ADAPTING TO THE IMPACTS OF CLIMATE CHANGE IN HIGHLAND

UPDATED JANUARY 2012

FOREWORD FROM THE CHIEF EXECUTIVE

"Climate change is one of the greatest threats to the Highland area. Any increase in flooding, erosion, landslides, storms and wind, and rising sea levels could disrupt the delivery of vital services. We recognise that as an employer, service provider and community leader we can raise awareness of these issues and encourage others to take action to prepare for and build resilience against future changes.

The environmental quality and the outstanding natural heritage of the Highland Council area are recognised internationally. The Council, in partnership with other public bodies, the third sector and communities, has a vital role to play in safeguarding this natural environment".

Alistair Dodds,
Chief Executive, Highland Council

EXECUTIVE SUMMARY

There is widespread scientific consensus that man-made greenhouse gas emissions are leading to rapid and potentially irreversible climate change. Even if all greenhouse gas emissions from the world ceased tomorrow, we would still face many decades of climate change, due to the ability of many greenhouse gases to persist in the atmosphere. Whilst efforts to cut emissions are vital if we are to avoid the worst effects of climate change in the longer-term, it is essential that we begin adapting assets, infrastructure and services to cope with the unavoidable impacts. Climate change in Highland is expected to result in:

- Hotter drier summers
- Milder wetter autumn and winters
- Increase in summer heat waves and extreme temperatures
- Reduced occurrence of frost and snowfall
- Sea level rise

The threat that inevitable climate change poses to the UK economy has been documented in the Stern Review, published by the Treasury at the end of 2006, as well as research published recently in the UK's Climate Change Risk Assessment. In Scotland, Section 44 of the Climate Change (Scotland) Act 2009 places a duty on public bodies to act:

- in the way best calculated to deliver any statutory adaptation programme, and;
- in a way that it considers most sustainable

This document, aims to gather evidence, present regional information and equip decision makers with the appropriate tools to take action. It was developed in consultation with many stakeholders and with guidance and advice from "Adaptation Scotland". Adapting to Climate Change in the Highlands uses the latest UK Climate Projections, information on past climate trends and weather events to help identify current climate risks as well as future threats and opportunities. The aim of this document is to explore only those changes that come about as a direct result of changes to our climate and weather patterns. Information on the Highland Council's other work to tackle climate change can be found at: www.highland.gov.uk/climatechange

A series of workshops were conducted with all seven Council Services, with various community groups and certain interest groups. Highland Council participated in workshops and research coordinated by partner agencies in the region and nationally, and in EU knowledge exchange projects Clim-ATIC and ROADEX. The first draft of this document was publicly consulted upon in early 2011.

The report identifies risks and opportunities under the twelve sectors as set out in Scotland's Adaptation Framework:

1. Water Resource Management
2. Agriculture
3. Forests and Forestry
4. Spatial Planning and Land Use
5. Biodiversity and Ecosystem Resilience
6. Transport
7. The Built Environment
8. Energy
9. Business and Industry
10. Marine and Fisheries
11. Health and Wellbeing
12. Emergency and Rescue Services

The climate change risks include:

- Increased frequency of flooding damaging homes and affecting people's wellbeing.
- Pressure on water resources leading to water supply demand deficits.
- Sea level rise leading to coastal erosion and flooding.
- Health risks from excessive heat, low level ozone or pathogens.
- Damage to ecosystems and habitats and the goods and services they provide.
- Transport disruptions due to weather related events.

The climate change opportunities include:

- Longer growing seasons and ability to grow new crops.
- Increased tourism opportunities for outdoor activities.
- Reduced heating demand in winter.
- Increased opportunity to harness renewables.
- Improved health and wellbeing due to increased opportunity to exercise outdoors.

Fifteen National Outcomes describe what the Scottish Government wants to achieve over the next ten years. National Outcome 12 states that *"We value and enjoy our built and natural environment and protect it and enhance it for future generations".* Developing actions to prepare for climate change impacts will contribute towards this national aim. The adaptation actions identified focus on the areas for which Highland Council has control and influence and are grouped into the themes of:

Theme 1: Demonstrating Leadership;
Theme 2: Building on the Knowledge Base;
Theme 3: Integrating into Policy;
Theme 4: Effective Communication; and
Theme 5: Working with relevant Stakeholders.

Actions are divided into those that Build Adaptive Capacity (creating supportive institutional frameworks and developing appropriate policies) and those that Deliver Adaptation Action (take practical actions to either reduce vulnerability to climate risks or to exploit positive opportunities). 52 actions have been identified and will be monitored and reviewed annually. Progress will be reported to the Council and the Scottish Government each year through the annual Climate Change Declaration report. In year monitoring will take place through quarterly performance reviews.

Regardless of any future climate change, the actions set out will result in improved service delivery by responding more effectively to our current climate and associated weather events. Actions will be built upon as our knowledge and understanding of the issues surrounding climate change impacts increases.

Priorities for the coming year will be to carry out vulnerability and risk assessments; highlight current adaptive capacity; and to map the opportunities and threats across the Highland communities.

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The purpose of this document is not to question the science of climate change but to present the best available data and explore it further in a regional context to assist in developing adaptive responses. The document will be updated annually as our knowledge and understanding of the issues improves and as further guidance and tools are developed for use by public bodies. The document has five sections:

- Setting the Context
- Projected Future Climate Change
- Identifying the impacts
- Adaptive Capacity
- Building Resilience

A conclusion, shaded in purple, is included at the end of each section and should give a summary of the findings. Presented within each section is the data from which the conclusions have been drawn and the methodology for the approach. Web links and footnotes allow the reader to explore this information further by locating the relevant reference. There is also a further reading section at the end of the document.

INTRODUCTION

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Fifteen National Outcomes describe what the Scottish Government wants to achieve over the next ten years. National Outcome 12 states that *"We value and enjoy our built and natural environment and protect it and enhance it for future generations".*

Preparing for a a changing climate will contribute towards this national aim. In Scotland, the Climate Change (Scotland) Act, 2009 places duties on public bodies to take certain measures to tackle climate change. Part 4 of the Act states that *'All public bodies need to be resilient to the future climate and to plan for business continuity in relation to the delivery of their functions and the services they deliver to the wider community'.*

The Highland Council Programme, "Strengthening The Highlands" contains the commitment *"In adapting to the impacts of climate change we will map the opportunities and threats facing Highland and develop appropriate actions to build resilience to such impacts by 2012"*

Effects of a changing climate in Highland will vary depending on each individual, community or sector's vulnerability to change. Impacts we are likely to experience include extreme precipitation, increased flooding, heat waves and extreme temperatures and increased variability in our weather. Some of these impacts are already being experienced in Highland and it has been demonstrated that the Highland people are already very adaptive, however, adaptations tend to be responsive rather than preparative.

An opportunity exists to develop actions which better equip and manage our response to climate change and weather related events. The aim of this document is to gather evidence, present regional information and equip decision makers with the appropriate tools to take action. Highland communities will also have to adapt to a changing society as Scotland moves towards a low carbon economy (for example, renewable energy infrastructure will lead to changes in our landscape and lifestyle choices) however such secondary impacts are not discussed here.

CLIMATE CHANGE OVERVIEW

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The Intergovernmental Panel on Climate Change (IPCC) rigorously assesses all scientific and technical aspects of climate change. The IPCC Report published in February 2007, provides strong evidence that human activities are increasing the rate at which the current climate is changing. The Earth's climate has changed repeatedly in the past, and there is evidence to show how life on our planet has responded to these changes. The scale and rate of the current change however, is greater than has been experienced for many hundreds of thousands of years.

There are two main ways in which to tackle climate change. The first is to reduce the man-made causes of climate change by reducing greenhouse gas emissions. Greenhouse Gases (GHG's), are released into the atmosphere as a result of our everyday behaviour, for example by burning fossil fuels like coal, oil and gas to heat and light our homes and to power our transport. Reducing the rate of GHG emissions and the cause of man-made climate change is called Climate Change **Mitigation.**

The second way to tackle Climate Change is through **Adaptation** –'the act or process of adapting'. In the context of climate change, this can be described as reducing the impact of changing conditions by preparing for, and adapting to, the anticipated effects. Even if we significantly reduce GHG emissions immediately, the ability for such emissions to persist in the atmosphere for many decades means that a degree of climate change is now unavoidable due to emissions in the past.

There are often synergies between mitigation and adaptation. Some actions we take to reduce greenhouse gases can also assist us to adapt to climate impacts. For example, reducing our need to travel helps to reduce CO_2 emissions from vehicles but also builds resilience against weather-related transport disruptions.

Climate is a long term average of weather (usually over 30 years) and trends in these average conditions are climate change. It is important to note the difference between climate and weather.

"Climate is what you expect, weather is what you get"
Robert A. Heinlein

Weather is what we experience hour-to-hour, day-to-day or even year-to-year, and as anyone living in Highland will know, it can be highly variable.

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SECTION 1 – SETTING THE CONTEXT

1.1 OVERVIEW OF HIGHLAND

1.1.1 The Highland Council area extends over an area of 26,484 square kilometres. This is 33% of Scotland's landmass and 11.4% of Great Britain. The Highland road network extends to approximately 7,000 miles. The population is estimated to be 219,400 in 2011 and, at 8 persons per square kilometre, Highland is sparsely populated compared with other Local Authority areas. Approximately 15% of Highland is forested, including over 300,000 hectares of commercial forest. The length of the coast line, including islands (low water) is 4,905 kilometres (49% of Scotland). The Highland coastal zone is home to the majority of the region's population, most of which is concentrated around the inner Moray Firth but which also includes widely scattered crofting communities on the north and west coasts. The coast is utilised in many different ways, including tourism, fishing, agriculture, aquaculture, residential and commercial use. It is also known internationally for its landscapes and wildlife.

1.1.2 The biggest employment industry in Highland is Public Administration, Education and Health, employing 32% of all workers. This is followed by distribution industries, hotels and catering employing 25.5% of people.

1.1.3 The Highland Area is home to many unique habitats and landscapes and wildlife species which are protected and valued for conservation purposes. In terms of international designations there are 12 RAMSAR sites, 90 Special Areas of Conservation (SAC's) and 46 Special Protection Areas (SPA's). In addition there are 368 Sites of Special Scientific Interest (SSSI's) which cover important biological, geomorphological and geological areas.

1.1.4 There are also 12 National Nature Reserves in Highland and in addition to this the Cairngorms National Park lies partly within the authority of the Highland Council. 455 of the priority species of conservation importance are found in Highland. The quality of the freshwater environment is also recognised internationally for its importance as a spawning ground for wild Salmon and use by whisky distilleries.

1.1.5 The many lochs and rivers that characterise the area are important for local economies and provide the scenic backdrop that encourages so many tourists to the area.

1.1.6 Most Highland soils are very shallow and soil erosion is becoming increasingly significant. Peat is very common throughout the Highlands and Caithness and Sutherland contain one of the largest and most intact areas of blanket bog in the world, supporting a distinctive wildlife community.

1.1.7 More information on Highland can be found at: Highland Council's Facts and Figures

1.2 HIGHLAND COUNCIL

1.2.1 The Highland Council currently employs approximately 12,000 staff working across seven Services. Each Service performs a specific role and function and these are summarised below:

1.2.2 Chief Executives Service: The Service manages and oversees the Council's performance in delivering services to local communities and covers E-Government and customer services, Policy, Performance and community planning, Legal and Committee Services, Personnel and Ward Management. There are six strategic committees that 80 elected Councillors sit on as well as area planning and licencing committees.

1.2.3 Education, Culture and Sport: The Service is responsible for 31,425 pupils across Highland. There are over 200 nursery education providers, 183 Primary Schools, 29 Secondary Schools and 3 Special Schools. Libraries, Leisure Centres and Museums are now managed by High Life Highland on behalf of Highland Council.

1.2.4 Finance: The Service is responsible for the financial affairs of the Council, including billing and collecting of council tax and water rates, administering Council Tax Benefit and Housing Benefit; Financial support to Services in terms of accounting, treasury management, supplier payments, income recovery and payroll; Treasury and investments, budget strategy, policy & taxation, Public Private Partnerships (PPPs) and Joint Ventures; Internal audit and Insurance and risk management; and procurement policy and strategy.

1.2.5 Housing and Property Service: The Service is responsible for the management of all council-owned buildings, comprising approximately 13,700 council houses and 1,900 non housing buildings. It delivers a range of services including the Highland Housing Strategy; developing and enabling affordable housing in Highland; energy management, advice and sustainability; provision of architectural and building engineering design and quantity surveying; asset management and property acquisition, disposal, valuation and lease negotiation; appointment and management of contractors and consultants for the Council's capital and revenue projects; tackling homelessness.

1.2.6 Planning & Development Service: Prepare plans for each of the Council's Areas, setting out the land-use planning framework for development and as such, the basis on which planning applications will be determined. Building standards are then the activity which sees a planning permission converted into buildings on the ground. A key function is to evaluate the potential for change and formulate policies relating to land and resource use

in Highland. The protection, conservation and enjoyment of the built and natural environment is a further significant activity, ranging from the protection given to historic buildings through archaeology to countryside ranger and access provisions.

1.2.7 Social Work Service: Provide advice, guidance and assistance on Mental Health Services; Community Care Services including residential care, day-care and home support services; Children's Services, including adoption and fostering services, services to the Children's Hearing Systems and the Courts, Probation and Aftercare. New arrangements are to be put in place in 2012 with NHS Highland for the delivery of health and social care services.

1.2.8 Transport, Environmental and Community Services: The Service covers a wide range of services, including Emergency Planning, Environmental Health, Roads and Community Works, Trading Standards, Transport and Infrastructure, Waste Management and Business Support.

1.3 HIGHLAND CLIMATE

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1.3.1 To understand the potential impacts a changing climate may bring to Highland, it is important to have knowledge of the climate of the region as it stands. The MET office provides a climate summary of the North Scotland region which comprises Highland, the Western Isles, Orkney and Shetland. The principal mainland geographic features of Highland comprise the Grampian Mountains and the northern Highlands, which rise steeply from the glens and fjord-like sea lochs. These mountainous areas include the Great Glen, running from Fort William north-eastwards to Inverness and containing Loch Ness. The region therefore has extensive areas of high ground and includes the highest point in the UK - Ben Nevis (1344 metres), near Fort William. The Highland area is large and within the region, climate can vary between East, West, coastal and inland areas and it is influenced by topography and altitude. More detailed descriptions can be obtained from the MET office website at:

www.metoffice.gov.uk

1.3.2 Temperature: Mean annual temperatures across the region at low altitude vary from about 8.5°C close to the Moray Firth, to just below 0°C on Ben Nevis (1,344 metres). Within Highland, significant variations in temperature arise from the combined effects of proximity to the coast and topography. Temperature shows both a seasonal and a daily variation. Minimum temperatures usually occur around sunrise and maximum temperatures are normally 2 to 3 hours after midday. January or February are the coldest months. Extreme minimum temperatures can occur in winter; examples include -27.2°C at Altnaharra (Highland) on 30 December 1995 (the UK record low temperature, shared with Braemar, Grampian). July or August are the warmest months. Extreme maximum temperatures are usually associated with heat-waves. For example, 32.1°C was recorded at Onich (Highland) on 1 August 1995. An 'air frost' occurs when the temperature at 1.25 metres above the ground falls below 0°C, whereas incidence of a 'ground frost' refers to a temperature below 0°C measured on a grass surface. The average number of days with air frost in Northern Scotland varies from less than 40 a year on west-facing coasts to more than 80 a year over the mountains. In Northern Scotland the frost-free season is often as little as 3 months.

1.3.3 Rainfall: Rainfall tends to be associated with Atlantic depressions or with convection. Atlantic low weather systems are more vigorous in autumn and early winter and bring most of the rain that falls in these seasons. Late spring and early summer is the driest part of the year. In summer, convection caused by solar surface heating sometimes forms shower clouds. A further factor that greatly affects the rainfall distribution is altitude. Moist air that is forced to ascend hills may be cooled below the dew point to produce cloud and rain. Much of Northern Scotland is exposed to the rain-bearing westerly winds, particularly the west coast. As a result, most of the western half of the region has an average annual rainfall of at least 1,700mm. The highest average annual rainfalls occur over the higher, west-facing slopes, with the wettest area being to the northwest of Fort William (over 4,000mm per year) whilst near the Moray Firth it is only about 700mm. Rainfall is generally well-distributed throughout the year. The frequency of Atlantic depressions is normally greatest during the autumn and winter but, unlike other parts of the UK, Scotland tends to remain under their influence for much of the summer too. In the western and northern areas there is an autumn/early winter maximum, whereas places close to the Moray Firth tend to have a more even distribution through the year. Late spring and early summer is normally the driest part of the year.

1.3.4 Snowfall : The occurrence of snow is linked closely with temperature, with falls rarely occurring if the temperature is higher than 4°C. Over most of the area, snowfall is normally confined to the months from November to April, but upland areas often have brief falls in October and May. Snow rarely lies at lower levels outside the period from November to April. On average, the number of days with snow falling varies from less than 40 per year along the west coast to over 100 days over the Grampians. The relatively plentiful supply of snow over the highest ground has led to the development of skiing areas such as Aonach Mor, near Fort William and the Cairngorms, near Aviemore.

1.3.5 Wind: The western and northern parts are, on average, the windiest in the UK, being fully exposed to the Atlantic and closest to the passage of areas of low pressure. The frequency and depth of these depressions is greatest in the winter, especially from December to February, and this is when mean speeds and gusts (short duration peak values) are strongest. Spring time tends to have a maximum frequency of winds from the north east. This seasonal effect is due to a build-up of high pressure over Scandinavia at this time of year. Inland, winds are much lighter and generally directed along valleys. For example, at Aviemore, south-westerly winds are very dominant, influenced by the Spey valley.

1.3.6 Sunshine: The number of hours of bright sunshine is controlled by the length of day and by cloudiness. In general, December is the dullest month and May or June, the sunniest because of the tendency for settled anti-cyclonic weather in late spring. Sunshine duration decreases with increasing altitude, increasing latitude and distance from the coast. Local topography also exerts a strong influence and in the winter, deep glens and north-facing slopes can be in shade for long periods. In Northern Scotland, the sunniest places are close to the Moray Firth where the annual average approaches 1,300 hours. Many other coasts average about 1,200 hours with sunshine averages lower inland.

1.4 HIGHLAND CLIMATE TRENDS

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1.4.1 Changes in climate across the North of Scotland in the last century are presented in 'A Handbook of Climate Trends in Scotland'. This publication was produced in 2006 by the Scottish and Northern Ireland Forum for Environmental Research (SNIFFER).More information can be found at the website below:

www.climatetrendshandbook.sccip.org.uk

For all diagrams presented the North of Scotland (which includes Highland) is represented in dark blue.

1.4.2 Average Precipitation The change in winter precipitation since 1961 shows a clear upward trend. We can see an increase of almost 70% in winter precipitation in North Scotland. The average precipitation each year also shows a trend towards much higher totals over the same period. Scotland has become 20% wetter between 1961 and 2004. There has been little or no change in average summer precipitation totals in each region. Changes in summer precipitation show no clear trend over the 1961 to 2004 period.

The largest changes have taken place in winter months across all but the most eastern areas of Scotland. In some areas of the west Highlands and the Hebrides, winter precipitation has more than doubled since 1961. In summer, northern areas of Scotland have become drier since 1961, particularly the northwest. This reduction in summer precipitation is more than 20% in some areas.

