bare peat surfaces.⁶³ Increased temperatures may also have a concomitant effect on plant decomposition. Modelling suggests that, under a high emission scenario for 2080s, the bioclimatic space for peatlands reduces by 84% with only parts of western Scotland remaining within this space.⁶⁴

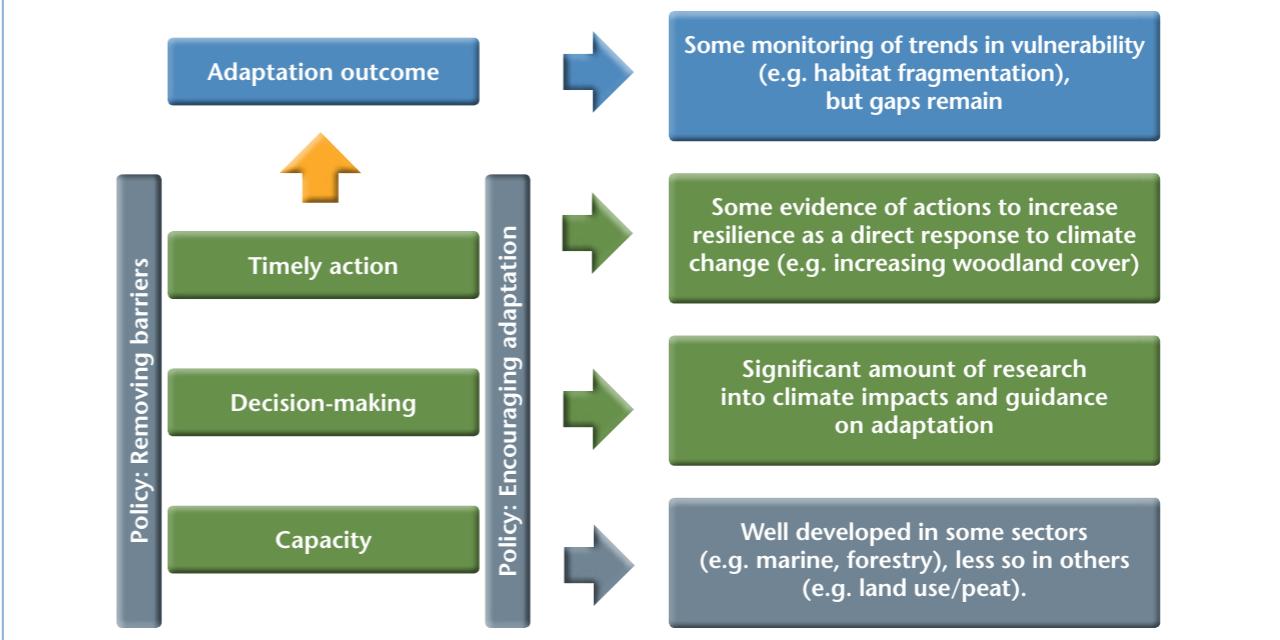
Current species composition will alter

Specialised peatland biodiversity, particularly bog mosses, build and maintain peat mass which delivers high levels of carbon storage and regulation of water flow and water quality.⁶⁵ Significant changes to peatland vegetation are likely to occur and indeed have done so periodically in the past. However, the evidence suggests that peat formation has continued through previous climates.⁶⁶ This suggests that key ecosystem functions such as carbon storage and water regulation can continue to be provided by healthy peatlands, even with different species composition.

Degraded peatlands are less likely to be able to continue to deliver ecosystem functions

Degraded peatlands are significantly less resilient to changing climatic conditions than healthy peatlands. Peatlands can be damaged by activity such as peat extraction, burning, grazing, drainage and forestry planting. Scottish Natural Heritage (SNH) has reported that 38% of designated upland blanket bog peatlands are in unfavourable condition⁶⁷ and research in England found that 70% of all peatlands are physically degraded.⁶⁸ The implications could be significant, particularly for carbon losses where it has been estimated that around 10 MtCO₂ are currently being lost annually from the UK's peatlands.⁶⁹

Figure 5.7: Summary of progress in adaptation in managing natural resources



5.4.2 Summary of findings

The relevant sector action plans reviewed to assess progress in this priority area were:

- Spatial planning and land use
- Biodiversity and ecosystem resilience
- Marine and fisheries
- Agriculture
- Forests and forestry

The evidence reviewed (Figure 5.7 and Table 5.4) suggests that the sector plans are generally well advanced. Work is on-going to improve understanding of climate change for current practices, in the co-ordination of research, and the publication of guidance and advice. There appears to be progress in developing and promoting practical approaches to adaptation, for example through the piloting of landscape-scale conservation projects.