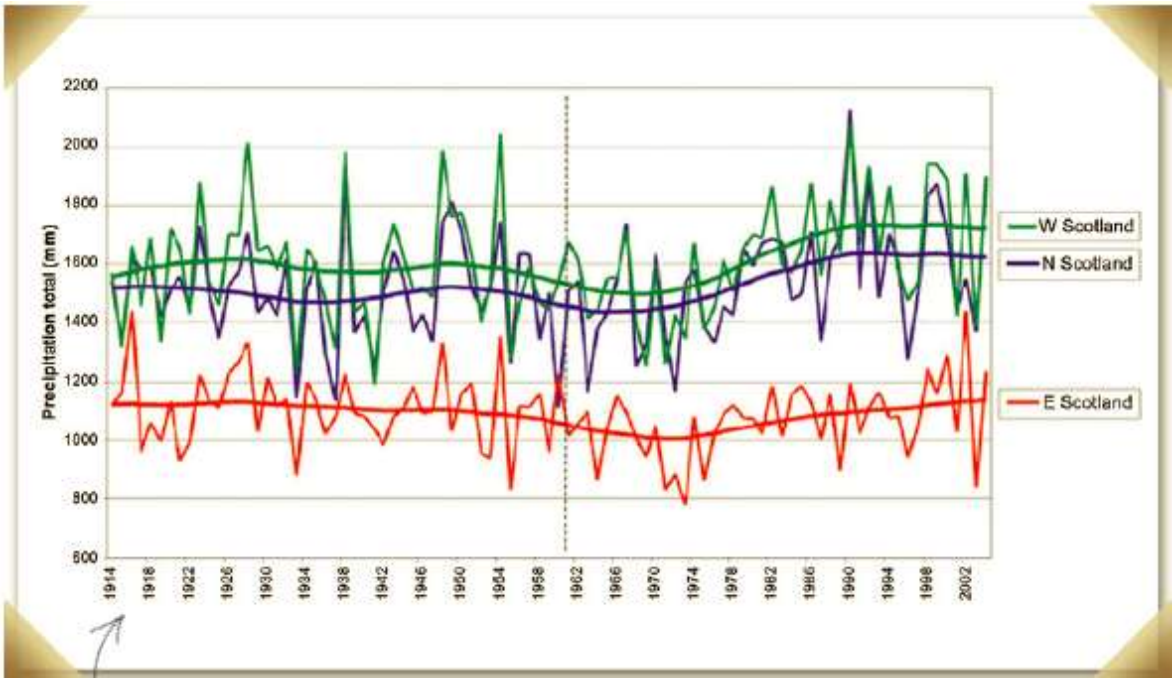
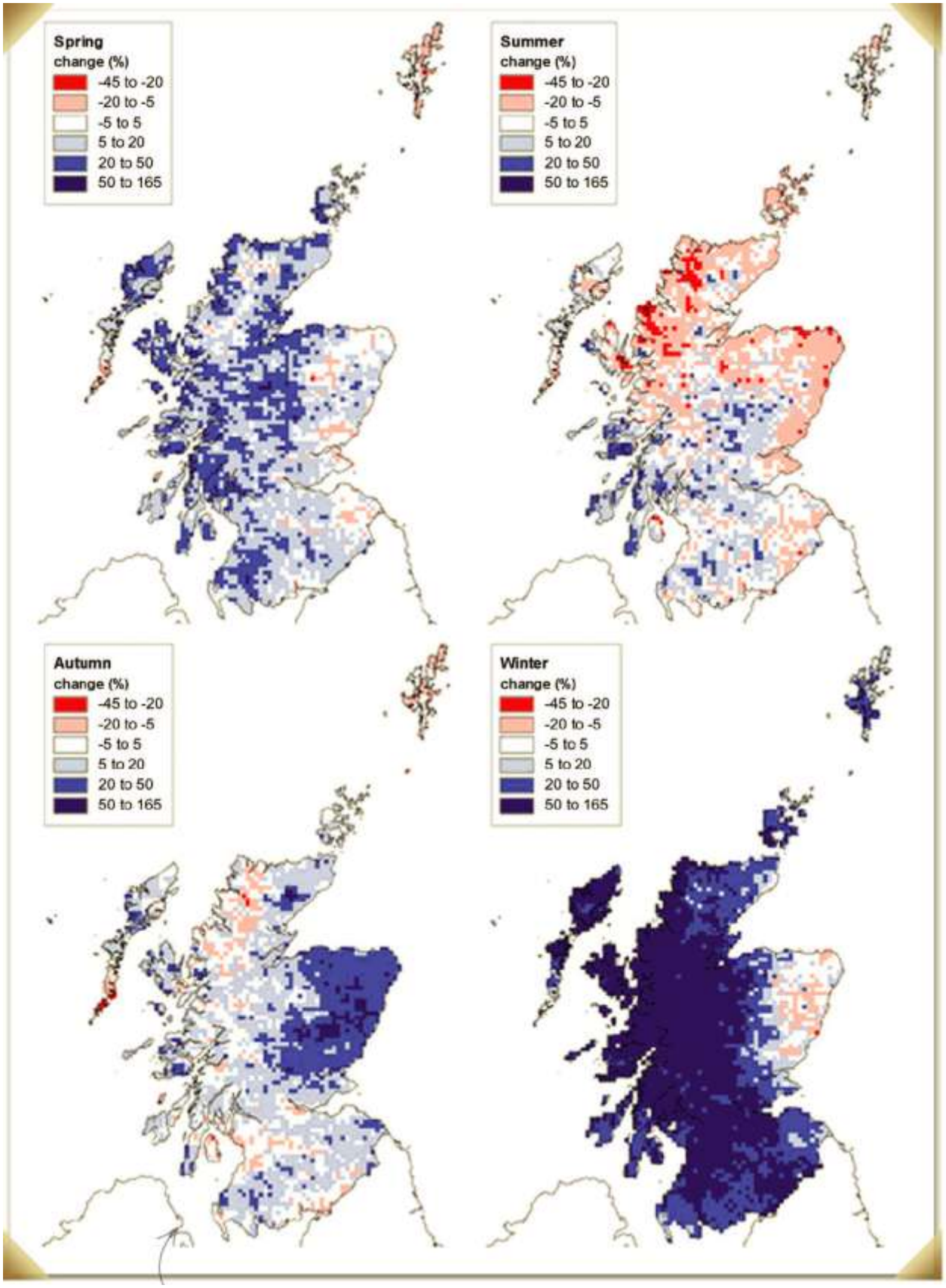


Figure 1 - Precipitation total (in millimetres) each year for Scottish regions, from 1914 to 2004, with smoothed curves to show a running average.



Map 1 - Patterns of change in precipitation totals (as a percentage) between 1961 and 2004 for each season.

1.4.3 Ground Frost: Ground frost, which happens when the minimum grass temperature falls to 0°C or below, is a common event in Scotland, even in the summer. Since 1961 there has been a reduction in the number of days of ground frost in every season. There is a downward trend in spring, summer and winter in all regions, as well as for autumn in North Scotland. The reduction in the number of ground frost days is especially noticeable in the western Highlands and the Hebrides in spring.

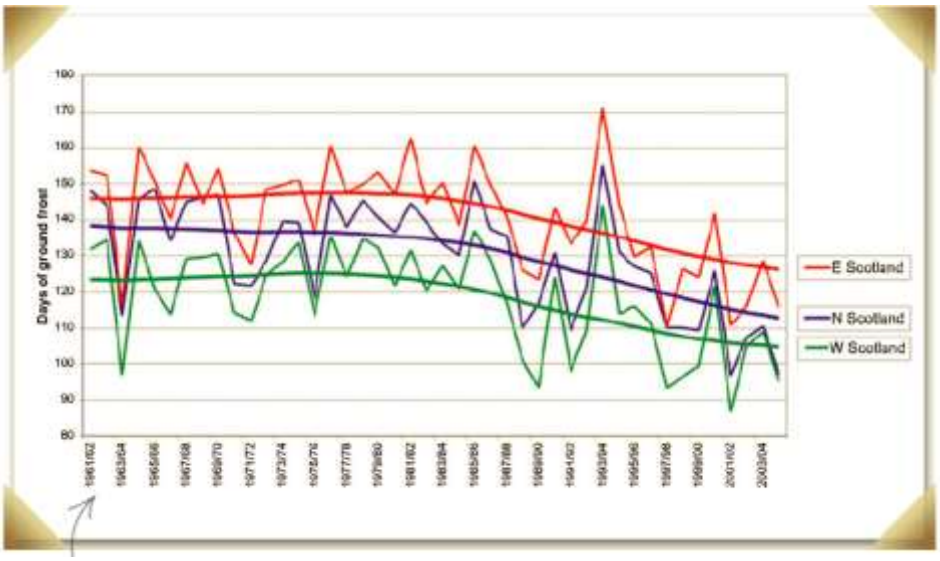


Figure 2 -Days of ground frost for Scottish regions each year from 1961/62 to 2004/05, with smoothed curves showing a running average.

1.4.4 24-hour Maximum Temperature: The maximum temperatures in North Scotland have increased at a faster rate than average temperatures since 1914. Since 1961, increases in the maximum temperature have consistently been greater than the increases in average temperature in all regions. The greatest rises in temperature have taken place in the winter rather than summer season, particularly in southern Scotland.

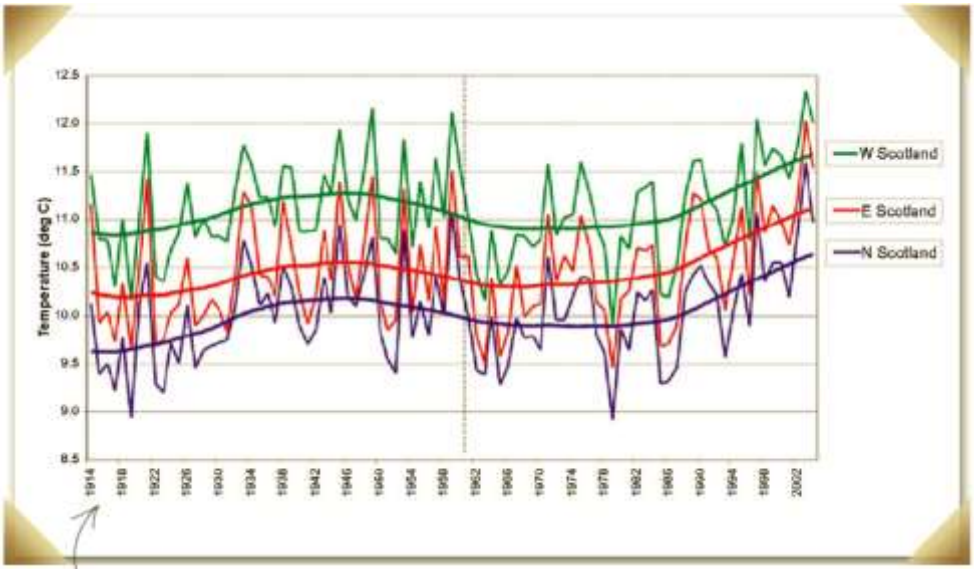


Figure 3 -The average 24-hour maximum temperature (in °C) each year or Scottish regions, from 1914 to 2004, with smoothed curves to show a running average.

1.4.5 Average Temperature The average annual temperature in each region is now higher than at any other time since 1914. Temperature increases have been greater since 1961 than between 1914 and 1961. The increases are smallest during autumn and there has been some slight cooling in Highland areas during autumn. The greatest increases have taken place during spring and winter and the largest in southern and eastern Scotland in winter.

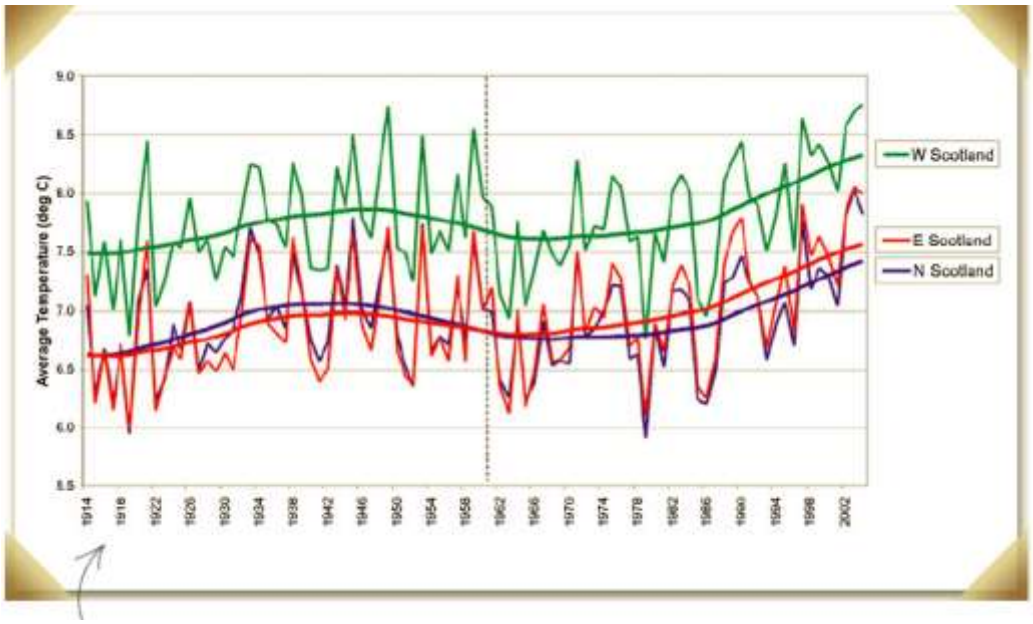


Figure 4 - The average temperature (in °C) each year for Scottish regions, from 1914 to 2004, with smoothed curves to show a running average. Vertical dashed line marks 1961.

1.4.6 Sunshine Hours The average number of hours of sunshine recorded each day is lowest in North Scotland but this is also the region that has seen some of the largest changes. Since 1961, the average number of sunshine hours in a day has increased by a small percentage each year in all three regions. As we have not seen a trend, any change may simply be part of natural variability. In some areas the changes are large, for example, up to a 40% reduction in sunshine hours in winter (December to February) in parts of North and West Scotland.

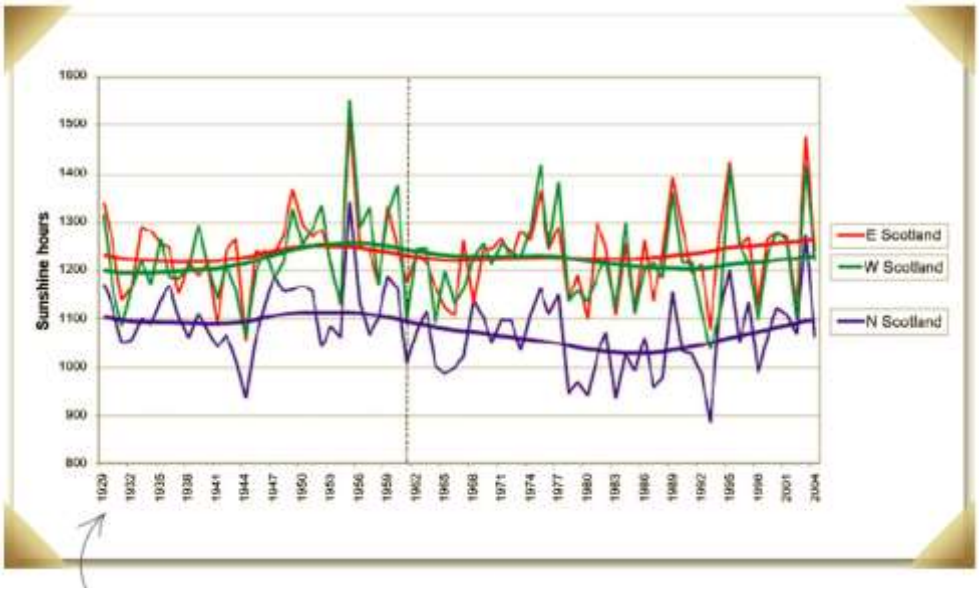


Figure 5 - Changes in total sunshine hours (as a percentage), from 1929 to 2004 and 1961 to 2004

1.4.7 Snow cover The number of days of snow cover has reduced in each region and in all seasons. In winter, the decreases are greater than 25%, and are the largest changes (in terms of total number of days), a decrease of 7 days. The average number of days of snow cover in spring is greater than in autumn. The west of the country and particularly the western Highlands show the greatest reduction in snow cover in terms of the number of days. It is important to note however, that these areas are also those that normally have the largest number of days of snow cover in any year. In some areas there has been an increase in the number of days of snow cover, particularly in northern mainland Scotland.

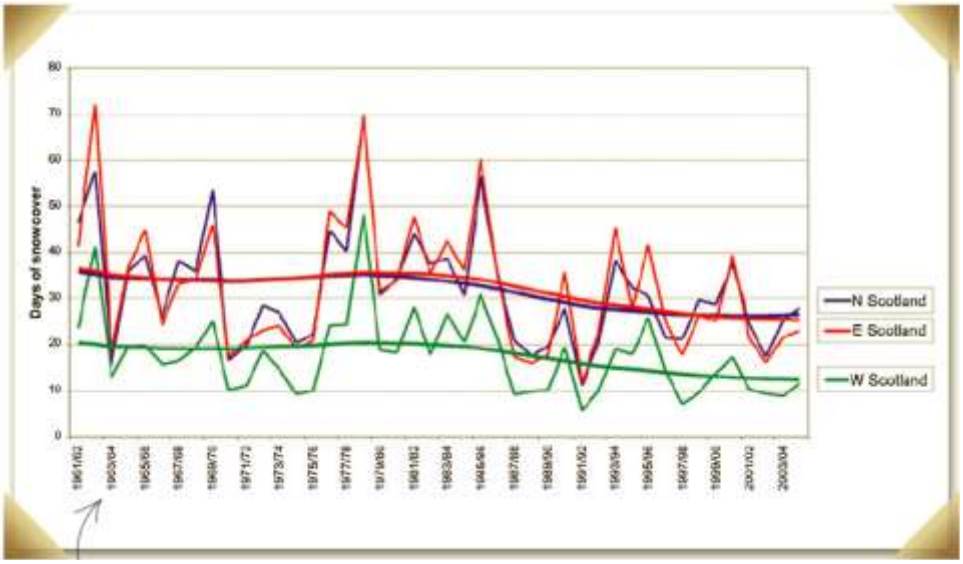
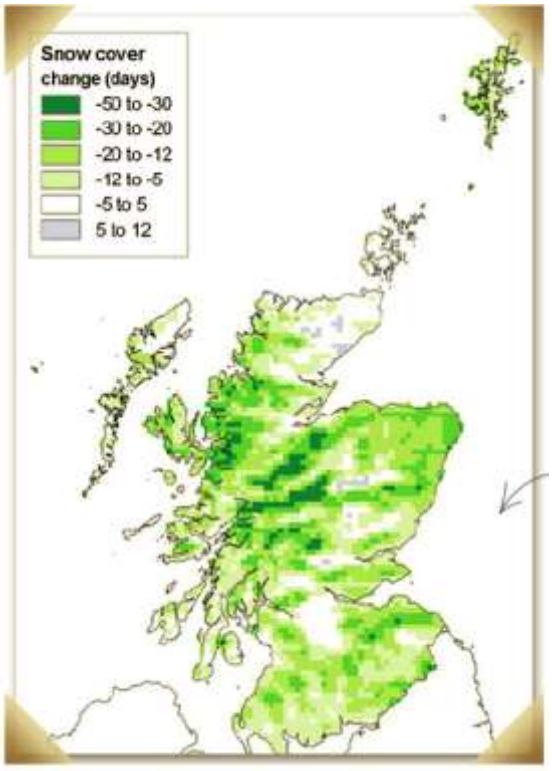


Figure 6 - Days of snow cover each year for Scottish regions, from 1961/62 to 2004/05. Note: days of snow cover are calculated according to seasons rather than a full calendar year (from September to the following May).



Map 2 - Pattern of change in snow cover (in days) each year, from 1961 to 2004.

1.4.8 Length of Growing Season: In the early 1960s, typical values were a growing season of about 217 days in North Scotland. All regions have seen an increase of more than four weeks in the length of the growing season since 1961.The West has shown the greatest increase and the North the least. The greatest increases in the length of the growing season are in coastal areas and the Shetland Islands where the season has extended by two months, or more. The length of the growing season has changed very little since 1961 in some of the more mountainous areas. A few upland areas show a reduction in the length of the growing season of up to eight days.

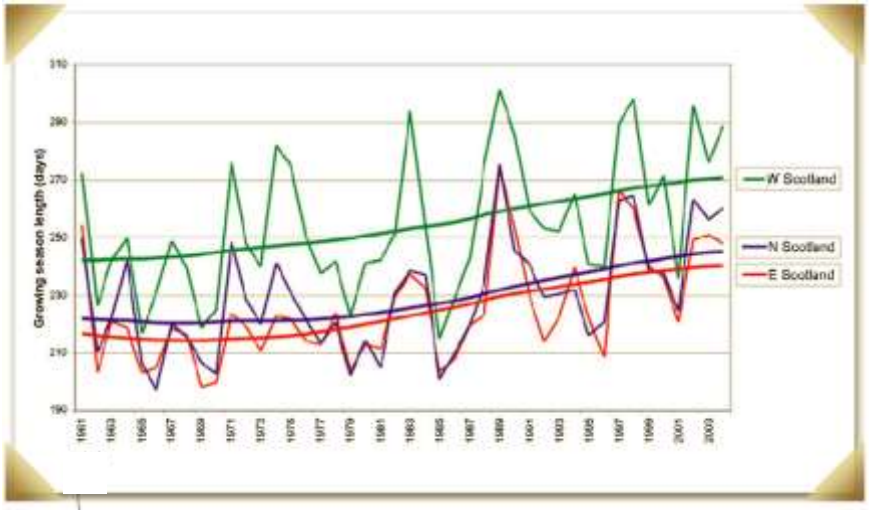


Figure 7 - Length of the growing season (in days) each year for Scottish regions, from 1961 to 2004, with smoothed curves showing a running average.