We generally found some knowledge of underlying trends in climate impacts and vulnerability. For example, the Marine Climate Change Impact Partnership⁷⁰ provides information on the impacts of climate change on the marine ecosystem. There are some gaps remaining, particularly in relation to understanding species responses, habitat fragmentation, long-term monitoring of ocean acidification in Scottish waters⁷¹ and trends in greenhouse gas fluxes from Scotland's peatlands.

⁶² Read (2009).

⁶³ RSPB (2009).

⁶⁴ Gallego-Sala et al. (2010).

⁶⁵ Littlewood et al. (2010).

⁶⁶ Gallego-Sala et al. (2010).

⁶⁷ Scottish Natural Heritage (2010).

⁶⁸ Natural England (2010).

⁶⁹ IUCN (2010).

⁷⁰ Marine Scotland is a partner of the Marine Climate Change Impacts Partnership which brings together scientists, government, its agencies and NGOs to provide co-ordinated advice on climate change impacts around the UK's coast and seas <http://www.mccip.org.uk>

⁷¹ There is currently only one site in Scottish waters being monitored for changes in pH.

There is less evidence of monitoring of the uptake of adaptation actions and the effectiveness of capacity building in materially affecting the vulnerability of Scotland's natural resources to climate risks.

The picture on policy to enable adaptation in this area is mixed:

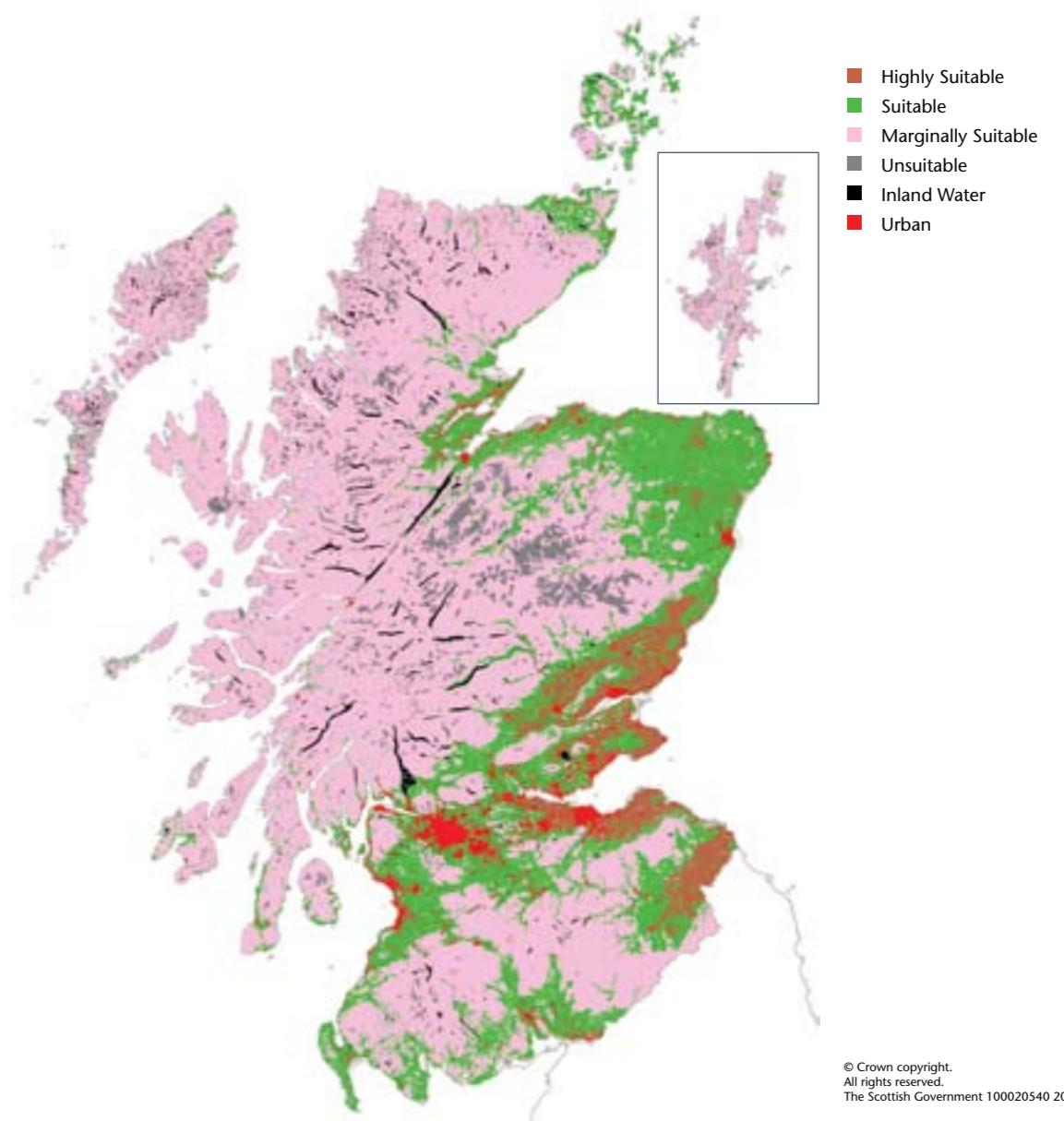
- The Land Use Strategy (LUS)⁷² includes a high-level principle that land use decisions should be informed by an understanding of the opportunities and threats brought about by climate change.
- Both the marine and forestry policy appear to be well advanced in accounting for the implications and opportunities of climate change.
- It is less clear how the biodiversity policy is explicitly accounting for the implications of climate change, particularly in the setting of conservation objectives and designations, although this is currently under review.
- Agricultural and fisheries policy is generally driven by wider EU-level mechanisms (i.e. Common Agriculture Policy and Common Fisheries Policy) and as such the policy drivers are generally agreed at the EU-level.