1.4.9 Heating Degree Days: Heating degree days are indicators designed to reflect the demand for energy needed to heat a home or business. In the UK 15.5 OC has commonly been set as the base temperature, as an estimate of the outside air temperature, at which no artificial heating is required. In all areas of Scotland, the number of heating degree days has reduced and this appears to be part of a clear downward trend. These trends are consistent with the temperature trends we have already described.

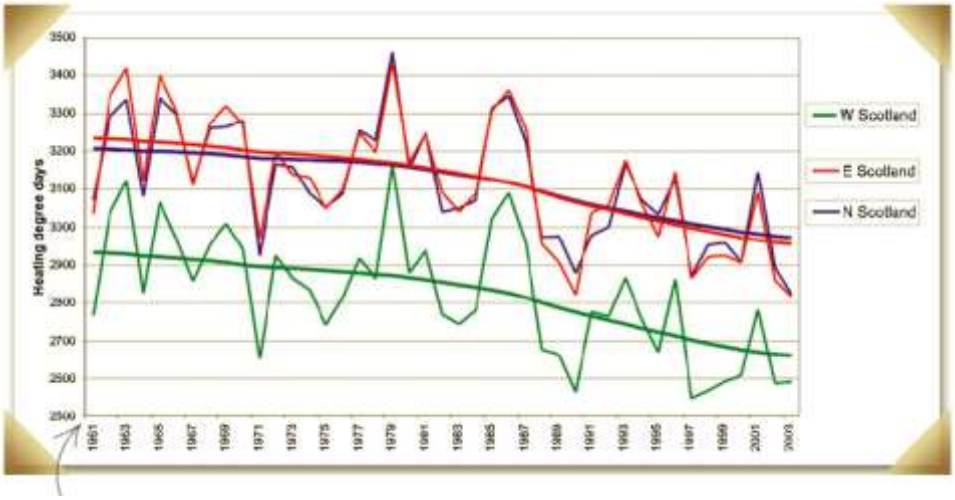


Figure 8 -The changes in heating degree days (HDD) between 1961 to 2003, with smoothed curves showing a running average.

The percentage change in heating degree days from 1961 to 2003 are shown below:

North Scotland	East Scotland	West Scotland	Scotland
-9.2%	-10.7%	-11.3%	-10.2%

1.4.10 Sea Surface Temperature: Marine air and sea surface temperatures have risen over the north-east Atlantic and UK waters in the last 25 years. The largest increase in air temperature has been over the southern North Sea at a rate of around 0.6° C per decade. The largest increases in sea surface temperature have occurred in the eastern English Channel and the southern North Sea at a rate of between 0.6 and 0.8° C per decade. Although temperatures are generally increasing, inter-annual variability is high.[1]

1.4.11 Sea Level: Global sea level has risen at a mean rate of 1.8mm per year since 1955. From 1992 onwards a higher mean rate of 3mm per year has been observed. Sea-level rise measured over the UK is consistent with the observed global mean[2] Although central Scotland has been rebounding since the last Scottish ice sheet started to melt 20000 years ago, the uplift rates are now modest (around 0.6 mm per year max). When this vertical land movement is compared to the more rapid rate that coastal waters around the UK are rising, all of Scotland is now experiencing net sea-level rise[3]

1.5 GLOBAL CLIMATE TRENDS

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1.5.1 The Earth has warmed by about 0.75°C in the last century and over the last four decades the Earth has warmed at an accelerated rate[4]. There has been an observed trend of increasing global temperatures from the late 1970s of about 0.16 °C per decade[5]. Evidence collated by the Intergovernmental Panel on Climate Change shows that the recent observed increases are very likely (over 90% likely) due to rising concentrations of greenhouse gases in the atmosphere caused by human activities.

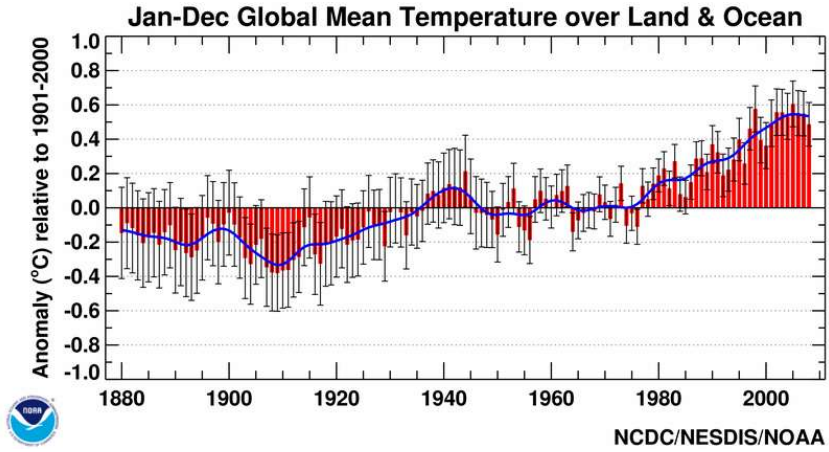

Figure 9 – Global mean temperature over land and ocean

1.5.2 Changes have now been observed in many different climate variables in addition to temperature: the amount of moisture in the atmosphere; continuing sea-level rise; and a decreasing Arctic sea-ice extent. All are consistent with a long-term warming trend. The average temperature over the first decade of the 21st century was significantly warmer than any preceding decade in the instrumental record, stretching back 160 years.

[1] http://www.mccip.org.uk/annual-report-card/2010-2011.aspx
[2] http://www.mccip.org.uk/annual-report-card/2010-2011.aspx
[3] http://www.snh.gov.uk/about-scotlands-nature/rocks-soils-and-landforms/coasts/sea-levels/
[4] http://www.epa.gov/climatechange/science/recenttc_triad.html
[5] http://www.metoffice.gov.uk/climate-change/policy-relevant/evidence

1.6 HIGHLAND OVERVIEW CONCLUSION

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1.6.1 At 33% of Scotland's landmass, the large size of the Highland area, combined with its rural nature and dispersed population mean that climate change impacts may be experienced differently in Highland than in other smaller and more populated Local Authority areas. The outstanding environmental and cultural heritage of the area and the valuable land-use and tourism industries that depend upon it are of great importance to the region. Action is needed to safeguard these assets which are of national and international importance.

1.6.2 Highland has 49% of the Scottish mainland coastline, and the majority of the population lives on or near to the coast. Sea level is currently rising at a rate of 3mm per year and this is greater than the rate the land is rebounding following the last ice age. Sea surface temperatures are rising faster in the areas to the South of Scotland than in the North.

1.6.3 The Northerly latitude and exposure to the Atlantic mean that Highland currently experiences colder, wetter and windier weather than other parts of the UK. The prevailing climate is variable within Highland, influenced by topography and location, particularly differences between mountainous, inland and coastal regions, East, West and North. Such regional variations make it difficult to design a one-size-fits-all strategy to adapt to the impacts of climate change at an area-wide level.

1.6.4 With 12,000 staff working across seven different Services, the Council is the largest employer in Highland. The Council delivers Services from administering benefits to waste collection, education, housing, social care, and road maintenance. Such a varied remit makes the development of an over-arching strategy on climate change adaptation very challenging as each Service will perceive and respond to climate change impacts in different ways.

1.6.5 The recent observed trends in climate show an increase in annual temperatures and daily maximum temperatures, and a decrease in the numbers of days of ground frost between 1961 and 2004. However there remains to be large variations from year to year. Change in precipitation shows a clear upward trend between 1961 and 2004. There has been little or no change in average summer precipitation but an increase in winter precipitation of 70% in North Scotland. The large variations between years and the seasonality of change make planning for, and anticipating the effects of continued climate change difficult.

SECTION 2 - FUTURE CLIMATE SCENARIOS HIGHLAND

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2.1.1 There are many sources of scientific information to assist in exploring future climate change. Highland Council has used the UK Climate Projections (UKCP09)[6]. These projections provide information on how the UK's climate is likely to change, as it responds to rising levels of greenhouse gases in the atmosphere. They have been funded by the Department for the Environment, Food and Rural Affairs (Defra), on behalf of the UK Government and the devolved administrations, and are based on sound science and projections provided by the Met Office.

(The purpose of this document is not to question the science but to accept the best available data and use it to assist in developing adaptive responses.)

2.1.2 Data from UKCP09 is presented in three scenarios of low, medium and high future greenhouse gas emissions. The low emissions scenario assumes that policy implementation successfully reduces global greenhouse gas emissions early, while the high emissions scenario follows a "business as usual" approach. Following the precautionary principal, the Highland Council has focused on data sets using the high emission scenarios, recognising that, despite policy implementation, there will be a time delay before any emissions savings are felt. The success of policy implemented locally will be affected by the measures taken to reduce emissions elsewhere in the UK and abroad and Highland Council recognise that many regions of the world are not currently taking the necessary steps to reduce their GHG emissions.

The Precautionary Principle
There is always a degree of uncertainty when dealing with climate change scenarios. The precautionary principle is used where a delay action could result in the risk of serious and irreversible harm to public health or the environment and where the financial consequences of inaction are great.

2.1.3 The projections presented in this section are provided in 30-year time periods. Highland Council has opted to look at the three time periods of the 2020's (2010-2039); the 2050's (2040-2069); and the 2080's (2070-2099).

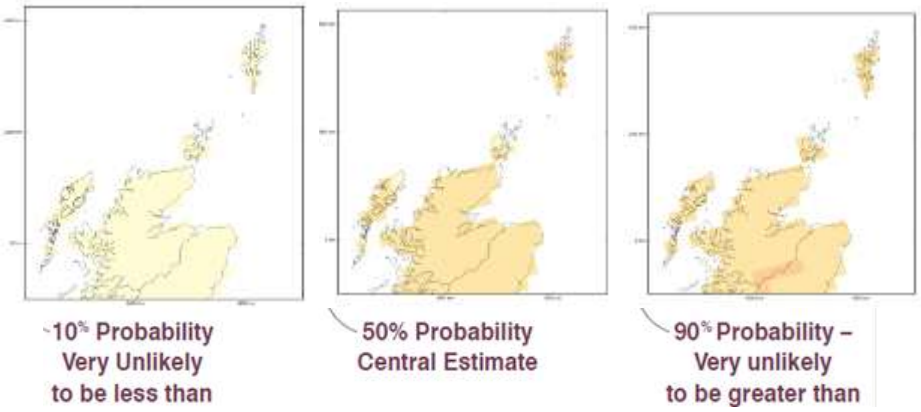
2.1.4 For each scenario, the data is presented in a range showing the maximum and minimum point that could be achieved within that climatic period, together with the central estimate (most probable outcome).

2.1.5 Summaries for the North of Scotland which includes all of the Highland Council area are provided on the following pages.

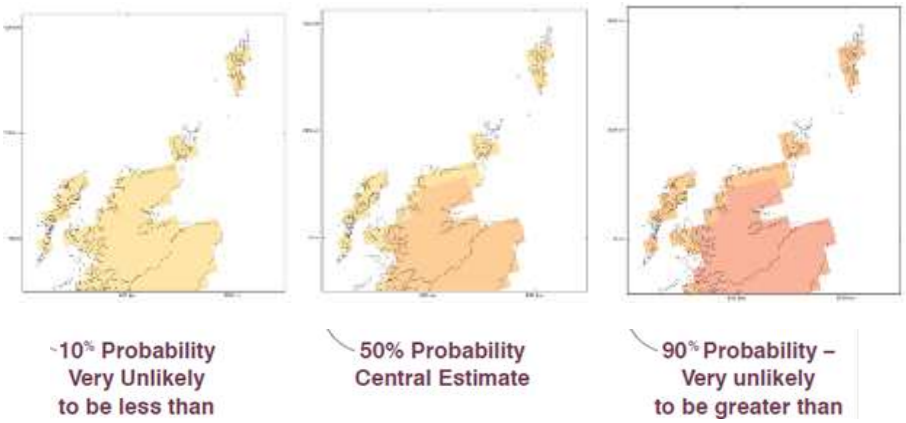
[6] http://ukclimateprojections.defra.gov.uk/ The UK Climate Projections data have been made available by the Department for Environment, Food and Rural Affairs (Defra) and Department for Energy and Climate Change (DECC) under licence from the Met Office, Newcastle University, University of East Anglia and Proudman Oceanographic Laboratory. These organisations accept no responsibility for any inaccuracies or omissions in the data, nor for any loss or damage directly or indirectly caused to any person or body by reason of, or arising out of, any use of this data.

2.1.6 North Scotland -Change in Mean Annual Temperature High Emissions Scenario

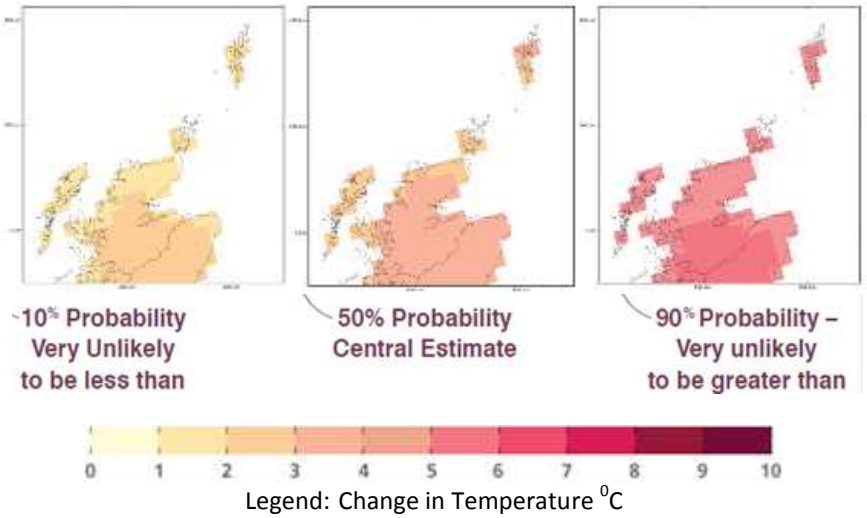
Scenario 1a - Change in annual mean temperature (ºC) 2020's, High emissions:



Scenario 1b - Change in annual mean temperature (ºC) 2050's, High emissions:



Scenario 1c - Change in annual mean temperature (ºC) 2080's, High emissions:

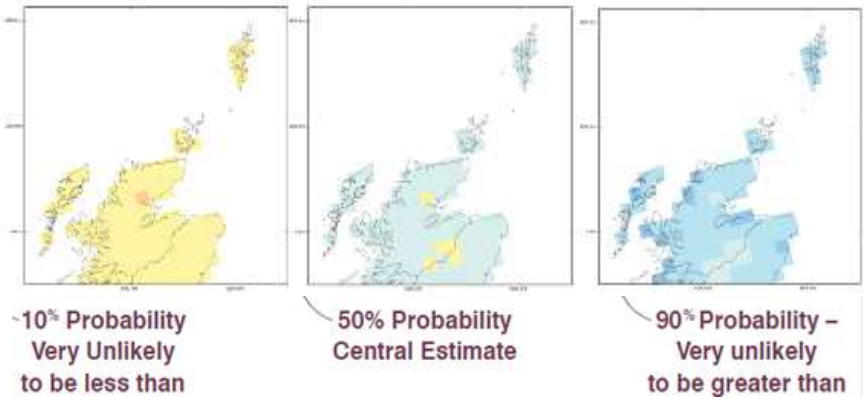


Legend: Change in Temperature ^{0}C

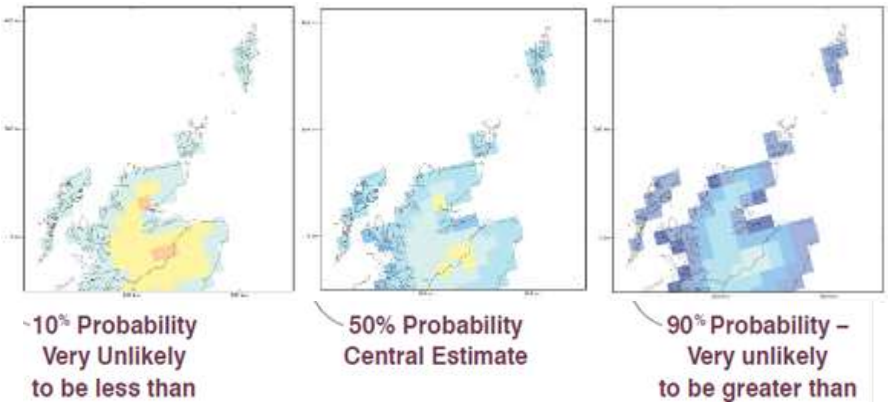
The central estimate for change in annual mean temperature is +1^{o}C in the 2020's (2010-2029) rising to +2^{o}C by the 2050's (2040-2069) and +4^{o}C by the 2080's (2070-2099) under a high emissions scenario. It is very unlikely to be less than +1^{o}C and is very unlikely to be more than +5^{o}C by the 2080's.

2.1.7 North Scotland Change in Winter Mean Precipitation High Emissions Scenario

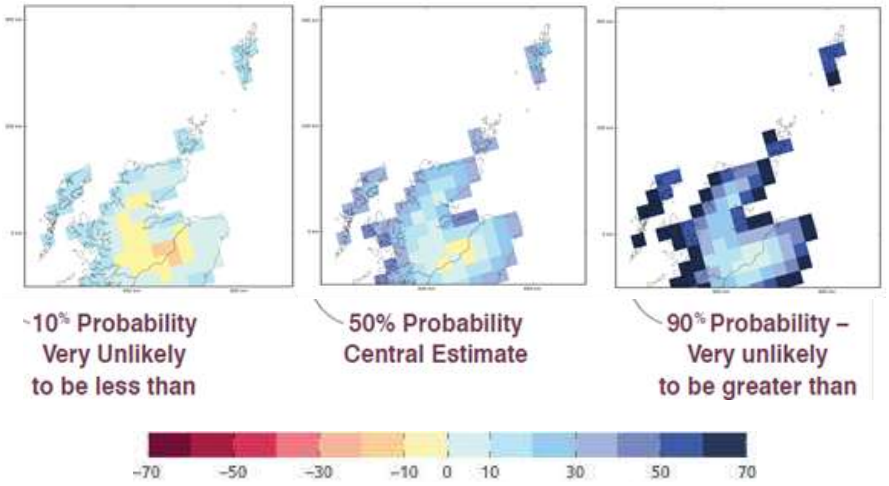
Scenario 2a - Change in mean winter precipitation (ºC) 2020's, High emissions:



Scenario 2b - Change in mean winter precipitation (ºC) 2050's, High emissions:



Scenario 2c - Change in mean winter precipitation (ºC) 2080's, High emissions:

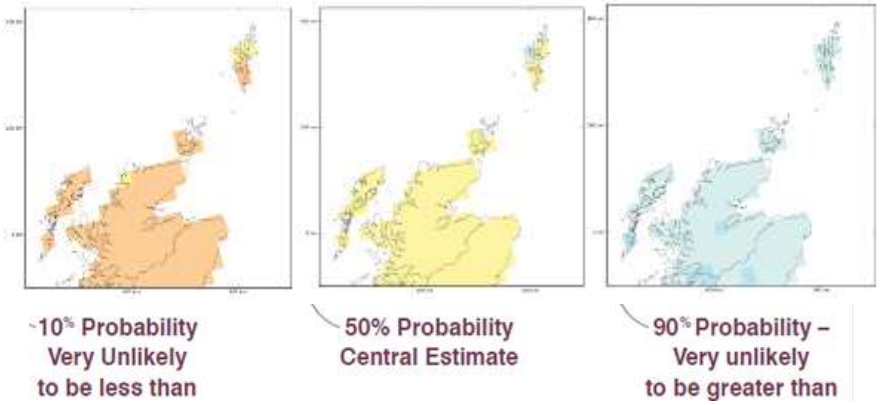


Legend: Change in precipitation %

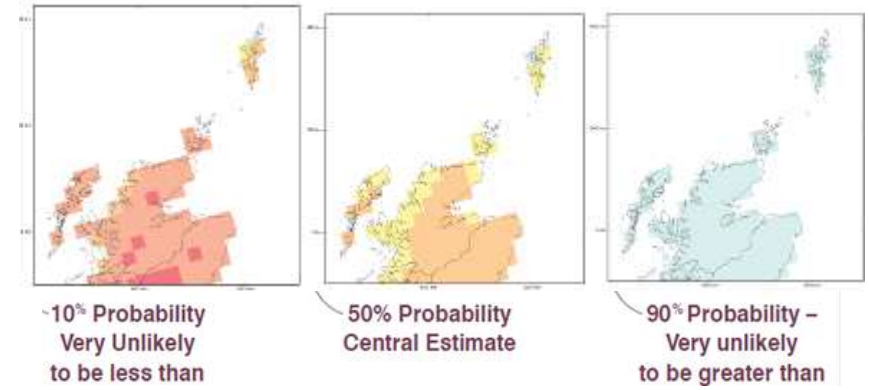
The central estimate for change in winter mean precipitation is +4% in the 2020's (2010-2029) rising to +13% by the 2050's (2040-2069) and +24%by the 2080's (2070-2099) under a high emissions scenario. Inland mountainous areas show a decrease in mean winter precipitation. By the 2080's, excluding the inland areas, the change is very unlikely to be less than +9% and is very unlikely to be more than +45% by the 2080's.