Changing climatic conditions may enable an expansion of agricultural production from current areas of suitability, which are predominantly in the east (Figure 5.8).

Any westward expansion could bring economic opportunities, although if not managed carefully could also have adverse impacts on Scotland's peatlands, which are mostly located in the western half of the country (Figure 5.9). Neither the Land Use Strategy nor the relevant adaptation sector plans explicitly consider the risks from both future land use change and climate change to Scotland's globally important peatlands. This could be a potentially significant gap in the adaptation framework.

Expanding the area of woodland cover is a stated policy ambition and, if managed carefully, could deliver a range of adaptation benefits (e.g. reduced flood risk, habitat connectivity, etc). Current woodland cover is around 17% of Scotland's land area and the target is to reach 25% by 2020. This will require a doubling of new planting from current levels of less than 5,000 ha (Figure 5.10). The suitability of land for new woodland has been mapped, to minimise the risks of inappropriate planting. However, it is less clear, if consideration has been given to the potential impacts of climate change on the type of new woodland being created, for example from pests and diseases.

Figure 5.8: Current suitability for agriculture in Scotland



Source: The Macaulay Land Use Research Institute (2010).

⁷² Scottish Government (2011b). The Land Use Strategy sets out the Government's policy on sustainable land use. Preparing the LUS is a requirement of the Climate Change Act. The Scottish Government believe it to be the first of its kind in Europe.