2.1.8 North Scotland Change in Summer Mean Precipitation High Emissions Scenario

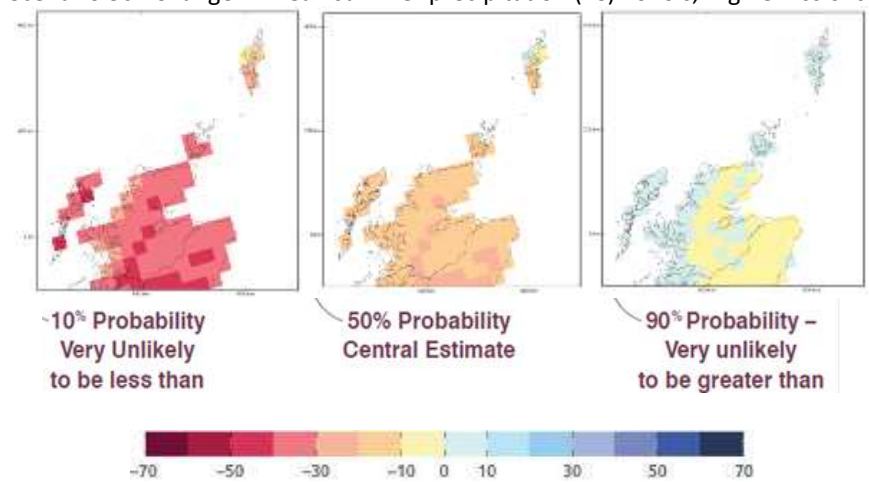
Scenario 3a - Change in mean summer precipitation (ºC) 2020's, High emissions:



Scenario 3b - Change in mean summer precipitation (ºC) 2020's, High emissions:



Scenario 3c - Change in mean summer precipitation (ºC) 2020's, High emissions:



Legend: Change in precipitation %

The central estimate of change in **summer mean precipitation** is –2% in the 2020's (2010-2029) reducing to –10% in the 2050's (2040-2069) and -16% by the 2080's (2070-2099). The decrease in summer precipitation in the west coast will not be as great as elsewhere in Highland. By the 2080's mean summer precipitation is very unlikely to be less than –36% and is very unlikely to be more than +4%.

2.2 NATIONAL CLIMATE SCENARIOS UK FINDINGS,

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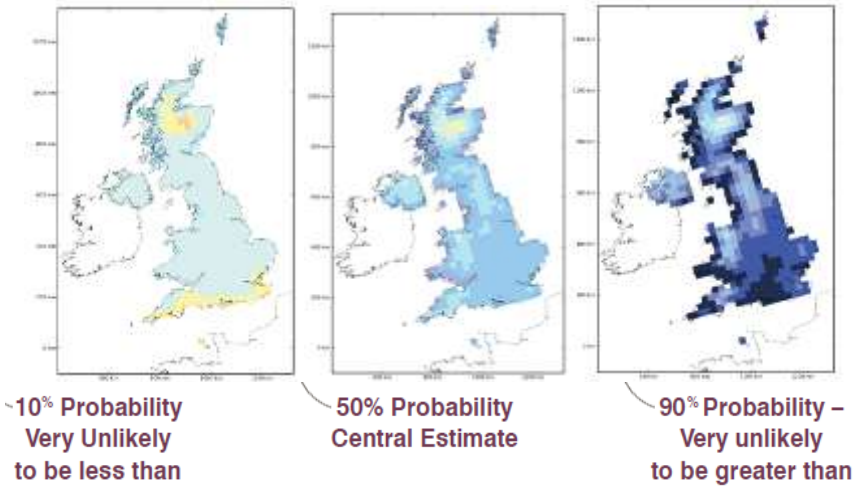
2.2.1 We live in a global society, trading goods and services beyond the boundary of the Highland Council administrative area. It is important that Highland Council has an understanding of how these effects will impact on the Highland region.

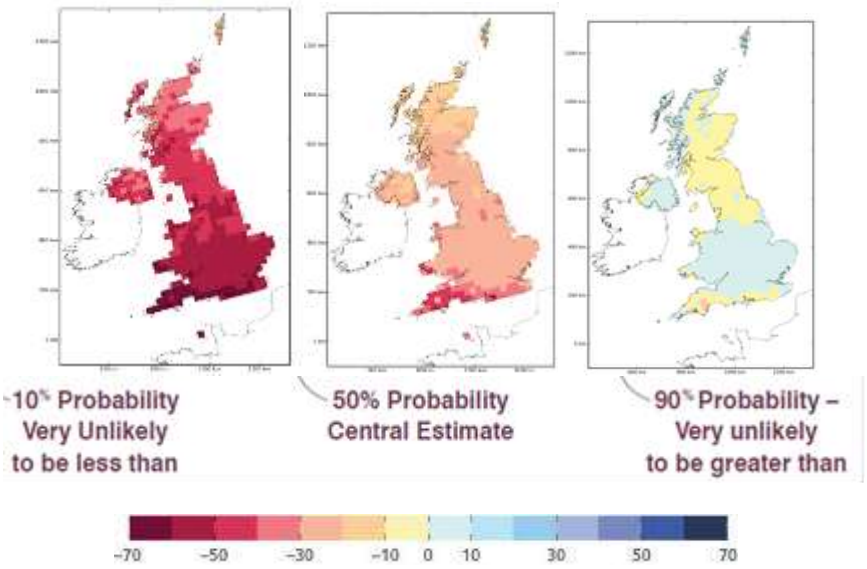
2.2.2 Scenario 4a shows UK wide changes in **mean winter precipitation.** Greater changes are anticipated in parts of Highland compared with elsewhere in the UK. The central estimate for mean winter precipitation is an increase of +20% in South England compared with +40% in North West Highland by the 2080's (2070-2099).

Scenario 4a - Change in winter mean precipitation (%) 2080's High emissions:



2.2.3 Scenario 4b shows that the opposite is anticipated for changes in **mean summer precipitation** with greater decreases in precipitation anticipated in the South and West of England than in Highland. The central estimate for mean summer precipitation shows a decrease of -40% in South England compared with -20% in Highland 2080's (2070-2099).

Scenario 4b - Change in summer mean precipitation (%), 2080's, High emissions:



Legend: Change in precipitation %

2.3 GLOBAL PROJECTIONS

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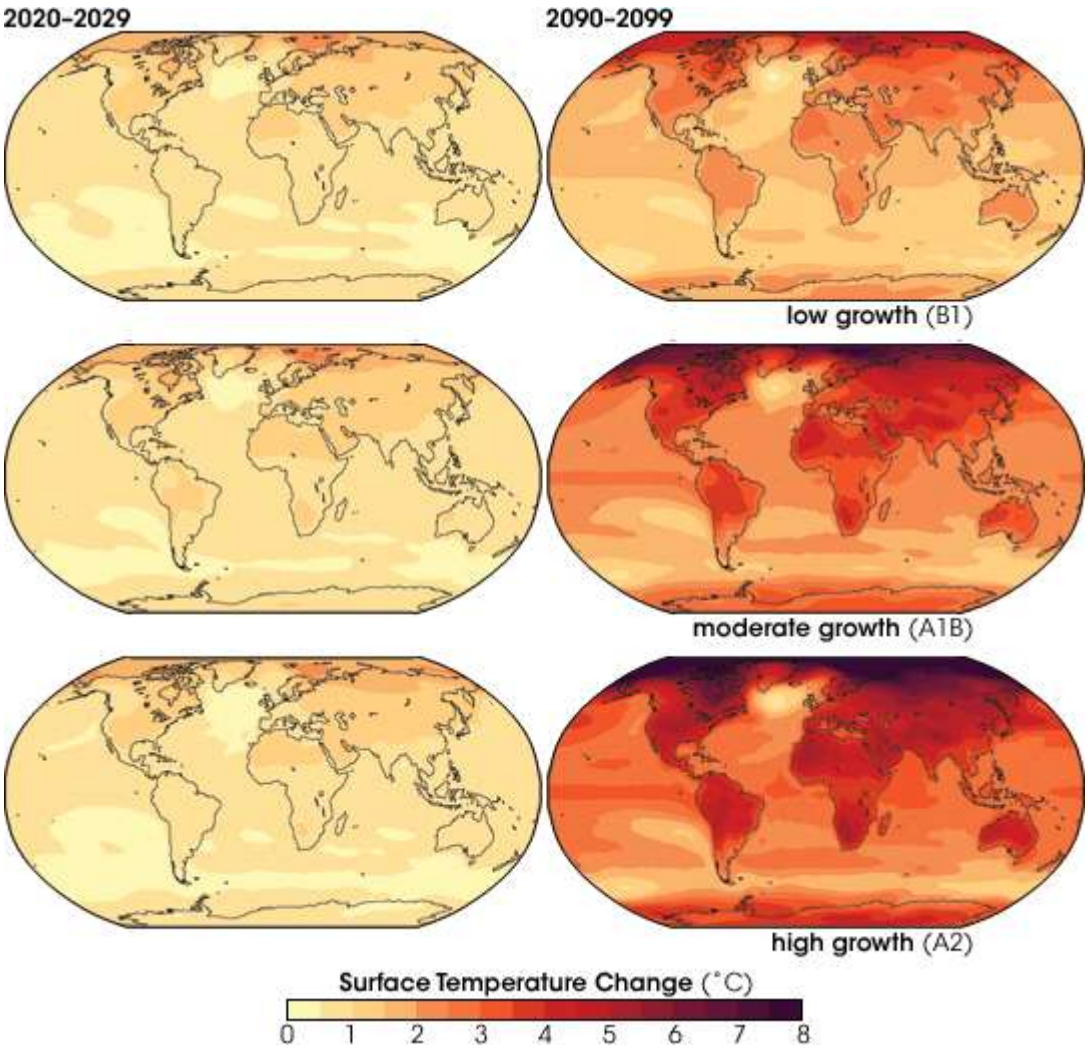
2.3.1 Climate change and its effects will vary greatly between regions and countries. The amount that global surface temperatures are likely to increase is dependent upon the success of global policies to reduce greenhouse gas emissions.

2.3.2 Scenario 5 shows future changes in surface temperature for low, medium and high emissions growth. The average surface temperature of the Earth is likely to increase by +1.1°C under a low emissions scenario to +6.4°C under a high emissions scenario by the end of the 21st century, relative to 1980-1990, with a best estimate of a +1.8°C to +4.0°C increase. The average rate of warming over each inhabited continent is very likely to be at least twice as large as that experienced during the 20th century.



Scenario 5 - Projected future regional patterns of warming based on three emissions scenarios (low, medium, and high growth). Comparing 2020-29 with 2090-29[7]

[7] Source: NASA Earth Observatory, based on IPCC Fourth Assessment Report (2007)

2.4 FUTURE SCENARIOS SEA

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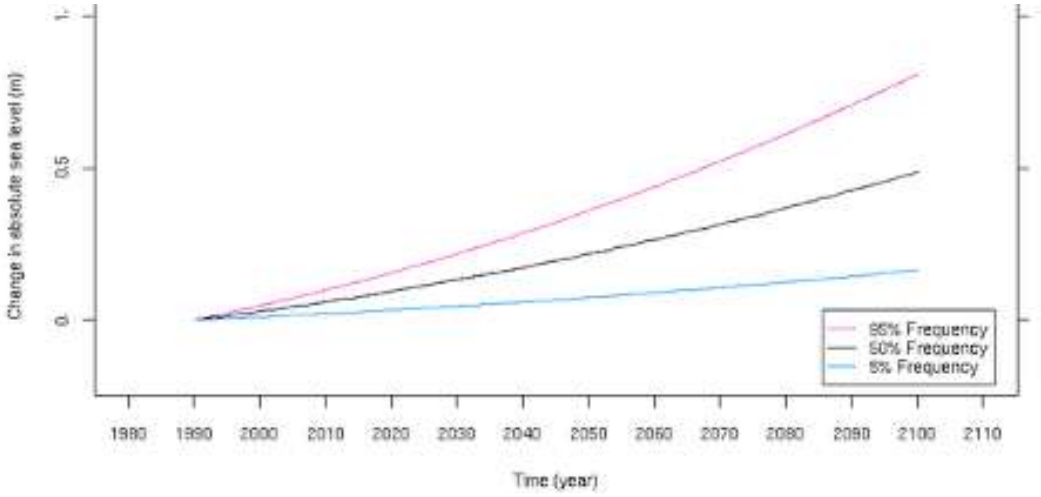
2.4.1 Climate Change Impacts will be felt in our coasts and oceans as well as on land. The UK climate is influenced by its proximity to the North Atlantic Ocean. The ocean acts as a buffer, absorbing heat in the summer and releasing it in the winter, and so moderating the seasonal cycle of temperature. The ocean also supplies moisture to the atmosphere, some of which falls as precipitation over the UK. The climatic influences of the Atlantic ocean are expected to continue.

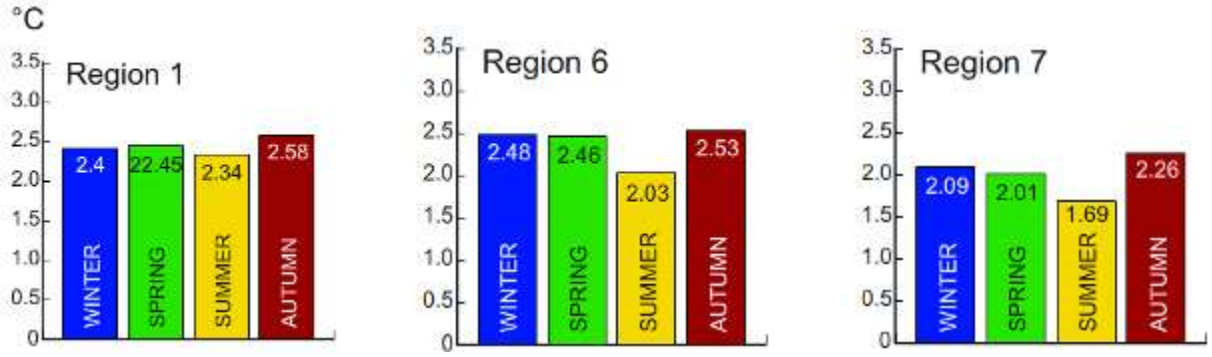
2.4.2 Seal Level rise: One of the effects of climate change on the Highland coast will be changes in sea level. Sea level can rise in two ways. Firstly, through the increased input of freshwater into the World's oceans following the melting of terrestrial glaciers. Secondly, due to thermal expansion of water as the ocean temperatures increase. Scenario 6 shows the projected rise in sea level around UK waters under a high emissions scenario. By 2100 the central estimate for sea level change is an increase of 50cm with the fuller range of between 10cm and 80cm.



Scenario 6 – Change in mean sea levels of UK waters under a high emissions scenario.

2.4.3 Sea Surface Temperature:
The Marine Climate Change impacts Partnership (MCCIP) have correlated projections data on seasonal mean sea surface temperature increases for the 2070-2099 period (compared with a 1960-1990 baseline) in degrees Celsius. This data is presented in regions as set out in the *Charting Progress* sub-divisions of UK waters to provide a stronger emphasis on regional issues, and to maintain consistency with *Charting Progress* reporting. Regions 1, 6 and 7 make up the waters around Highland and the seasonal changes in surface temperature are shown in Scenario 7. Changes are based on the UKCP09 model projections under a medium greenhouse gas emission scenario (the only available for this variable).

Charting Progress sub-divisions of UK waters



Scenario 7 – Sea Surface Temperature increase in °C for the 2080's (2070-2099) under medium greenhouse gas emissions scenario for regions 1, 6 and 7[8]

2.4.4 Meridional Overturning Circulation (MOC): The climate of the UK is warmer than other places in the world at similar latitudes due to the influence of the Meridional Overturning Circulation (sometimes referred to as thermohaline circulation, or Gulf Stream). Warm and relatively salty water flows north from the subtropics towards the UK. As it travels northwards, some heat is lost into the atmosphere, particularly in the Northwest Atlantic and Nordic Seas. The water then cools and as it is relatively salty its density causes it to sink and return southwards several kilometres below the surface. Without this circulation, our climate would be much colder and the UK would receive up to 20% less precipitation.

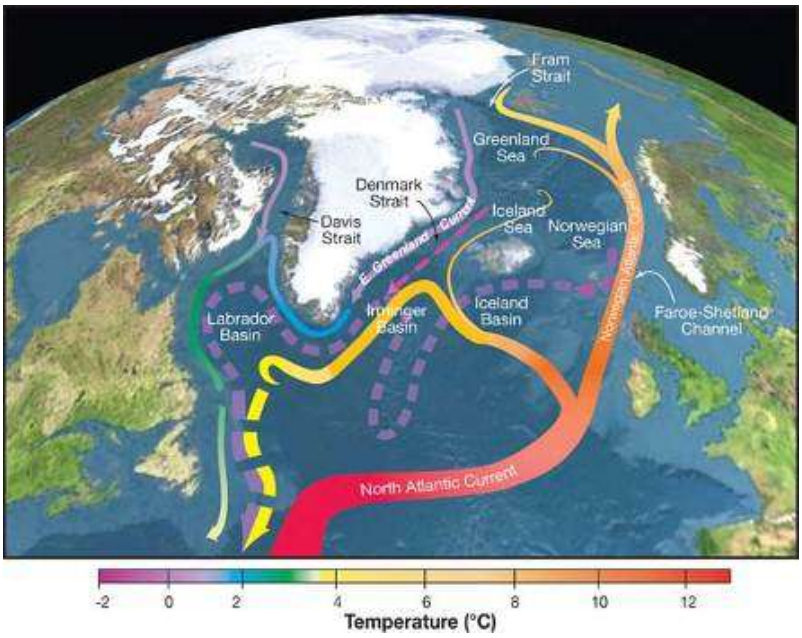


Figure 10 – The Atlantic Meridional Overturning Circulation[9]

[8] http://www.mccip.org.uk/annual-report-card/2010-2011/future-sea-surface-temperature.aspx

[9] U.S. Geological Survey (Lead Author);Peter Saundry (Contributing Author);Michael Pidwirny (Topic Editor) "Atlantic meridional overturning circulation". In: Encyclopaedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopaedia of Earth March 2, 2010; Last revised Date September 15, 2011; Retrieved February 15, 2012 http://www.eoearth.org/article/Atlantic_meridional_overturning_circulation

2.4.5 The MOC also affects regional sea level by redistributing water within the global ocean. Without the MOC, sea level could be around 25cm higher over some parts of the UK coastline. Future Climate Change may result in terrestrial glaciers melting and increasing the amount of freshwater entering the North Atlantic. This could dilute the salty water, reducing its density and slowing the turning of MOC. Climate models suggest that the MOC will weaken gradually in response to increasing greenhouse gas emissions. It is considered very unlikely to slow significantly in the next century. The effects of any weakening have, however, been incorporated into the UKCP09 projections outlined in the previous pages.