Figure 5.9: Depth of peat in Scotland

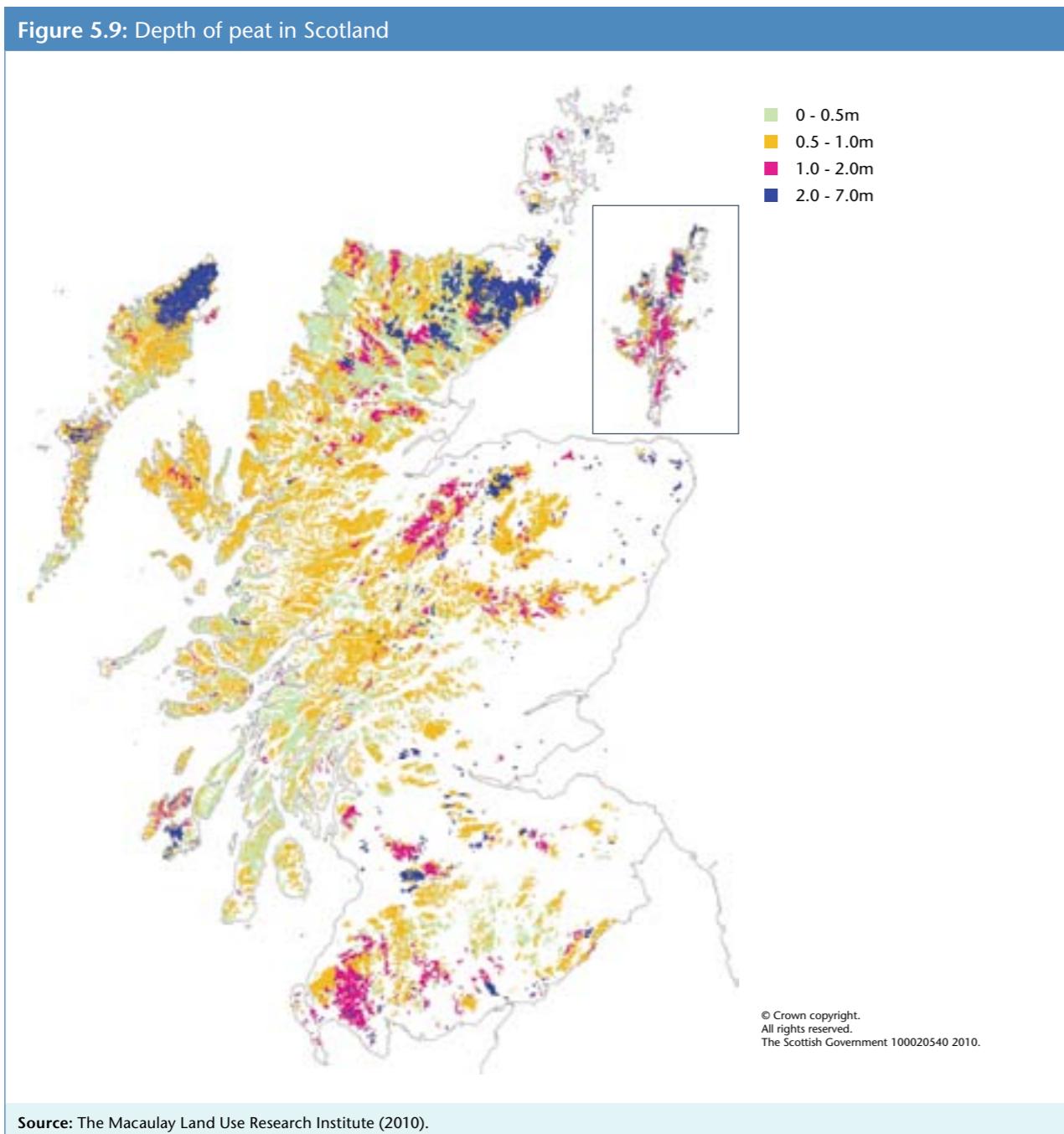


Figure 5.10: Area of annual conifer and broadleaved woodland planting (1976-2010)