2.5 FEEDBACK LOOPS

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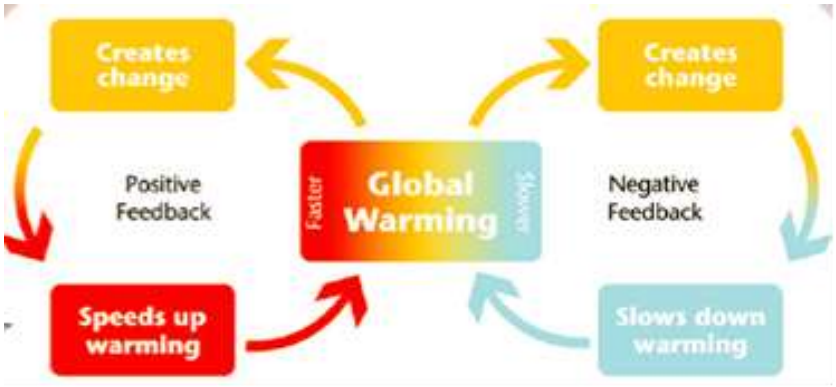
2.5.1 Feedback Loops happen when a change in our climate causes an impact which could change our climate further - a knock-on effect which feeds back into our climate. Feedback loops are very complex and scientists are working hard to understand more. The purpose of highlighting them here is to acknowledge that policy areas not immediately apparent as being related to climate change may assist or obstruct efforts to both mitigate and adapt to climate change. There can be both negative and positive feedbacks:



2.5.2 Negative Feedback Loops: An impact which offsets the prevailing change in climate. Under global warming, this would create a cooling effect, balancing out the changes. For example, for every tonne of carbon dioxide (CO_2) released into the atmosphere, within a year about half of that will be absorbed by the ocean and land, e.g. through trees and plants. An example of this in Highland would be through the expansion of the forestry network which could absorb more CO_2 from the atmosphere thus slowing the rate of climate change.

2.5.3 Positive Feedback Loops: This is an impact which increases the change in the climate. It would add to global warming by creating further heating. For example, as temperatures increase, soils, plants and trees will become more heat stressed - potentially releasing huge amounts of carbon they store back into the atmosphere. In Highland, one of the largest stores of Carbon is our extensive peat bogs. Should these peat bogs begin to dry out, they will turn from being carbon stores to carbon emitters releasing many tonnes of $C0_2$ into the atmosphere, speeding up the rate of climate change.

2.6 FUTURE CLIMATE SCENARIOS CONCLUSIONS

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2.6.1 Climate change in Highland is expected to result in:

- Hotter drier summers
- Milder wetter autumn and winters
- Increase in summer heat waves and extreme temperatures
- Reduced occurrence of frost and snowfall
- Sea level rise

2.6.2 Under a high emissions scenario, for all the variables presented, climate change in Highland is likely to be minimal in the 2020's (2010-2029). From the 2050's (2040-2069) these changes become more noticeable and by the 2080's (2060-2099) clear regional patterns emerge in Highland. For some variables, the changes are not expected to be as severe as other parts of the UK.

2.6.3 For example, by the 2020's, under a high emissions scenario, the central estimate of **mean annual temperature** remains relatively unchanged in Highland but will be noticeably changing elsewhere in the UK by this time.

2.6.4 Under a high emissions scenario, the central estimate of **mean summer precipitation** is expected to decrease over time and more so in the inland areas of Highland than the coastal west. However, a decrease in summer precipitation in Highland of -20% by 2080 is considerably less than the -40% expected in South West England and Cornwall. This could lead to parts of Britain experiencing drought while Highland maintains sufficient water supply.

2.6.5 Certain variables show greater change in Highland than in other parts of the UK. For example, changes in **mean annual precipitation** do not differ greatly from the rest of the UK but the seasonality of this rainfall does vary between regions. Under a high emissions scenario for the 2080's, the central estimate for change in **mean winter precipitation** is expected to be +40% in parts of West of Highland and Moray, while the rest of the UK will see changes of +10% to +30%. The seasonality of rainfall could lead to an increased frequency and intensity of extreme precipitation events.

2.6.6 Mean winter temperature is expected to increase between +2 to +3^{o}C in Highland by the 2080's. Combined with the projected decrease in **mean winter precipitation** for inland mountainous regions of Highland, such changes may impact negatively upon the ski industry.

2.6.7 Sea level is expected to rise by between 20cm and 80cm by 2080 with a central estimate of 50cm under a high emission scenario. Our climate will continue to be influenced by the Meridional Overturning Circulation which maintains a warmer and wetter climate over Highland than other parts of the World at similar latitudes. The Highland Climate will continue to be affected by its proximity to the Atlantic Ocean.

SECTION 3 IDENTIFYING THE IMPACTS OF CLIMATE CHANGE

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3.1 THE IMPACT OF CURRENT CLIMATE IN HIGHLAND

3.1.1 The climate is fundamental to almost all aspects of Highland life. It directly affects our economy, ecosystems, food, water, health, homes, infrastructure, trade and leisure. The Highland people have experience of dealing with a continually changing climate and the associated long and short term variability of the associated weather systems. The climate can have a significant effect on Highland people and can impact on Council Service delivery. By exploring the current impacts of our climate, we can anticipate what future change may bring, and our ability to respond to such change.

3.1.2 In 2011, The Highland Council carried out a trawl of weather related articles reported in the media between 2001 and 2011. The project researched regional weather incidents and the associated impacts for the Highland Council but did not attempt to establish any climate-related trends from the acquired information. A total of 262 articles were logged. The information gathered, along with Council information on responding to severe weather events, was used to consider the Council's ability to respond to current events and the impacts such events have on Council Service delivery.

3.1.3 The significance of each weather incident was estimated in terms of Highland Council Service delivery. Articles were categorised as:

- **Low Significance**: affecting individuals in a given locality with little responsibility or cost to Council.
- **Medium Significance**: affecting groups or communities over a larger area, Highland Council shared responsibility with other agencies, and bearing some costs.
- **High Significance**: Highland Council directly responsible, occurring over a widespread area with high costs.

3.1.4 The majority of weather incidents reported were of high (52%) or medium significance (40%) with only 8% of articles being of low significance to Highland Council. This demonstrates that Highland Council is viewed as an important stakeholder involved in the response to weather events.

3.1.5 The tone of each press article was also examined to see whether it would affect the reputation of the Highland Council in a positive or negative way. 66% or articles logged were negative about the Council and its ability to deliver Services, however, some articles praised the efforts being made and 34% of press releases had a positive impact on the Council's reputation.

3.1.6 Winter weather made up the greatest proportion of events being reported, followed by storm events, wind and rain (including flooding). This is reflective of our Northerly latitude and cool climate. There were very few articles relating to high temperatures, fog and electrical storms. While these events are known to occur, this would suggest that the impacts are less significant for individuals and communities and therefore not worthy of reporting by the media. The greatest impacts reported were disruptions to travel and transport leading to problems with access to Services, disruptions to public transport, delivery of goods and maintenance of road and rail networks.

3.1.7 For a full report of the methodologies please visit the Local Climate Impact Profile webpage.

3.1.8 The table below gives examples of the impacts associated with weather events in Highland in the recent past and the effect these have had on Council operations. It is important to note, that some events may have been the cumulative result of different factors including non-weather factors.

Weather Event	**Impact on Council Service Delivery**
High Winds, February 2002	Power cuts leading to school closures.
Electrical storm and heavy rain, September 2002	Distribution of sandbags and setting up of incident room and 24 hour helpline. Highland Council emergency response centre unreachable due to floodwaters.
High winds and high tide, November 2002	A 20 meter hole appearing in Wick harbour pier putting the town at risk. Urgent repairs and strengthening of the pier was needed.
Dust Storm, April 2006	Parts of the A96 were in dustbowl conditions as soil from nearby fields was blown off. Road safety announcements were needed to alert drivers asking them to slow down and use headlights.
Frozen Rain, January 2008	Resulted in increased traffic hazards and number of accidents. Required more salt on the roads and vehicle maintenance. The Highland Council was criticised by the public in the media.
Frozen Pipes, November 2010	Pipes burst resulting in the flooding of the Highland Council IT server room. The Highland Council lost access to its website and e-mail at a time when 95 schools were closed due to snow and ice. School closure online alert system inoperative.
Freezing Conditions, December 2010	School Closures, bus delays and problems with supply of fuel oil.
Continued cold and freeze-thaw conditions, February 2011	Increased number of pot holes on roads. Damage to cars, accidents and claims. Complaints to the Council. Disruption as roads closed to repair damage.
Good Weather, May 2011	Nairn Show recorded higher than normal visitor numbers leading to increased volumes of road traffic.
Floods, July 2011	Floods close the A862 near Beauly. Added disruption due to Black Isle Show and Belladrum music festival taking place in the area at the time.

3.1.9 While the media trawl did not attempt to quantify weather events nor explore trends, the Highland Council does hold relevant data on past weather events in the area. One aim of the Adaptation Strategy will be to continue to gather and examine such data and look for new areas to monitor in the future.

3.1.10 Flooding is a natural process that cannot be prevented entirely**.** The map in Figure 11 highlights all of the recorded flooding events in Highland as at May 2011. Different types of flooding occur, including River flooding, Coastal flooding and Surface water flooding (when there is heavy rainfall on ground that is already saturated, or on paved areas where drainage is poor). There can also be Groundwater flooding (when rainfall causes the water that is naturally stored underground to rise to the surface) and drain and sewer flooding (this can occur during heavy rain when drains have become blocked or full). Flooding can have a devastating effect on people, property, businesses, infrastructure and land. There have been many occurrences of urban flooding throughout Highland including large scale events in Evanton, Golspie and Dingwall in the past

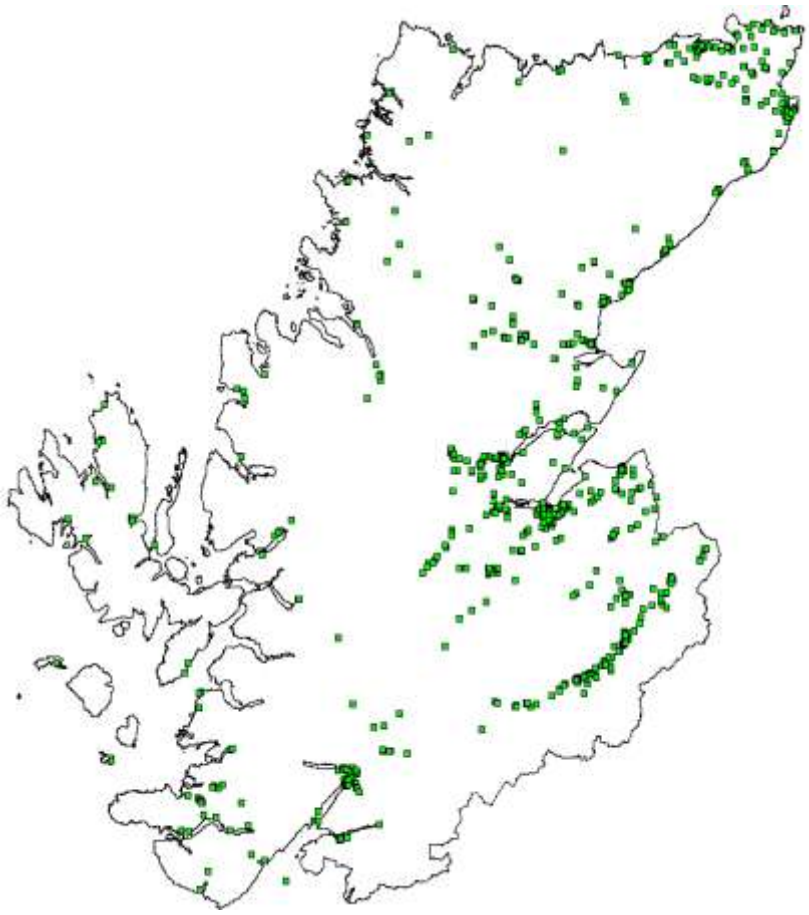

Figure 11 – Historic Flooding Events in Highland up to May 2011 (The Highland Council)

Case Example: No play at Scottish Open, flash floods at Castle Stuart.

Inverness Courier 09/07/2011

Overnight flooding at Castle Stuart has forced the Scottish Open to be suspended for more than 12 hours. Heavy rain has fallen across Inverness, with some of the city's road network flooded. Surface water is affecting parts of the A9 and A96. There are also deep puddles in Harbour Road in Inverness.

The deluge - which included an early morning thunderstorm - has cast doubt over the future timetable of the Scottish Open, which was due to finish on Sunday. Yesterday, golf stars were called off the course mid-afternoon due to the threat of lightning and play did not resume. Several players were set to start at 7am today in a bid to complete round two - which should have finished yesterday. The course and car parks are temporarily closed off to the public.

2.2

Figure 12 - Map of coastal flood events in Scotland, 1849-2008. Note: Events shown 'offshore' are too broad in spatial extent to be attributed to one or a few specific locations (Sniffer report FRM10)[10]

3.1.11 Figure 12 above shows the historical coastal flooding events in Scotland and that there has been a number of events occurring along the Highland Coastline including the populated areas of Nairn, Inverness, Wick, Thurso and Fort William.

[10] http://www.sniffer.org.uk/Resources/FRM10/Layout_Default/0.aspx?backurl=http://www.sniffer.org.uk:80/project-search-results.aspx&selectedtab=active

3.1.12 Landslips: The Scottish Road Network Landslips Study (2005) highlights debris flows, a particular type of landslide, as representing a hazard to the road network and its users. Debris flows can be triggered by rainfall events. In recent years, debris flows appear to have had an increasing effect on Scotland's road and rail networks but sufficient records are not available to draw any robust conclusions as to trends. Figure 13 demonstrates the extent of Scottish debris flow. The majority of occurrences happen in the North and West of the country, namely the Highland Council area.

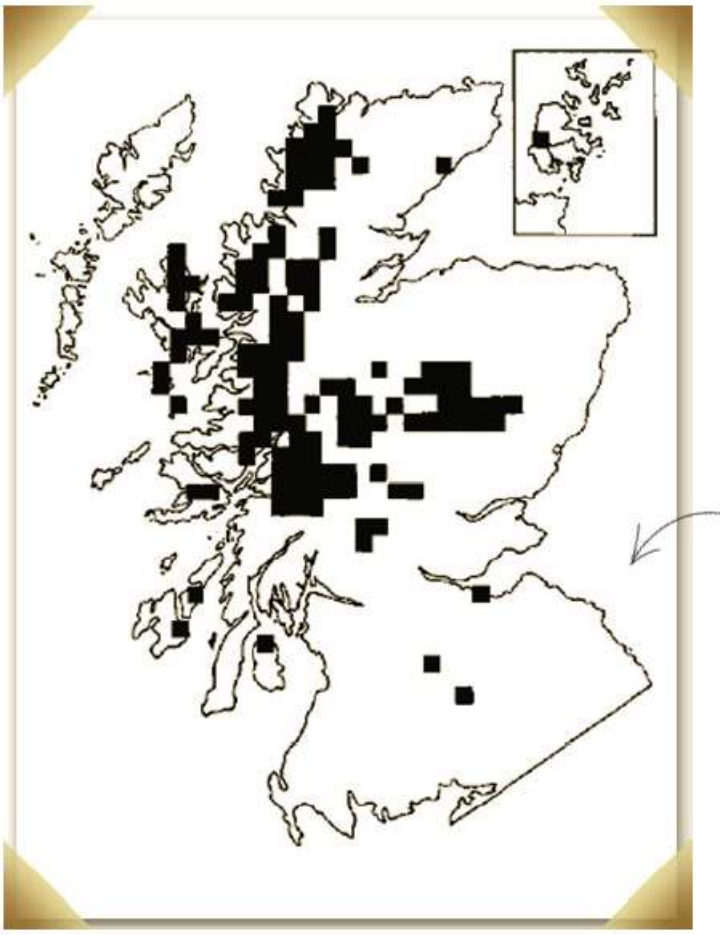

Figure 13 – The Extent of recorded Debris Flow in Scotland (Jones and Lee, 1994)[11]

Case Example: Stromeferry Bypass Closure, *Highland Council 15/02/2012*

The A890 Lochcarron to Kyle of Lochalsh road was closed on the 22 December 2011, and remained closed until March 2012, as the result of landslides and the continuing danger of further rock fall.

Scotrail provided an extra train service between Inverness and Kyle, which allowed school pupils to reach Plockton High School in time for the start of the school day. They return home by bus and passenger ferry. A 6-car turntable ferry was put in place to divert traffic across the Strome Narrows with priority given to local traffic. The passenger ferry will operate a limited service on Sunday.

As a matter of urgency, the Highland Council is examining long term options for replacing the by-pass, including a bridge across the Strome Narrows, a new by-pass and an extension of the avalanche shelters.

[11] www.scotland.gov.uk/Publications/2005/07/08131738/17395

3.1.13 Snow and Ice affect parts of Highland every winter. The relatively plentiful supply of snow over the highest ground has led to the development of skiing areas in Fort William and Aviemore. Winter weather in Highland is variable from year to year and can change suddenly leading to transport disruptions, damage to property, injury and increased costs through road maintenance and heating bills. The Council is prepared for cold weather and has a fleet of 116 road gritters and 48 pavement gritters. In 2009/10 and 2010/11 the winters were particularly severe affecting a wide area. Recent annual road salt usage is shown below:

Year	Tonnes road salt used	Comments
2004/05	57,233	
2005/06	57,612	
2006/07	29,406	Mild winter
2007/08	57,253	
2008/09	79,575	
2009/10	77,674	Longer cold spells than 2008/09, salt was restricted due to national rationing.
2010/11	69,589	Salt restricted due to rationing

3.1.14 Such prolonged periods of cold weather result in increased demand for energy to heat buildings and homes and result in increased costs to the Council. However, two prolonged winter seasons in 2009/10 and 2010/11 attracted more visitors to Highland ski areas, boosting the economy.

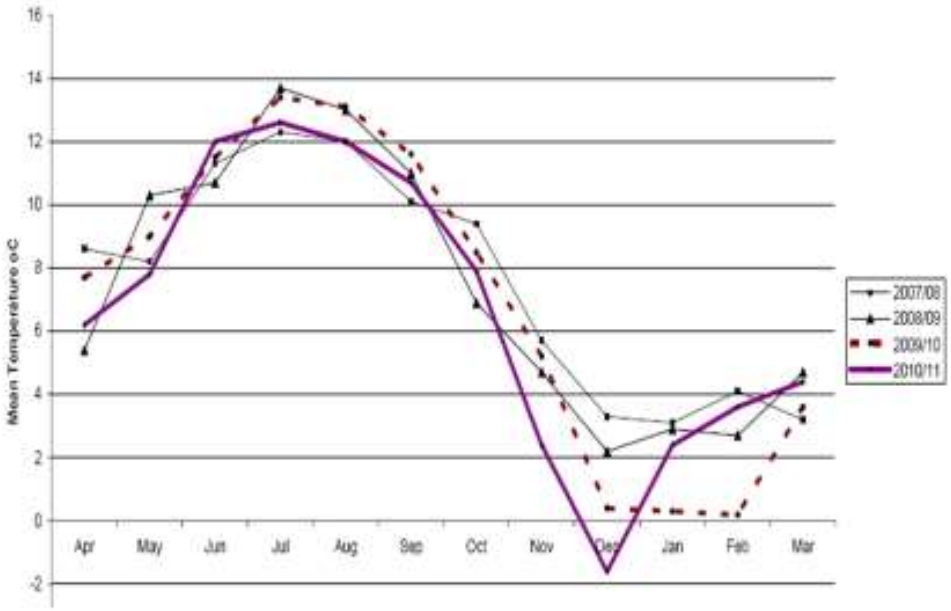

Figure 14 – Monthly temperature North Scotland 2007/08-2010/11

Case Example: Scotland's Bumper Ski Season Ends with Summer Snow,

BBC, 01/06/2010

About £37.5m has been injected into the local economy by the ski season. Since late November, Scotland's five mountain resorts have attracted 373,782 customers. With fresh snow on the slopes, CairnGorm Mountain expects skiing during the first weekend of June. Recent figures from Ski Scotland showed that this season's figures were better than the last bumper season of 2000-2001. Chair of Ski Scotland Heather Negus said: "All winter, we realised we were heading for a great season. We had hoped to match the figure for 2001, but didn't realise we had beaten it until recently, when everything was added up - and of course, CairnGorm Mountain is still operating, so we're still counting." It is estimated that for every pound spent on the slopes another £3 is spent in the local economy with more than £28m being spent this winter in local accommodation, cafés, bars, restaurants, shops and filling stations.