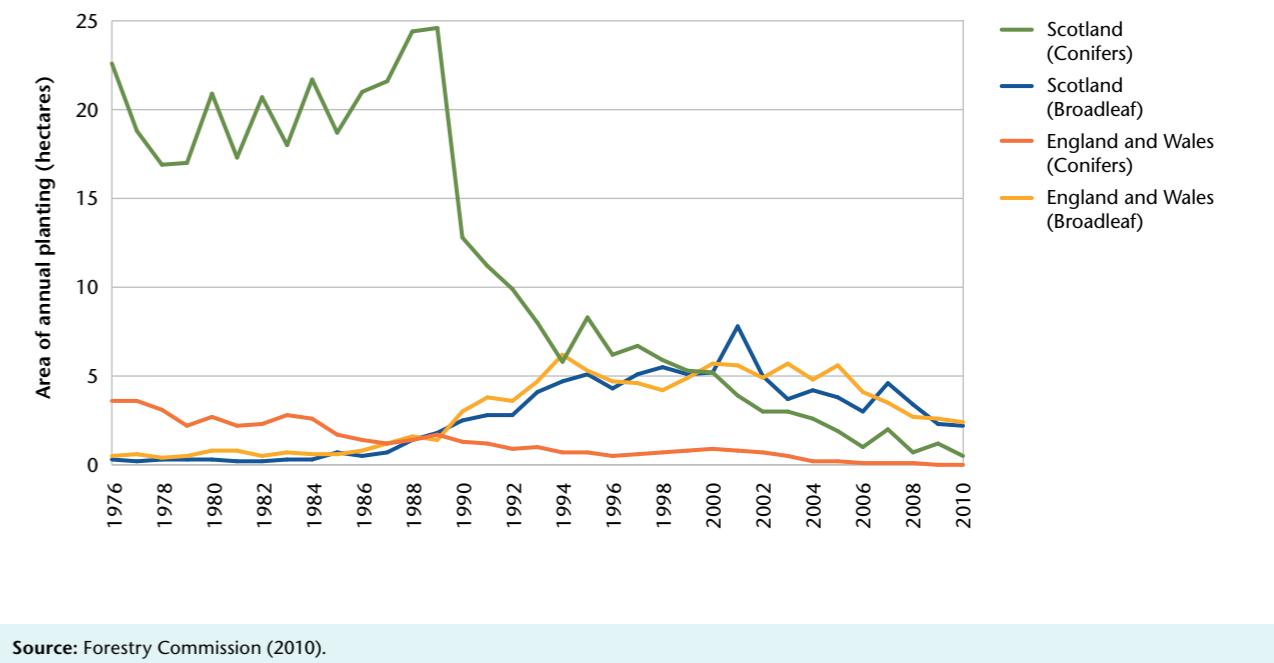


Table 5.4: Assessment of progress in adaptation in managing natural resources

Adaptation component	What we found
Adaptation outcome – trends in climate impacts and vulnerability	<ul style="list-style-type: none"> Latest figures (2008) show that 26% of Scotland's priority habitats are declining, 21% are stable and 13% increasing. Connectivity of some of Scotland's priority habitats (broadleaved, mixed and yew woodland) has declined at the UK level (1990 – 2007).⁷³ UK Marine Climate Change Impacts Programme report a general increase in sea temperature (although with high inter-annual variability), changes to some fish distributions, and a decrease in sea bird populations.
Timely actions	<ul style="list-style-type: none"> Pilot projects underway to evaluate benefits of the landscape-scale approach to land management – for example in the Borders, the Trossachs and Glen Affric. Ecologically coherent network of Marine Protected Areas (MPAs) to be established by 2012. Building on the findings of the UK Peatland Programme Commission of Inquiry,⁷⁴ SNH seeks to work with others in this field to develop a programme of peatland restoration, prioritising areas which promote resilience, biodiversity and net carbon gain. The Scotland Rural Development Programme⁷⁵ offers funding for adaptation related improvements, such as providing manure/slurry storage and treatment facilities, provision and upgrading of farm infrastructure, and funding towards habitat creation and management.

⁷³ UK Biodiversity Partnership (2011).

⁷⁴ IUCN (2011).

⁷⁵ The SDRP is primarily funded through IUCN (2011). Pillar II of the Common Agricultural Policy.

Table 5.4: Assessment of progress in adaptation in managing natural resources

Adaptation component	What we found
Decision-making and capacity	<ul style="list-style-type: none"> • Scottish Natural Heritage is undertaking a significant amount of work on adaptation, including: <ul style="list-style-type: none"> – assessing climate change impacts on erosion and flooding on Scotland's coastline (with SEPA and Adaptation Scotland) to inform adaptive management of key coastal habitats; – undertaking a risk assessment for each of the five Scottish Biodiversity Strategy ecosystem groups to inform future options for adaptive management; – assessing the possible implications of climate change on Scottish landscapes and their contribution to quality of life; and – piloting ecological network modelling with Highland Council and mapping habitat networks through Central Scotland Green Network partnership. • Scottish Government's <i>Farming for a Better Climate</i> programme aims to raise awareness of adaptation and provides practical advice and guidance on adaptation measures that can be taken on farm. • Understanding of climate risks and opportunities to forestry is well advanced, in part through the UK-wide Forestry Standard and associated guidelines, the evidence synthesised by the Read Report⁷⁶ and the work of Forest Research's Centre for Forestry and Climate Change. • Forestry Commission Scotland is working with SNIFFER to improve the evidence base for the contribution that forests, woodlands and trees make to flood management and urban cooling.
Policy enabling adaptation	<ul style="list-style-type: none"> • The National Planning Framework (2009) includes policies encouraging: <ul style="list-style-type: none"> – the development of green networks in urban areas and the expansion of urban woodland; – the creation of national ecological networks, encompassing landscape-scale strategic habitat restoration projects with the aim of making it easier for biodiversity to adapt to climate change; and – an integrated approach to water management through river basin management planning and a catchment-based approach to flood management. • The Government's Land Use Strategy (2011) includes a high-level principle that the use of land should contribute to delivering adaptation objectives. • The Marine Scotland Act (2010) sets a clear framework for marine planning including measures to manage marine biodiversity and the establishment of a network of Marine Protected Areas. The Act requires the production of a national marine plan which must include climate change objectives. • The Scottish Forestry Strategy sets out the Scottish Government's priorities for forests and the forestry sector and includes both mitigation and adaptation objectives.

⁷⁶ Reed (2009).

5.5 Emergency planning

5.5.1 Importance to adaptation

As most current and future climate impacts are felt through extreme weather events such as flooding, storms, snow and heatwaves, emergency planning can reduce the costs and disruption of extreme weather. While the work of the emergency services is clearly critical, there is also a wide range of other organisations that have a direct role to play in emergency planning, including local authorities, healthcare providers and utility companies.

Businesses themselves can also plan to minimise the risks and costs of disruption caused by extreme weather, both within Scotland but also internationally where there could be implications for businesses reliant on global supply chains. In a well-preparing society, businesses should also be proactively planning to take advantage of potential new market opportunities from a changing climate.

Possible adaptation measures that could be taken in this area include:

- ensuring business continuity management accounts for severe disruptions to the supply chain during floods and storms;
- creating plans that ensure effective social care and reduce the impacts on vulnerable groups, and ensuring healthcare is sufficient during heatwaves and floods; and
- making use of probabilistic weather forecasts to anticipate extreme weather events effectively and improve preparedness.

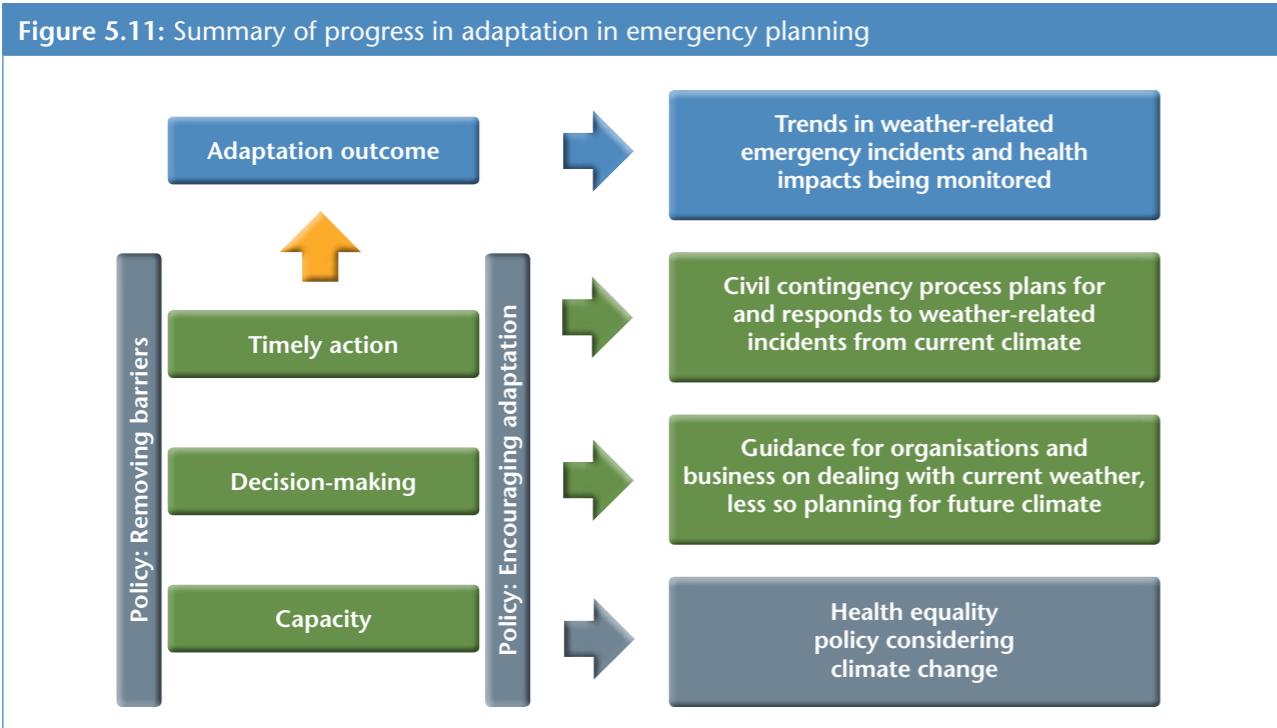
5.5.2 Summary of findings

The relevant sector action plans reviewed to assess progress in this priority area were:

- Emergency and rescue services
- Business and industry
- Health and well-being

Our analysis (Figure 5.11 and Table 5.5) shows that emergency planning is primarily carried out through the civil contingency planning process, which includes extreme weather events. As such, standard processes are already in place for both regularly assessing vulnerability and responding to climate hazards. These processes should be able to identify and respond to any changes in the frequency and/or magnitude of extreme weather events. A good example is the approach taken to heatwaves, where a decision has been made not to produce a heatwave plan for Scotland because there is currently no evidence of increased summer mortality or morbidity. However, this will be kept under review through regular monitoring.

Figure 5.11: Summary of progress in adaptation in emergency planning



It is not entirely clear if current assessments being made of the vulnerability of NHS properties and wider social infrastructure, such as care homes and other facilities housing vulnerable people, are accounting for future climate risks.

We found some evidence that businesses are proactively assessing their exposure to climate risks with support and advice from organisations like Adaptation Scotland.

There was less evidence of any systematic consideration of new market opportunities.