3.1.15 Heat waves and drought: Although not as frequent, the Highland area has experienced prolonged dry periods and high temperatures. The highest summer temperature recorded was 32.1 °C, recorded at Onich on 1 August 1995. Such dry conditions can result in increased risk of forest and moorland fires and affect water supplies. It can also lead to topsoils becoming dry and eroded by winds. Good summer weather can encourage more people to come to the Highlands to enjoy the outdoors and visit our mountains, beaches, rivers and Lochs.

3.1.16 Fog and low visibility: Valley fog can form in winter leaving low lying areas with poor visibility. Freezing fog can stay all day in some parts during winter. Low level cloud can affect visibility on some of the more mountainous travel routes. Coastal regions can experience fog (or haar) from the sea. Inverness airport is in the coastal Moray Firth region and has experienced flight cancellations due to poor visibility and fog.

3.1.17 High winds and storms: High winds and storms can lead to fallen trees blocking roads and damaging electricity and communication links. The Kessock and Skye road bridges have been closed to high-sided vehicles as a result of high winds and damage to pylons and wind turbines has occurred in the past, resulting in power cuts. High winds lead to rough seas and disrupt ferry links to the islands as well as causing damage to coastal roads and harbours.

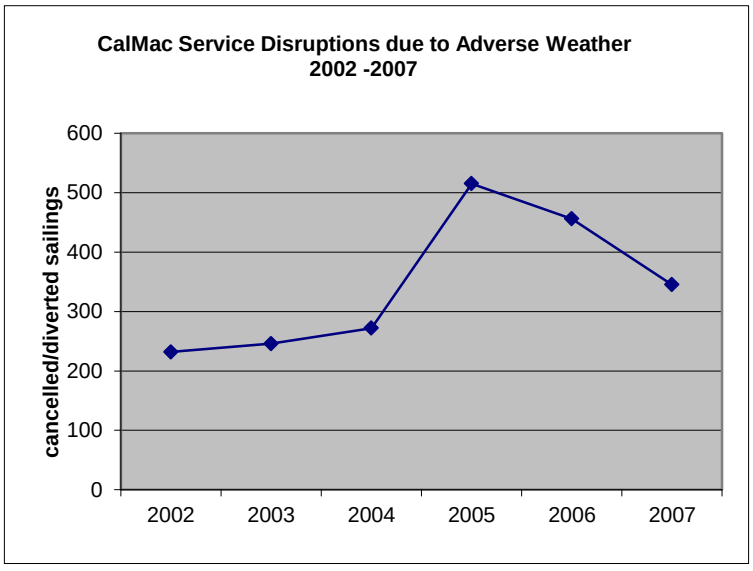

Figure 15 – Cal Mac Service Disruptions due to Adverse Weather

Case Example: The Cost of Tackling Wildfires Revealed.

Inverness Courier 17/05/2011

The direct financial cost of tackling wildfires in the Highlands and Islands is estimated to be more than £125,000. This includes £5000 in destroyed equipment.

Highlands and Islands Fire and Rescue Service responded to more than 70 significant wildfires - brought on by a period of very dry weather - between 29th April and 5th May.

However, Chief Fire Officer Trevor Johnson said the extended cost was much more difficult to quantify as landowners had provided both staff and financed helicopters in some areas.

He also said there was an environmental impact, including damage to sites of conservation and special scientific interest, cultural and heritage costs and there had been an impact on business and tourism.

It is estimated that 9100 hectares of vegetation, including 3200 hectares of forestry, was destroyed. This represents a potential loss of between £7.2 and £26.4 million based on the costs associated with reinstating moorland following fires in Yorkshire in 2003…..

3.2 FUTURE IMPACTS OF A CHANGING CLIMATE IN HIGHLAND

BACK TO TOP

3.2.1 The Highland Council have explored the impacts of climate change at a more regional level by following the framework of 12 sectors as set out by the Scottish Government[12].

- Water Resource Management
- Agriculture
- Forests and Forestry
- Spatial Planning and Land Use
- Biodiversity and Ecosystem Resilience
- Transport
- The Built Environment
- Energy
- Business and Industry
- Marine and Fisheries
- Health and Wellbeing
- Emergency and Rescue Services

3.2.2 A series of workshops were conducted with all seven Council Services, with various community groups and certain interest groups. In addition, Highland Council participated in workshops and research coordinated by partner agencies in the region. A summary of the different workshops and geographical locations is shown below:

3.2.3 Highland Council Services, 2009: Workshops were carried out with managerial and operational staff in each of the Council's seven services of Chief Executive Service, Housing & Property Service, Finance Service, Education, Culture and Sport, Social Work Service, Transport, Environment and Community Service and Planning & Development Service. Between 15 and 20 Service employees were present at each workshop.

3.2.4 Glenurquhart and Aviemore, 2009: Workshops were organised by ClimATIC, an EU Peripheries funded project looking at community adaptation to climate change. The Glenurquhart workshop focused in and around issues surrounding the river Enrick and 15 members of the public attended. The Aviemore workshop focused on issues for the Tourism Sector and approximately 30 people mainly involved in the tourism industry were in attendance. The Highland Council was in attendance at both.

3.2.5 The Black Isle Ward Forum, 2009: A ward forum meeting organised by Highland Council focused on adaptation issues for residents of the Black Isle. 50 people were in attendance.

3.2.6 Land Users Group, 2009: Representatives from eight organisations involved with land management and land use issues in Highland attended a workshop hosted by Highland Council.

[12] www.scotland.gov.uk/adaptationframework

3.2.7 Highland Council Members, 2010: An adaptation workshop was carried out with the 15 cross-party Members of the Highland Council's Climate Change Working Group.

3.2.8 Highland Youth Voice, 2010: A workshop took place with 15 representatives of the 16-25 age-group in Highland.

3.2.9 Nairn, 2010: Three workshops were carried out by Scottish Natural Heritage in Association with Sciencewise, the UK's national centre for public dialogue in policy making involving science and technology. The Highland Council were in attendance and there was between 12 and 20 members of the public at each workshop.

3.2.10 A9 Corridor Project Group, 2010/11: Coordinated by Adaptation Scotland this series of workshops looked at issues affecting the areas adjacent to the A9 trunk road with around 30 representatives from private, public and voluntary sector organisations at each.

3.2.11 Inverness and Grantown on Spey, 2011: The Scottish Council for Voluntary Organisations carried out a series of workshops focusing on the effects of climate change on vulnerable groups in our society. Two of these workshops took place within Highland.

3.2.12 Gairloch and Loch Ewe Community, 2011: Three workshops were carried out by Highland Council to discuss climate change adaptation issues with the community of Gairloch and Loch Ewe in the North West of Highland.

3.2.13 Inverewe Parent and Toddlers Group, July 2011: Highland Council officers joined a child day care centre to engage with approximate 10 young parents who may not have had the opportunity to join evening workshops elsewhere.

Workshop Locations:

3.2.14 More information and details of individual workshop results can be found at:

http://www.highland.gov.uk/yourenvironment/sustainabledevelopment/climatechange/adaptation/

3.2.15 After examining current weather incidents and exploring future climate scenarios as provided by UKCP09, workshop participants were asked to identify potential impacts for Highland from a changing climate. The combined results of all 25 workshops carried out between 2009 and 2011 are shown in the following pages, presented by sector and separated into threats and opportunities. These impacts are illustrative and not exhaustive however, they provide a fairly comprehensive view of regional impacts for Highland as perceived by Highland residents. They represent the views of a cross-section of Highland Council employees and communities and can help to enhance those impacts identified nationally. Such impacts can be explored further and added to in coming years as our knowledge and understanding of the issues increases.

THREATS	CROSS-CUTTING THEMES											
1: WATER REOURCE MANAGEMENT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Drought could lead to mandatory water conservation measures being enforced.	X		X						X	X	X	X
There could be an increase in the prevalence of water-borne disease contamination particularly following flooding.	X		X						X		X	X
Flooding events could be more local and short term with the exception of coastal flooding which may increase as a result of climate change.	X		X	X		X	X	X	X		X	X
Flash flooding could lead to rapid run-off in localised areas which are hard to predict putting pressures on drainage systems, transport links, emergency services and creating a risk to public safety.	X			X		X					X	X
An increase in coastal flooding could be experienced due to a combination of storm surges, increased wave height and sea level rise. Those areas most at risk from coastal flooding in Highland are also the most populated (Moray Firth).	X			X			X				X	X
Low flows in water courses during the spring and summer could have a negative impact on water quality affecting fish stocks, farming and drinking supply.	X		X							X	X	
Drier conditions could see an increased demand for agricultural irrigation and there could be competing demands for the water resource.	X	X	X		X							
Toxic algal blooms could threaten public health particularly if they occur at a time when there is increased water sports.	X		X								X	

THREATS	CROSS-CUTTING THEMES											
1: WATER REOURCE MANAGEMENT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Increased canoeing and white water rafting opportunities could lead to more disputes between different river users (e.g. canoeists and fishermen).	X										X	X
There could be increased erosion of river banks and possible changes in river course.	X	X	X	X	X		X			X		
Flooding and coastal erosion could affect coastal recreational sites including golf courses.							X					
If sewers over flow during flood events there could be increased risk of pollution of natural water courses.	X		X		X						X	
OPPORTUNITIES												
The changing climate could force water users to conserve water and use it in a more efficient manner, reducing the costs associated with treatment and transport.	X							X				
The Highland area is likely to have a more plentiful supply of water than other parts of the UK and Europe during the summer months and there could be opportunities to sell this good quality drinking water to areas with less in reserve.	X								X		X	
No rivers flow into Highland but two Highland rivers are trans-boundary and flow out of Highland into neighbouring Moray, the rivers Nairn and Findhorn. There will be opportunities to work with neighbouring Authorities in the management of these catchments.	X	X	X	X	X				X			
An increased frequency of high peak river flows could lead to more canoeing and white water rafting opportunities in Highland.	X								X		X	
Harbours could see greater water depths as a result of sea level rise, allowing larger vessels to moor.	X								X	X		

THREATS	CROSS-CUTTING THEMES											
2: AGRICULTURE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There could be an increased loss of good agricultural land for farming crops/ livestock to flooding.			X		X				X			
There could be an increase in topsoil wash-off from intense rainfall or from dry spells where is blown away.			X		X						X	
Disruption to transport links caused by climate change could lead to difficulties in getting food products out to market.			X			X			X		X	
Farmers and crofters may have increased difficulty watering animals during periods of drought as well as during period of prolonged frost.	X		X									
Warmer temperatures and lower summer rainfall may lead to heat and soil moisture stress, reducing growth.			X									
There is increased risk to agricultural land from extreme event damage (e.g. droughts or floods).			X									
If warmer summers result in faster crop growth, faster growth by itself can reduced yield quality, with grain failing to fill properly and grass digestibility falling unless grazed or cut sooner.			X									
Water availability may become a problem for livestock but heat stress can also directly inhibit feed intake and breeding. Prolonged dry spells mean there is not enough grass for grazing.	X		X									

THREATS	CROSS-CUTTING THEMES											
2: AGRICULTURE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Higher winter rainfall and intense summer rainfall may lead to reduced field access and possible flood damage. Wet ground makes it difficult to operate machinery or grow crops. Sheep get foot rot from damp conditions. Increased run-off and rapidly rising rivers are a problem when moving livestock.	X	X	X			X					X	
Livestock may face new diseases such as West Nile virus, or an increased prevalence of bluetongue or parasitic worms with warmer and wetter conditions. The distribution of weeds, pests and disease may alter. Milder winters will fail to kill some existing pathogens and insect vectors, and that warmer summers may introduce new threats. Warm mild conditions could lead to more slugs on vegetables.		X	X		X						X	
Climate change may change the behaviours of certain migrating birds. Geese may remain longer in one area destroying crops.			X		X							
Climate Change is a global phenomenon and even if agriculture is sustained in Highland there could be issues with food security for the local population as they compete with more populous areas to guarantee food supply.			X						X		X	
There could be a loss of natural field boundaries as trees and small woodlands fail to adapt to changing climate thus further opening up the landscape.				X	X							

OPPORTUNITIES	CROSS-CUTTING THEMES											
2: AGRICULTURE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Highland farmers could be able to grow new or different crops. Along with elevated CO2 levels, warmer temperatures will increase growth rates for grasses and arable crops. This may lead to higher yields for existing crops, plus the possibility of new crops becoming viable as the northern limit of their range extends.		X	X						X			
Extended dry periods improve the opportunities for access to land, for both field operations and livestock grazing.			X			X						
There could be an increase in Local Food Groups being set up or Grow Your Own schemes developing resulting from the more favourable weather and longer growing seasons. Allotment schemes could see an expansion and communities could become less reliant on imports from elsewhere.			X	X			X		X		X	
Fair weather in the summer could see good hay making helping sustain livestock through the winter season.			X									

THREATS	CROSS-CUTTING THEMES											
3: FORESTS AND FORESTRY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
In Highland, most of the commercial trees planted in the 70's will be harvested soon resulting in increased run-off leading to increased risk of flooding, particularly on transport routes.	X	X		X		X				X		
Trees in Highland may be more susceptible to wind blow due to increased frequency or intensity of storms combined with the increased prevalence of disease that weakens the tree. Winter water logging and an increased frequency of extreme weather events may increase the risk of wind throw;		X									X	
Highland Council may experience an increase in the number of call-outs to inspect the safety of trees.		X										
Highland region contains one of the last vestiges of Elm in the UK but already Dutch Elm disease has made it as far North as Golspie. The disease is also evolving and attacking once disease resistant strains. Other new pest species could be prevalent in Highland as milder winters prevent the killing off of insect species in hard frosts.		X										
Tree species with exacting requirements are more vulnerable to a changing climate, as are trees grown in locations and on soil types subject to the greatest change.		X										
Early budburst, coupled with delayed dormancy in autumn, can increase the risk of frost damage;		X			X							

THREATS	CROSS-CUTTING THEMES											
3: FORESTS AND FORESTRY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Warmer winters may mean that some species' chilling requirements for flowering or seed germination are not met;		X			X							
Increased winter rainfall may limit the ability to thin crops on some soils due to reduced accessibility for machinery and increased risk of wind throw.		X				X						
There is an increased threat of forest fire if warm dry spells are prolonged, this would result in a loss of timber and possible damage to property.		X					X				X	X
Where forests grow close to the coastline there could be increased salinity of soil as a result of sea level rise and tree lines could retreat, further reducing stability of sandy soils and increasing erosion.		X		X								
Historic Trees (such as those at Cawdor Castle) could be at risk from storm damage.		X			X							

OPPORTUNITIES	CROSS-CUTTING THEMES											
3: FORESTS AND FORESTRY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There may be increased opportunities to grow timber for sustainable construction and biomass fuel as a result of a warmer climate with increased C02 levels and a longer growing season.		X					X	X	X			
Following storm damage there could be more opportunities for communities to collect logs and kindling for their fires.		X							X			
Forests can provide natural flood management, protection of water quality, or urban climate control.	X	X			X							

THREATS	CROSS-CUTTING THEMES											
4: SPATIAL PLANNING AND LAND USE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
One future impact of a changing climate could be the in-migration of people from places worst affected by changing weather patterns both in the UK (low lying areas such as East Anglia) and Europe Mediterranean and areas affected by excessive heat waves). Couple this with the expected renewable energy potential of Highland region and the potential is for a population increase with more mixed cultures and languages. School accommodation and teaching staff may have to increase to provide for any increased populations	X			X			X	X	X		X	
Demand-led Services will see increased workloads. Currently Highland planners are working on 200/ 300 planning applications each per year. In total the area sees 5000 applications per annum which is above the national average.				X								
Sporting estates in Highland may have difficulty in managing muirburn, requiring more staff time or back up from neighbouring estates or the emergency services.		X	X	X					X			X
Water-logging will lead to stalking access issues as it washes out access tracks and causes 4X4 vehicles to be bogged down off road.					X	X			X			
The risk of damage or loss of cultural heritage sites, as a result of erosion or flooding, is likely to increase.							X		X			

THREATS	CROSS-CUTTING THEMES											
4: SPATIAL PLANNING AND LAND USE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There are likely to be development pressures resulting from competition for land as a result of the changing climate, for example, natural flood plains and agricultural use.	X	X	X	X	X		X					
Landslip risk will have implications for what particular land can be used for in the future. Currently the majority of Scottish Landslips occur in Highland due to its topography.	X	X	X	X		X		X	X			
Areas which are likely to be increasingly susceptible to flooding may become unsuitable for residential developments. Existing low lying villages will be under threat from flooding.				X			X					
Coastal flooding and erosion will impact on the locations for future business and industrial developments.				X			X		X			
In terms of flood risk management, consideration of areas adjacent to developments is needed as developments could increase water run-off or conversely could be at risk of run-off from nearby locations.	X			X			X					
There could be an increase in the number of trees falling on to property. Currently the Highland Council policy preference is for properties to be 20m away from the nearest tree however as competition for land increases, more and more developers are building closer to trees that could pose a threat.		X					X					

OPPORTUNITIES	CROSS-CUTTING THEMES											
4: SPATIAL PLANNING AND LAND USE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
No spatial planning or land use opportunities have been identified through the workshops to date.												

THREATS	CROSS-CUTTING THEMES											
5: BIODIVERSITY AND ECOSYSTEM RESILIENCE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Climate Change could degrade ecosystem function to the extent that they cannot maintain the level of services, such as flood mitigation, productive land capacity and water supply that are of value to people.	X	X	X		X							
There could be an increase in invasive species moving into Highland habitats. Many invasive species spread along watercourses and it could be anticipated that with wetter winters and increased flooding more new species will get the opportunity to take hold.	X	X	X		X						X	
Larger deer populations (as more survive winter) could lead to overgrazing and erosion.	X	X	X	X	X							
Salmon stocks are at risk from the spread of the parasite *Gyrodactylus salaris* and river systems are already being invaded by the American Cray fish with detrimental effects on native wildlife.	X				X					X		
There could be a loss of inter-tidal habitats (e.g. Culbin sands) from changes to erosion and deposition brought about by climate change.					X							
Increased storm surges and sea level rise could lead to erosion of coastal sand dunes.					X							

THREATS	CROSS-CUTTING THEMES											
5: BIODIVERSITY AND ECOSYSTEM RESILIENCE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Effects on biodiversity are likely to be severe with species potentially becoming extinct as a result of their being unable to adapt to a rapidly changing environment. There is a risk that existing nature reserves could lose the key species on which they were established. The small size of many protected areas do not provide sufficient habitat to ensure species populations will be resilient to climate change in the future. Movements may occur up hillsides, and species already confined to high mountains may be lost as conditions become unsuitable or other species replace them.		X	X	X	X					X		
Habitat fragmentation and the specialisation of land use in the countryside have reduced the resilience of species to pressures. These pressures will increase with climate change.				X	X							
Warming can cause earlier timing of spring events such as leaf unfolding, bird migration and egg laying. Where species adapt at different speeds this may impact on their populations. For example, caterpillars may emerge earlier than birds' eggs hatch, leading to a lack of food for some bird chicks.		X	X		X							
There will be physical effects on habitats, including loss of saltmarsh and machair to coastal erosion, loss of salmon spawning beds to flash floods, and peat erosion from drying out of wetlands.	X			X	X					X		

OPPORTUNITIES	CROSS-CUTTING THEMES											
5: BIODIVERSITY AND ECOSYSTEM RESILIENCE	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There could be fewer midges as a result of drier weather reducing the available wet habitat for eggs and larvae to grow.					X				X		X	
New and increased species and habitats could move into the area.				X	X							
Ecosystems can provide cost-effective long-term services. For example, saltmarsh and coastal habitats can provide cost-effective coastal flood prevention due to sea level rise.	X				X		X					
Sustainable Urban Drainage Systems can relieve the pressure on sewerage systems and provide valuable habitats for wildlife.	X			X	X		X					
The finer weather combined with the increased deer populations could see more people taking part in hunting which in turn will assist with deer population control.					X				X			
Drier and warmer weather could result in increased forest fire which can assist in clearing out old growth and benefit habitats.		X			X							
Drier summers could lead to better heather growth and easier grouse moor management.				X	X							
Many natural habitats store carbon in the soil and vegetation, in addition to providing multiple ecosystem services including natural climate adaptation benefits.				X	X							