Table 5.5: Assessment of progress in adaptation in emergency planning

Adaptation component	What we found
Adaptation outcome – trends in climate impacts and vulnerability	<ul style="list-style-type: none"> Heatwave conditions have only been observed once in the last 20 years (June 1995). The Scottish Government is monitoring causes of mortality on a quarterly basis and will identify any trends in heat-related deaths.
Timely actions	<ul style="list-style-type: none"> Annual assessments of vulnerability of emergency service (i.e. fire and police stations, hospitals, etc) including from extreme weather. Police service monitors trends that are likely to impact on crime and policing on a three-yearly cycle. This process could be used to identify any changing trends in crime or anti-social behaviour that may be aggravated by climate change. Health Protection Scotland monitor the incidence of infectious diseases and environmental hazards. They are looking at whether the current system can be used to track diseases triggered by climate change.

Table 5.5: Assessment of progress in adaptation in emergency planning

Adaptation component	What we found
Decision-making and capacity	<ul style="list-style-type: none"> SEPA deliver: <ul style="list-style-type: none"> <i>Floodline Warnings Direct</i> service, which provides free advance flood warning messages direct to landline or mobile phones; and Scottish Flood Forecasting Service, which integrates hydrological and meteorological information for the first time, as well as sharing expertise to improve accuracy of flood forecasts for the whole of Scotland. Scottish Government funds the Scottish Flood Forum, which works with communities and businesses to raise awareness of flood risk and build resilience. Chief Fire Officers Association (Scotland) Severe Weather Capability Group formed to assess operational preparedness and response capability to severe weather events. Development of a <i>Ready Scotland</i> web portal – a central point of information for businesses and members of the public about preparing for extreme weather events. Scottish Resilience Development Service supports emergency services by providing learning and development to enhance the knowledge, skills and behaviours required for effective multi-agency emergency planning, response and recovery. Scottish Wildfire Forum set up to reduce the risk and damage of fires in the countryside. A Wildfire Strategy for Scotland has been developed and adopted by the Fire and Rescue Services. The Business Gateway provides a one-stop portal for information aimed at small businesses which includes information on climate risks. Most large businesses have business continuity plans. Anecdotal evidence of some businesses assessing their current climate risks, especially to flooding. Adaptation Scotland provided tailored, sector-specific advice and guidance on key risks and opportunities to businesses in 2010.
Policy enabling adaptation	<ul style="list-style-type: none"> Flooding Protocol between Scottish Government and emergency services published in 2010. Review of Scottish Government's <i>Equally Well</i> policy (on addressing health inequalities) to consider inequalities that may be caused or exacerbated by climate change.

Chapter 6: Conclusions and advice



This report has provided an initial assessment of progress in adaptation in Scotland. It first asked why adaptation is an important issue in Scotland, then looked at progress across the priority areas for early adaptation action, using the five questions from our ladder. Where possible, it has identified indicators that can be used to track trends in the impacts from extreme weather events, in the components of vulnerability to climate impacts, and in the uptake of adaptation actions.

6.1 Synthesis of analysis

The adaptation policy framework and sector action plans demonstrate that the issue of adaptation to climate change is firmly on the Scottish Government's agenda.

Adaptation is also a key issue for a number of public sector agencies with a national remit (for example Scottish Natural Heritage, Scottish Environmental Protection Agency, Forestry Commission Scotland and Historic Scotland), most of whom have explicitly considered in some detail what climate change is likely to mean for their organisation and responsibilities.

The sector plans are an important first step in Scotland's preparedness. They are, in many respects, similar to the UK Departmental Adaptation Plans⁷⁷ in that they set out high-level overviews of the risks and opportunities each sector faces from climate change and give an indication of the types of policy-led responses from central Government and its agencies. However, they are generally much lighter on the role that local government, communities and businesses need to play in adaptation.

The sector plans show that most of the activity to date has been focussed on building capacity and incorporating adaptation into existing policy. Most sectors are taking steps to expand the evidence base through dedicated research into the risks and opportunities of climate change. There are a number of support groups in place to facilitate capacity building, such as Adaptation Scotland whose services are highly regarded, as well as the work of Scottish Natural Heritage and the Scottish Environmental Protection Agency in developing and promoting guidance.

We found the sector plans did not generally allow for an assessment of the uptake of adaptation actions. There is some evidence of action being taken, for example a high deployment of sustainable drainage systems in new development, but at the same time a low uptake of property-level flood protection measures in existing buildings. This suggests that the policy framework is having varied success in incentivising adaptation, although there can often be a time-lag between setting policy and action on the ground.