THREATS	CROSS-CUTTING THEMES											
6: TRANSPORT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There is a risk of widespread and frequent transport disruption with road and bridge closures, cancellation of flights and ferries preventing access to and from the islands, difficulty of vehicle access and disruptions to rail services.						X			X			X
There could be an increase in problems with drainage and run-off on roads leading to localised flooding.	X					X						
Roads are vulnerable to sea level rise and coastal erosion/flooding.	X					X	X					
Landslides can block roads and in Highland road diversions can be very long or not at all. Landslips can also disrupt railway lines and coastal erosion could necessitate the relocation of coastal roads.						X	X		X		X	
Some bus services are seasonally dependent on tourism. There is a lack of public transport servicing rural communities out with the tourist season. Within the tourist season buses are overcrowded. Impacts on Highland tourism from Climate Change will also impact on transport links to rural communities. For example, if a decrease in winter tourism is observed in some areas transport provisions may be withdrawn, isolating local residents.						X			X		X	
Rising sea levels could reduce the usefulness of existing harbour infrastructure.	X					X				X		

THREATS	CROSS-CUTTING THEMES											
6: TRANSPORT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
For some Council operations the geography and distribution of control is spread out over a large area leading to long response times. The car is still the only option for most site visits and vulnerable to road closures as result of flooding or landslips brought about by climate change.						**X**	**X**				**X**	
There is a risk that certain services provided by Social Work could be impaired or stopped because of home carers or support workers being unable to reach the location of their clients.						**X**					**X**	
Walking and cycling to school is a positive Climate Change **Mitigation** action because it reduces carbon emissions from car exhausts, but it also helps to build resilience against adverse weather when roads and other transport may be disrupted so can be viewed as **Adaptive.**						**X**					**X**	
Rapid Freeze/Thaw or flash flooding can increase the number of pot holes in the roads leading to hazardous driving conditions and expensive repairs for the Council. Increased peak temperatures could damage road surfaces and distort railway tracks.						**X**	**X**					**X**
Damaged tree limbs can fall on to roads causing a hazard.						**X**					**X**	**X**

OPPORTUNITIES	CROSS-CUTTING THEMES											
6: TRANSPORT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
As average temperatures increase, disruptions from snow and frost may become less frequent, reducing reliance on resources to deal with cold weather (e.g. gritting, snow plough provision etc).						**X**						
There could be an increase in numbers walking, cycling and using of public transport as weather becomes fairer in the summer.						**X**					**X**	

THREATS	CROSS-CUTTING THEMES											
6: THE BUILD ENVIRONMENT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There may be a need for increased grounds maintenance as growing seasons lengthen.	X						X		X			
There will need to be adequate clearing of drains to allow for water run-off etc	X						X					
Access on long distance routes could be damaged and lead to costs in repair and management as wetter winters lead to more erosion of paths and trails. More staff may be required to safety check routes and the Council will need to pre-empt the likely impacts and increase in staff needed to manage this. There will be maintenance, revenue cost and staff resource issues.							X		X			
Increases in wind driven rain can raise the severity of expected rain penetration (e.g. from moderate to severe) to a level where a building's external elements, materials or joints, may no longer provide the precipitation resistance needed. Poor quality housing will not withstand the weather. Currently Highland buildings have greater exposure than other parts of the UK (wind/rain). This can lead to problems with dampness and moisture damaging cavity wall insulation. Such problems could reduce if weather is to get warmer and drier but could be exacerbated if weather gets warmer and wetter.							X		X		X	
Historic and traditional buildings and sites made of traditional materials may be more vulnerable to increased precipitation adding to maintenance costs.							X		X			
Archaeological sites may be susceptible to seal level rise, erosion or landslip.							X		X			

THREATS	CROSS-CUTTING THEMES											
7: THE BUILT ENVIRONMENT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There could be a need to alter piers, jetties and coastal roads in response to rising sea levels in the future.							X			X		
There may be increased damage to the Council's own estate through flooding and other weather impacts. As more property is damaged due to extreme weather this could add further pressure on already limited budgets.							X		X			
The Council and individuals could find insurance premium payments increase or they may have difficulty finding insurance cover at all in places at risk from climate impacts.							X		X			
Increased run-off from tarmac on playgrounds in winter and increased heat reflection in summer could result in the need for more trees and vegetation in school playgrounds. Climate Change will require more investment.							X		X			

OPPORTUNITIES	CROSS-CUTTING THEMES											
7: THE BUILT ENVIRONMENT	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Innovative ideas could be developed in Highland (e.g. grass roofs, grey water systems etc).							**X**					

THREATS	CROSS-CUTTING THEMES											
8: ENERGY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Changes to our climate may alter patterns of energy consumption and use. For example, increased need for energy for air conditioning in the summer.								X			X	
The increased risk of extreme weather events and rising sea levels may pose a threat to critical energy infrastructure, including exposure to flooding, extreme temperatures, and subsidence.								X	X			
Overhead cables can be particularly vulnerable to temperature fluctuations and extreme weather.								X			X	
If electricity supply becomes increasingly reliant on renewable power generation, electricity generation will necessarily vary according to the weather as it will affect the wind/water and wave power used to generate electricity.								X				
There could be an increased risk in fuel supply in the future if transport links are disrupted. Many Highland homes are off the gas network and heated by electricity or oil. Any disruption could see homes without heating and put people's health at risk.				X		X	X	X				
There is greater capacity to store oil rather than biomass wood pellets which are bulky. If trucks cannot distribute regularly, buildings with biomass systems in place risk running out of fuel.						X	X	X	X			
There could be an increase in wind damage to turbines or complaints about noise if wind speeds are high. There is a risk to PV/Solar panel installations in high winds.							X	X	X			

OPPORTUNITIES	CROSS-CUTTING THEMES											
8: ENERGY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There could be an opportunity for more outdoor learning/office use resulting in less need for energy to provide internal lighting and heating.								X			X	
There could be more opportunities for small scale hydro schemes in Highland with the added benefit that it will store water, maintaining year round supply and also provide pump storage to meet fluctuations in demand.							X	X	X			
Fuel consumption for heating will reduce if winters are to get milder.								X	X			
There will be less use of tumble driers as weather allows clothes to be hung outside in the spring and summer.								X				
There may be increased opportunities to harness wind/hydro/wave for energy generation. Finer summers could lead to increased effectiveness of Solar PV heating.								X	X			

THREATS	CROSS-CUTTING THEMES											
9: BUSINESS AND INDUSTRY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There could be over stretched resources in the public sector responding to adverse weather and climate impacts.									X			
Prolonged lack of access may lead to problems in getting food supplies in but also for producers to get products out.			X			X			X		X	
With an increase in transport disruptions due to bad weather more people will be unable to commute to work when transport disrupted. This has an effect on business and retail.						X			X			
Climate Change may see more business failures. Weather events could lead to temporary closures resulting in lost income. Small businesses do not have the ability to cope.									X			
Climate change may see an increased risk of people claiming against the Council?									X			
Freedom of Information requests – there could see upsurge in requests for information or complaints against the Council in the future.									X			
Dispersed staff may be harder to communicate with in the event of a weather-related catastrophe.									X			
Currently borrowing interest rates are at an all time low. The Highland Council is seen as a blue chip organisation and one of the few, lenders are willing to lend to. If Climate Change is going to affect the global economy we may be at an advantage over other organisations due to our size and security.									X			

THREATS	CROSS-CUTTING THEMES											
9: BUSINESS AND INDUSTRY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Funds (e.g. pensions) are invested in equities which are vulnerable to changing climate. Should investments perform poorly in the future due to climate change, investments would have to be moved elsewhere.									X		X	
Staff time and resources is an issue. The Highland Council may need to scale-up equipment if there are to be more severe weather events or alternatively rely on contractors.							X	X	X			
The Council's reputation and relationship with the public is at risk if climate change prevents delivery of services in the time the public expect. People have high expectations.									X			
There could be a loss of employment in some areas. For example if winters become warmer, Winter Tourism may disappear. There will be less winter walking /skiing/ice climbing available making businesses hard to market themselves over the winter months.									X			
Tourists won't stay long in bad weather they will move elsewhere particularly if indoor leisure centres are closed due to adverse weather.									X			
Sometimes flooding can prevent guests from checking out and business owners are faced with the dilemma of whether or not to charge for continued stay. If there is to be in-migration of people from areas worst affected by climate change then this could result in the Council having to pay out more in benefits. This would add pressure on staff resources. Would the Department of Work and Pensions realise the extra pressures on Highland in a circumstance such as this, and offer relevant assistance?	X								X			
Influx of people from other parts of the UK and Europe more adversely affected by Climate Change could result in increased competition for jobs.									X			

OPPORTUNITIES	CROSS-CUTTING THEMES											
9: BUSINESS AND INDUSTRY	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There could be new opportunities for tourism – finer summers could draw in more visitors.									**X**			
We could see increased numbers of people choosing to holiday at home or close to home, rather than travelling abroad, due to the finer weather and increased opportunities for activities.									**X**			
Increased wind farm development could have adverse effects on tourism. Such impacts however may be balanced by the benefits to the economy.				**X**					**X**			
More people moving into the area could result in the opportunity to employ more labour force and reduce benefit claims.									**X**			

THREATS	CROSS-CUTTING THEMES											
10: MARINE AND FISHERIES	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Increased sea levels will mean that existing harbours will offer less shelter.						X				X		
Moored boats may become damaged by storms.						X				X		
Contamination of freshwater may increase as a result of coastal flooding (potentially occurring as a combination of storm surge, sea level rise and increase in wave height).	X	X	X		X					X		
Coastal flooding and the breakdown in defences could see the destruction of harbours and coastal features as well as put low lying communities at risk.						X	X			X		
There could be a reduction in fish stocks due to changes in availability of marine food source.					X					X		
There could be a loss of sea birds as food source moves elsewhere or disappears.					X					X		
Salmon can already suffer from severe weather events if they happen at the wrong time of the year. The cycle of Salmon is changing, with fish coming in from the oceans a month later than before. It is unclear whether this is part of a natural cycle or down to climate change. There is an economic problem associated with this, a risk that the angling season becomes shorter.					X				X	X		
When there is flash flooding, Salmon eggs on the gravel beds high upstream are washed out. Previously when snow stayed on the hills for longer this did not happen, however frequent snow falls and subsequent melting cause rapid run-off and increased erosion of river beds.	X				X					X		
The feeding ground of Salmon out at sea is changing as it is dependent on water temperature. It is possible that Salmon may have to travel further to feed and this is delaying their return to Scottish waters. There is a direct correlation between sea surface temperature and salmon abundance.					X					X		

THREATS	CROSS-CUTTING THEMES											
10: MARINE AND FISHERIES	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Farmed species of fish may become more susceptible to new exotic diseases as temperatures increase.					**X**					**X**		
Variable weather could see an increase in the number of boats getting into trouble out at sea and increase call-outs from the coast guard.										**X**		**X**
New species of jelly fish could move into Scottish waters.										**X**	**X**	
Warmer seas around Scotland could allow some existing non-native species to become invasive and new ones to spread into Scottish waters from elsewhere. This is likely to increase the adverse effects of non-native species on marine ecosystems in Scotland					**X**					**X**		

OPPORTUNITIES	CROSS-CUTTING THEMES											
10: MARINE AND FISHERIES	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Rising sea temperatures could increase growth rates for some important aquaculture species such as Atlantic salmon, mussels and oysters, yet also cause cultivation difficulties of other species such as Atlantic halibut. It may also be possible to cultivate new species such as sea bass and bream.									X	X		
Higher winter rainfalls could increase the flow in some fishing rivers and improve fishing conditions.										X		
More frequent storm surges to see an increase in surfing activities particularly in the North and West.									X	X	X	

THREATS	CROSS-CUTTING THEMES											
11: HEALTH AND WELLBEING	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Power cuts and damage to communication links could leave isolated individuals vulnerable particularly if they are elderly or disabled. Many homes are heated by electricity and there is a risk of hypothermia if power cuts are prolonged.						X	X	X			X	X
Transport disruption could limit the supply of fuel and food to rural areas resulting in people being unable to keep warm or meet their daily nutritional needs.						X		X			X	
There could be an increased risk of injury from flying debris in storms if storms become more severe. Domestic bins/clothes on clothes line could get blown away. Parents of young children will be unable to take their prams out.							X				X	X
The risk of loss of life or injuries will increase through slips and falls particularly in the elderly (e.g. during wintry or wet weather).											X	X
Transport disruption could lead to a lack of access to medication supply/dialysis. Life-line routes to hospitals may be affected. The air ambulance may not be able to fly in poor weather.						X					X	X
Flooding may lead to an increased need for temporary accommodation or increased populations in care homes if elderly have to be evacuated. After a flooding event, there can be an increase in self-reported illnesses, particularly relating to skin, respiratory and gastro-intestinal conditions. There can be psychological impacts of physical damage to property and floods can have long term impacts on mental wellbeing.							X				X	
There could be an increase in crime or civil unrest after a major weather event.											X	X

THREATS	CROSS-CUTTING THEMES											
11: HEALTH AND WELLBEING	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Transport disruption could lead to increased feelings of isolation in rural areas where individuals are unable to leave their home or social gatherings are cancelled due to poor weather. This will be detrimental to mental health.											X	
There are old or frail people, not currently in need of social care who would have no contact with Social Services until an emergency arises and would not be registered as vulnerable with the Authorities until they do. Current projections for the region anticipate a substantial increase in older people living in the Highlands leading to difficulties in Social Services knowing where the at risk groups are.											X	
Dealing with the effects on communities of an increasing frequency of weather related emergencies will increase the impact of what is an already stressful job for many people in Social Work. Home carers may be unable to reach their service users.									X		X	X
There may be an increase in traditional seasonal or other illnesses that could lead to a staff resource gap in Service delivery.									X		X	
Changing seasons may lead to changes in recreational and sporting activities. For example, the junior shinty season has been altered in the past because of the poor winter weather. Sporting fixtures may be cancelled due to water logging of pitch's.							X				X	
Fair weather results in fewer people making use of leisure centres and indoor sporting facilities. This could lead to reduced revenue for the Highland Council. Longer drier summers could see more seasonality in the use of sports centres.							X				X	

OPPORTUNITIES	CROSS-CUTTING THEMES											
11: HEALTH AND WELLBEING	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
New leisure opportunities could arise, for example, more people may swim in the sea as summer weather becomes finer.									X	X	X	
Improved air quality and conditions could benefit asthma sufferers.											X	
With milder winters, we can expect substantially less cold related deaths and illness. These benefits are expected to outweigh any increase in heat related deaths or hospitalisation.											X	
Warmer weather is likely to encourage more recreational outdoor physical activities and possibly healthy eating if sustainable farming and food policy are adapted. This will lead to improved physical and mental health as people enjoy the fine weather.			X						X		X	

THREATS	CROSS-CUTTING THEMES											
12: EMERGENCY AND RESCUE SERVICES	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Due to the incremental increase of events across a large geographical area and the numerous factors involved, it will be difficult to know when to declare an emergency. Once an emergency is declared it will demand a lot of resources. There is a risk to the Council if we get the call wrong.									X			X
Weather related emergency planning is a response to an accumulation of lots of little things making it very hard to predict the different variables.												X
Major storm events lead to problems with road access and communication within and between Emergency Service providers.						X			X			X
Highland has not had to deal with a large scale major event in a long time. We have a lack of experience in dealing with such events. Good staff members that have been with the Council a long time will leave or retire and the knowledge and experience will leave with them.									X			X
Forward/contingency planning – need to be careful not to take away from Emergency Planning. Having to plan for drought/fire/flooding all at once will make it difficult to make contingency plans.									X			X
Location of emergency planning response centres may become vulnerable to weather events in the future affecting access.						X	X		X			X
Emergencies can cause considerable stress to Council Officers attending events and will create additional workloads should events increase in frequency											X	X
The length of emergency duration may increase as we move from one-off catastrophes to more frequent events. Responsible officers have to be relieved or replaced to allow rest. Some events, for example, the foot and mouth outbreak of 2001, lasted many weeks.									X		X	X

THREATS	CROSS-CUTTING THEMES											
12: EMERGENCY AND RESCUE SERVICES	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
There could be a risk of large scale emergency evacuations of whole communities.											X	X
Fire crews could be stretched dealing with large scale muirburns leaving little capacity for other incidents.											X	X
We could see an increased demand for coast guard and lifeboat service as well as mountain rescue service, particularly if outdoor recreational pursuits also increase due to changes in the climate.									X	X	X	X

OPPORTUNITIES	CROSS-CUTTING THEMES											
12: EMERGENCY AND RESCUE SERVICES	Water Resource Management	Forests and Forestry	Agriculture	Spatial Planning and Land Use	Biodiversity and Ecosystem Resilience	Transport	The Built Environment	Energy	Business and Industry	Marine and Fisheries	Health and Wellbeing	Emergency and Rescue Services
Climate Change could lead to improvements in forecasting weather events (when, how severe, where) and identification of patterns including temperature gradients that can assist emergency services to prepare.									**X**			**X**
There will be opportunities to learn from each new event and the emergence of innovation.												**X**
Major incidents tend to be infrequent, overwhelming and continue to escalate. There could be benefit in responding to lower scale yet still significant events and so preventing escalation.												**X**

3.3 NATIONAL IMPACTS OF FUTURE CLIMATE CHANGE

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3.3.1 The Government published the UK Climate Change Risk Assessment (CCRA) on 25 January 2012, the first assessment of its kind for the UK[13]. The CCRA has reviewed the evidence for over 700 potential impacts of climate change in a UK context. Detailed analysis was undertaken for over 100 of these impacts on the basis of their likelihood, the scale of their potential consequences and the urgency with which action may be needed to address them. The results, describe what would happen under business as usual and do not take into account any future responses to climate risks such as planned adaptation. With the exception of population growth where this is relevant, the results do not include societal change from non-climate related such as economic growth, or developments in new technologies.

3.3.2 Key messages from the assessment are that:

The UK is already vulnerable to extreme weather, including flooding and heat waves.

- Flood risk is projected to increase significantly across the UK. Increases in the frequency of flooding would affect people's homes and wellbeing, especially for vulnerable groups (e.g. those affected by poverty, older people, people in poor health and those with disabilities), and the operation of businesses and critical infrastructure systems. Annual damage to UK properties due to flooding from rivers and the sea currently totals around £1.3 billion.
- UK water resources are projected to come under increased pressure. As a result of climate-driven changes in hydrological conditions, as well as population growth and the desire to improve the ecological status of rivers. By the 2050s, between 27 million and 59 million people in the UK may be living in areas affected by water supply-demand deficits (based on existing population levels).
- Potentially, there are health benefits as well as threats related to climate change, affecting the most vulnerable groups in our society. For example, premature deaths due to cold winters are projected to decrease and premature deaths due to hotter summers are projected to increase. Other health risks that may increase include problems caused by ground-level ozone and by marine and freshwater pathogens.
- Sensitive ecosystems are likely to come under increasing pressure. These impacts would have knock-on effects on habitats and on the goods and services that ecosystems provide (e.g. regulating water flows, pollination services).Potential climate risks in other parts of the world are thought to be much greater than those directly affecting the UK, but could have a significant indirect impact here.
- Some changes projected for the UK as a result of climate change could provide opportunities for agriculture and other businesses, although not outweighing the threats.
- Despite the uncertainties related to future climate change and its impacts, the evidence is now sufficient to identify a range of possible outcomes that can inform adaptation policies and planning.

[13] http://www.defra.gov.uk/environment/climate/government/risk-assessment/#keyfindings

3.4 GLOBAL IMPACTS OF FUTURE CLIMATE CHANGE

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3.4.1 The consequences for the UK of climate change occurring in other parts of the world could be as important as climate change directly affecting these shores. Globally, climate change could lead to a reduction in agricultural yields for all major cereal crops in all major regions of production. The available land suitable for cultivation could reduce. Food shortages through climate change could result in tens to hundreds of millions of additional people at risk from hunger. The availability of water could become a serious problem and many more people could be living in areas with limited water availability. Low-lying coastal areas will become prone to flooding as sea levels rise and as a result, more land will become unusable[14].