It is not clear what processes are being put in place to assess the effectiveness of the sector action plans in enabling adaptation. We found that there are a number of gaps in data that make it difficult to objectively assess trends in factors affecting vulnerability, such as the amount and type of development in flood risk areas or the uptake of adaptation actions. Without this sort of information, it is not easy to come to a judgement on how the sector action plans are enabling adaptation.

Adaptation has been incorporated into a number of relevant policy frameworks, particularly where new legislation or policy guidance has been developed relatively recently, for example in marine planning, forestry, land use planning and building regulations.

In some critical sectors for Scotland, more could be done to strengthen adaptation into existing policy. Our analysis highlights some particular gaps that may require attention by policy-makers:

- **Renewable energy** – climate risks could be more explicitly accounted for in decisions on the deployment and location of new renewable energy generation and associated distribution infrastructure.
- **Information and Communications Technology** – the current adaptation framework is thin on the vulnerability of this sector to climate impacts.
- **Land use and peat** – the impacts of both future land use change and climate change could have significant adverse implications for Scotland's internationally important peatlands. This issue is not yet given the weight we would expect in Scotland's adaptation policy.

In some other sectors, such as agriculture and fisheries, the over-arching policy frameworks are determined at the European level, although Scotland retains a certain amount of flexibility in their interpretation and delivery. It is encouraging that the relevant sector action plans make clear that the Scottish Government will consider the implications of climate change when involved in negotiations on these mechanisms, for example reforms to the Common Agriculture Policy and the subsequent Scottish Rural Development Programme.

⁷⁷ Published under the previous UK Government in spring 2010.

6.2 Advice to the Scottish Government

The statutory framework created by the Climate Change (Scotland) Act requires the Scottish Government to lay an adaptation programme before the Scottish Parliament following the publication of the UK Climate Change Risk Assessment (CCRA). We advise that in developing the statutory programme, the Scottish Government should consider the following broad principles:

Setting adaptation outcomes and evaluating the effectiveness of policy

Establishing clear policy priorities and setting agreed adaptation outcomes for the most significant risks identified by the CCRA will be important for ensuring that the policy framework enables those risks to be addressed. The sector plans make a good start to doing this, but could go further in setting agreed adaptation outcomes for their areas.

It will be important that the Scottish Government puts in place a process for evaluating the effectiveness of the programme. Key to this will be understanding trends in Scotland's vulnerability to climate risks and the uptake of adaptation actions, so that a robust and objective assessment of progress can be made. To do this, the Scottish Government should consider reviewing how the data gaps identified in this report can be bridged so that progress in implementing the statutory adaptation programme can be objectively assessed in future years.

Enabling the uptake of low-regret adaptation actions

The programme should identify the types of low-regret adaptation actions that can be taken up in the short term, particularly those identified as being cost-effective (for example some types of retrofitting in buildings)⁷⁸ or which deliver a range of multiple and co-benefits both now and in the future climate (for example, restoring degraded peatlands).

In doing this, the programme will also need to review barriers to the uptake of low-regret actions and the policy mechanisms to remove them, such as incentives or regulation.

Ensuring key actors explicitly consider adaptation in their decision-making

Many adaptation decisions are taken at a local level by individual organisations and action across all sectors is needed. It will therefore be important that in developing the statutory programme, the Scottish Government builds on the sector plans by engaging with local authorities and communities, infrastructure providers, businesses and statutory agencies on how they should explicitly account for climate change in their decision-making. It will also be important to assess how guidance is being used and implemented in key long-term decisions, particularly around the provision of infrastructure, the design of buildings and on the location of new development.

Strengthen adaptation in some policy areas

There are some priority areas that will require more focus in developing the adaptation programme over the next two years, particularly adapting Scotland's critical national infrastructure and building the resilience of Scotland's peatlands.

The statutory adaptation programme will be able to play an important role here in encouraging all priority sectors to explicitly consider and account for climate risks in their relevant policies.

Ensure effective overlap with the UK National Adaptation Programme

As a number of policy areas remain reserved, it will be important that the Scottish and UK adaptation programmes dovetail to avoid any gaps in Scotland's overall approach to adaptation.

6.3 What we will do next

Over the coming three years, we will focus on developing an adaptation indicator framework to measure how well the UK is preparing for climate change, in line with our statutory remit under the UK Climate Change Act. We will develop the framework in such a way that it has UK-wide applicability, consulting with the Scottish Government and the other devolved administrations, and drawing on relevant evidence at the UK and national levels. Given such a framework, we would be in a good position to use this to report on progress in preparing for climate change in Scotland, if so requested by Scottish Ministers under the Scottish Climate Change Act.

⁷⁸ As identified by the ASC (2011).

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