3.4.2 The Foresight Report, *International Dimensions of Climate Change*, identified a large number of international risks that could affect the UK, as well as some opportunities including:[15]

- **Increase in International instability**, either directly through extreme weather events and water system stresses, or indirectly as social and political systems in vulnerable parts of the world come under increasing strain. In the most vulnerable areas, governance at the state level is already overstretched, and there will be a limited capacity to adapt to climate change. These regions may stretch the UK's ability to provide international aid, humanitarian assistance and peacekeeping interventions.
- There may be shifts in the UK's **international role and global influence** for example the UN, G20 and the Commonwealth. Seemingly localised climate change effects may have wider global implications, affecting, for example, access to resources, stability of infrastructure, borders, international law and security.
- The **financial sector and business** generally may fail to evaluate and take account of changes in the balance of risks associated with climate change overseas.
- Adverse economic impacts could affect overseas **resources and infrastructure** on which the UK depends. For example, disruption to vital infrastructure serving global markets, disruption to energy supplies, global food production, the extraction of vital raw materials, the impact of extreme weather events on communications networks.
- There may be impacts on **global health** arising from temperature change, water stresses and extreme weather events. This could result in changes to communities, migration and the provision of aid overseas.

3.4.3 Key opportunities recognised were:

- There will be opportunities for the UK to **influence** the global stage, by playing a leading political role as international institutions and individual countries grapple with the challenges of climate change
- **Business and financial services** opportunities will arise in areas of UK strength: science and engineering, in insurance and in climate forecasting, and where there is a need to adapt to climate change

[14] http://www.avoid.uk.net/

[15] http://www.bis.gov.uk/assets/bispartners/foresight/docs/international-dimensions/11-1042-international-dimensions-of-climate-change.pdf

- There will be an opportunity to influence and prompt **behavioural change** within the UK by raising awareness of the impacts of climate change overseas, and therefore highlighting the necessity for domestic mitigation and adaptation strategies.

3.5 VULNERABILITY TO CLIMATE CHANGE BACK TO TOP

3.5.1 Effects of changing climate in Highland will vary depending on each individual, community or sector's vulnerability to change. The Highland area is geographically large with many rural and dispersed communities. Climate impacts are likely to vary dependent upon topography and location. While the Highland Council has a fundamental role to play to protect Highland communities, such communities need to be made aware of potential impacts of changing climate and develop individual actions to address their specific needs.

3.5.2 In 2011, a pilot project was undertaken in the communities of Gairloch and Loch Ewe in Wester Ross to assess how sensitive community assets were to climate change. The exercise concluded that the area most vulnerable to climate change in this community was transport and the sub-sections within this area most vulnerable to climate change were transport for the elderly and emergency services. The community was also very concerned about the effects climate change may have on the community culture as society adapts to its effects.

3.5.3 Results from the vulnerability assessment are shown below:

V1 = least vulnerable V5 – most vulnerable

Culture: Community Culture	V2
Health: Home Care Services	V2
Culture: Community Groups	V2
Health: of the Elderly	V3
Culture: Recreational Facilities	V3
Transport: Commuters	V4
Transport: Food and Fuel Supplies	V4
Health: Physically Disabled	V4
Culture: Mountains/Woodland	V4
Transport: Elderly	V5
Transport: Emergency Services	V5
Culture: Beach and Coastline	V5
Culture: Traditional Ways of Life	V5

3.5.6 More information on the methodology used and full workshop reports can be found at: http://www.highland.gov.uk/yourenvironment/sustainabledevelopment/climatechange/adaptation/communityaction.htm

3.5.7 Vulnerability Assessments will now be conducted more widely across Highland communities and with Council staff to build a picture of the areas most vulnerable to climate change in Highland.

3.6 IDENTIFYING THE IMPACTS OF CLIMATE CHANGE CONCLUSIONS

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3.6.1 The UK is vulnerable to extreme weather but Highland is very experienced in dealing with extreme weather events.

3.6.2 The impacts of changing climate in Highland align with those identified with the UK Climate Change Risk Assessment (CCRA) 2012 but with some issues particular to Highland. Certain effects of climate change will not be as severe in Highland as in other parts of the UK and abroad, particularly extreme summer temperatures and water shortages. However, milder and wetter winters could result in the loss of the ski industry in Highland and an increase in the frequency of flooding could lead to landslips, damaging homes, infrastructure and disrupting transport services.

3.6.3 In line with the UK CCRA, a greater number of threats associated with climate change have been identified in Highland, than opportunities, although opportunities can be found in certain sectors.

3.6.4 The CCRA highlights the risks of damage to sensitive ecosystems as a result of climate change. The Highland area is 33% of the Scottish landmass and home to many protected landscapes, species and designated areas on which the Highland economy depends. The value at stake in terms of the natural heritage of Highland may therefore be greater than other parts of the UK and Scotland. In addition, Highland peat bogs and forestry provide valuable carbon sinks at risk of damage as a result of climate change.

3.6.5 Warmer winters will reduce the health risks associated with the extreme cold and fair weather will promote more uptake of outdoor activities improving health. However, power cuts, transport disruption and flooding associated with frequent severe weather events will impact on the most vulnerable members of the Highland community.

3.6.6 Opportunities exist within the business and industry sector including increased tourism, renewable energy development, and more productive agriculture and forestry as a result of finer weather, longer growing seasons and the ability to grow new species.

3.6.7 The scale of change in the Highland climate is expected to increase with time. The associated impacts may not be as severe or frequent in the 2020's (2010-2029) as can be expected by the 2080's (2069-2099).

3.6.8 Globally, the scale of change will also increase with time and at a greater rate than Highland. The associated impacts of such changes will affect the international resources and infrastructure on which the Highland people depend.

3.6.9 The process of identifying the key climate impacts in Highland is an on-going one and more work is scheduled to assess vulnerability to such impacts in key sectors and communities to highlight the impacts of greatest significance for the Highland people and for Council Service delivery.

SECTION 4 IDENTIFYING ADAPTIVE CAPACITY

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4.1.1 How people and communities are impacted upon by climate change depends upon how vulnerable they are. Figure 16 shows how social-economic factors play a significant role in determining vulnerability to climate change.

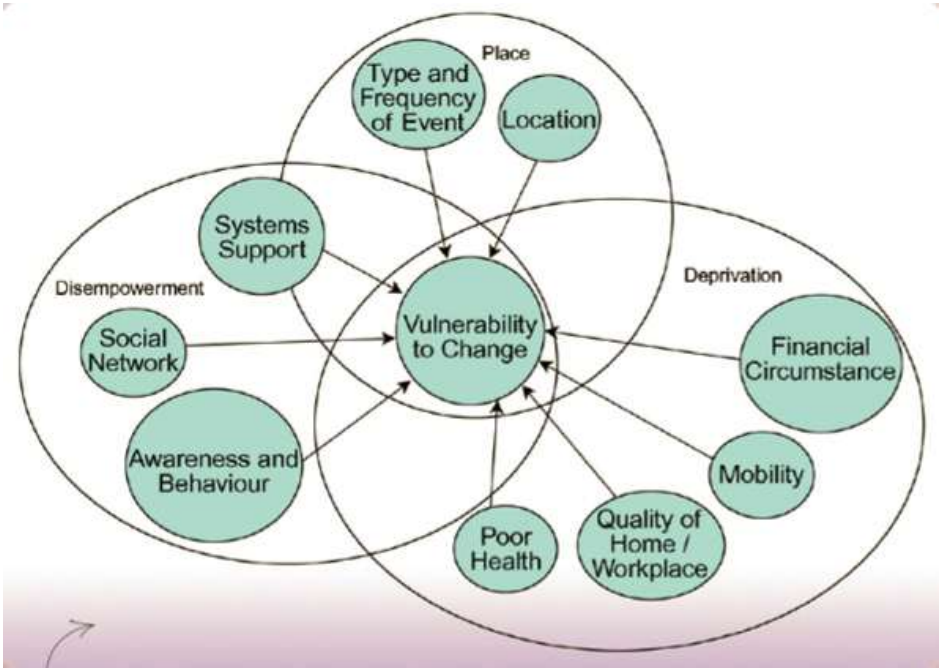

Figure 16 - Factors affecting vulnerability to climate change (adapted from SNIFFER)[16]

4.1.2 In 2011, the annual public performance survey conducted by Highland Council asked residents whether they had personally experienced adverse effects of climate and weather in Highland. Of the 82.1% of people that had experienced adverse weather 67% had not required assistance from the Highland Council, suggesting a degree of self-resilience in existence. 18.4 % received assistance from the Council without requesting it and 4.8% received assistance upon request. Of those respondents that received assistance 69.4%were satisfied with the Service they had received from the Council. However, 9.7% of respondents did not receive assistance though they requested it. A higher percentage of respondents within this latter group were within the 25-44 age category.

4.1.3 The full public performance survey report is available on the Highland Council website at:

Citizens' Panel Results on Council Performance, full report 2011

4.1.4 Future climate change may be experienced in a world that is socially and economically very different from the world in which we currently live. While it is not the purpose of this document to explore these changes it is worth noting that socio-economic conditions will have a strong influence on our vulnerability to climate change and our ability

[16] http://www.sniffer.org.uk/Resources/UKCC22/Layout_ClimateChange/12.aspx

to adapt. It is acknowledged that more work is needed to explore these issues and the linkages with climate change further.

4.2 Staff Attitudes

4.2.1 As a first step to assessing the adaptive capacity within Highland Council as an organisation, a survey was carried out to explore staff understanding of the issues and willingness to change. The Highland Council "Staff Environmental Attitudes and Behaviour Survey" was carried out in 2009.

4.2.2 The results show that Council staff members overwhelmingly consider climate change as a global problem requiring immediate action. Compared with other issues facing people living in Highland, climate change was ranked the fourth most important after the economy and recession, the rising cost of living and drug and alcohol abuse (see Figure 19).

4.2.3 Knowledge and understanding of climate change amongst staff was widespread, with 70% of all staff claiming to know a great deal or a fair amount about climate change. There was no noticeable difference between the seven Council Services, with the exception of Finance Service, where reported knowledge of climate change was relatively low at 52%.

4.2.4 Most staff members believe that climate change has human causes with CO_2 emissions from transport, factories and power stations seen as the main causes. The main impacts of climate change highlighted in the survey, were global warming, melting ice caps and rising sea levels, changes in weather and seasons, increased flooding and droughts. Water shortage did not rank highly and there remained some confusion over the issue of climate change and the depletion of the ozone layer (see Figure 20).

4.2.5 More information on the survey and a full report can be accessed at:

http://www.highland.gov.uk/yourenvironment/sustainabledevelopment/greencouncil/StaffEnvironmentalAttitudes.htm

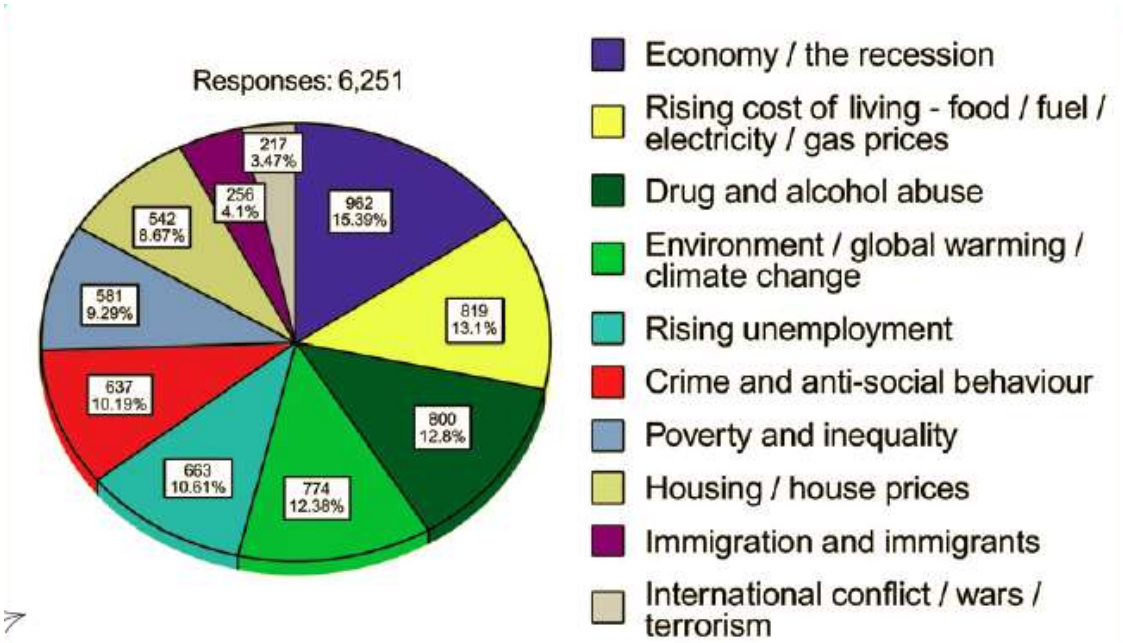

Figure 17 – Most important issues affecting Highland Council staff, 2009 Staff Environmental Attitudes and Behaviour Survey.

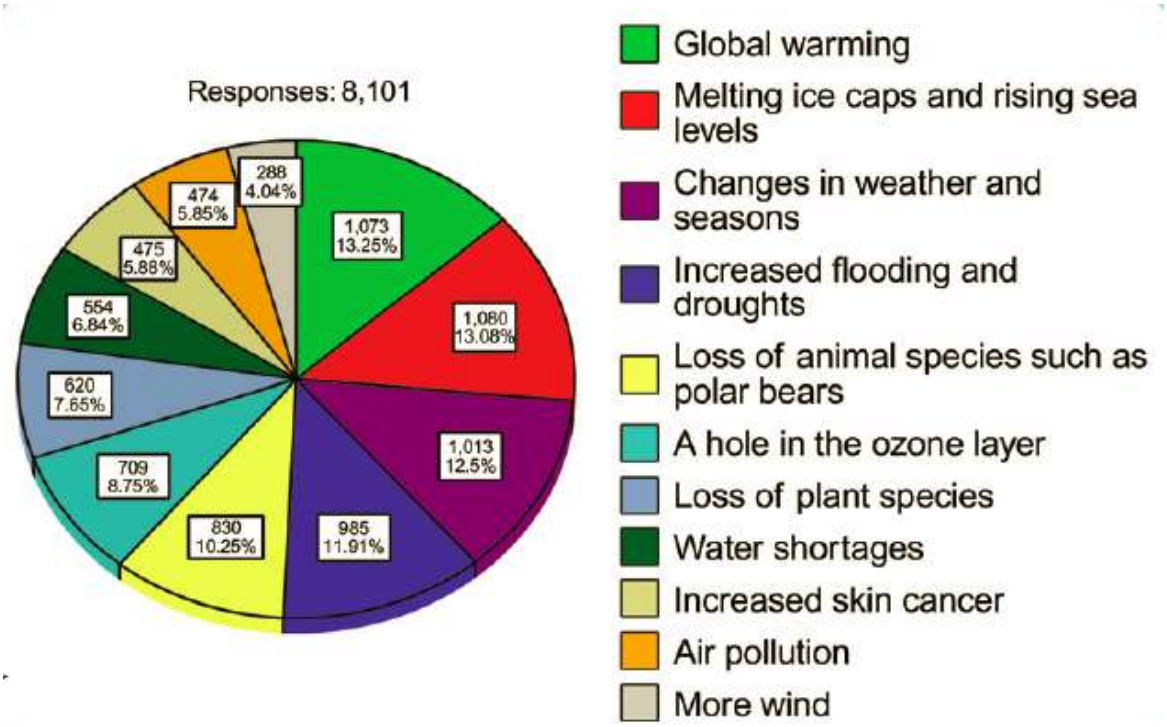

Figure 18 – Main impacts of climate change as identified by Highland Council Staff, 2009 Staff Environmental Attitudes and Behaviour Survey.

4.3 ADAPTIVE CAPACITY CONCLUSIONS

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4.3.1 It is acknowledged that adaptive capacity to climate change is dependent upon many social and economic factors and that indeed, the society and economy in which we live is influenced by the prevailing climate. Therefore both may change in the future. The purpose of this document is not to explore future social and economic changes but to propose that linkages with related work in this area be made.

4.3.2 The majority of people in Highland have experienced adverse weather conditions in the recent past and have been able to cope with such events independently. More work is required to explore how such adaptive capacity may be affected by our changing society in the future and how changes in that adaptive capacity will affect Highland Council Service delivery. Highland Council will work to understand the location and needs of the most vulnerable groups and individuals in the region and tailor a response to climate change that meets theneeds of different groups.

4.3.3 Highland Council employees have demonstrated a good knowledge and understanding of climate change issues to date and are receptive to the need to adapt to its impacts.

SECTION 5 - BUILDING RESILIENCE

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5.1.1 Adaptation aims to increase the resilience of natural and human systems to current and future impacts of climate change. Successful adaptation at a local level involves effective decision-making at all levels and coordinated work across different organisations. Adaptation is a cross-sector and trans-boundary issue which requires comprehensive integrated approaches.

5.1.2 In Highland, Adaptation actions are integrated into sector policies and for Highland Council, requiring individual Services to take responsibility for sector-specific measures. Actions should be appropriate, proportionate and cost-effective in the long term, and links between adaptation and mitigation need to be considered when they are being developed.

5.2.3 Actions developed can be described in two ways:

- Building Adaptive Capacity (BAC) - creating supportive institutional frameworks and, developing appropriate policies, plans and strategies to contribute towards Building Adaptive Capacity, particularly when considered in the context of mainstreaming climate change adaptation across different service and business areas.
- Delivering Adaptation Actions (DAA)* - taking practical actions to either reduce vulnerability to climate risks or to exploit positive opportunities.

5.2.4 Different types of maladaptation should be avoided, including :

- actions that conflict with mitigation (e.g. installation of energy intensive air conditioner),
- actions that use resources unsustainably (e.g. artificial snow-making),
- actions that distribute the benefits of adaptation unequally across society (e.g. increase of water rates uniformly across all users),
- actions that achieve their objectives at higher costs than benefits.

5.2.5 Maladaptation may be avoided by a detailed assessment of different options and a sustainability check which helps to clarify potential impacts.

5.2.6 Adaptation is an ongoing process for which systematic monitoring and evaluation is very important. Regular monitoring and evaluation will keep the adaptation process focused on prioritised impacts of climate change and ensures that adaptation responds without delay to changes in the evidence base.

5.2.7 New scientific knowledge should regularly be reviewed and included in the adaptation process. Adaptation monitoring will follow the same time frames as those used to evaluate the main relevant existing policies (into which adaptation is mainstreamed).

5.2.8 Performance will be reviewed on a quarterly basis by the Highland Council and results will be shared with all participating stakeholders and the public. In Highland, actions fall into five over-arching themes. The action plan will be reviewed by the Council annually to reflect changes in our knowledge and understanding of the issues. Progress will be reported to the Scottish Government, alongside all 32 Scottish Local Authorities in the annual Climate Change Declaration Report.

HIGHLAND CLIMATE CHANGE ADAPTATION ACTION PLAN

CEXO = Chief Executives Service
FIN = Finance Service
TECS = Transport, Environment and Community Service
H&P = Housing and property Service
P&D = Planning & Development Service
SW = Social Work
ECS = Education, Culture and Sport

G Green = on target
A Amber = some slippage in progress
R Red = behind target
P Purple = to be progressed

BAC = Building Adaptive Capacity
DAA= Delivering Adaptation Action

THEME 1 - DEMONSTRATE LEADERSHIP

Adaptation in a region, sector or in an organisation, requires a clear commitment from decision makers (e.g. political leaders, business managers) at inception, that they will support the adaptation process. Decision makers should be aware of the time-scale required for adaptation. They should take responsibility for building medium and long-term capacity for society and ecosystems to adapt to climate change. An organisation or individual should be designated to lead the adaptation process. Leadership is a driver for change, pointing the way and motivating others to follow a certain adaptation path voluntarily and/or through the use of coercive measures. As adaptation can be a resource intensive process, resources for the leading organisation or individual should be assured in the long term.

	ACTION	Lead Service	Action Type	Review Timescale	Status	Comment
1.1	Include Climate Change Adaptation issues within the key priorities and commitments of organisations in Highland.	CEXO	BAC	July 2012	G	Included in the Highland Councils Programme 2009-2012.
1.2	Make public organisational commitment to adaptive action, monitor and evaluate progress and make public the results.	CEXO	BAC	July 2012	G	Annual monitoring of progress towards commitments outlined in the joint Regional Climate Change Declaration.
1.3	Maintain a leadership role with partners through the Highland Environment Forum.	CEXO/ P&D	BAC	July 2012	G	Through the Highland Environment Forum which meets bi-annually.
1.4	Have our process and performance peer analysed/audited.	CEXO	BAC	Dec 2012	P	
1.5	Attend knowledge and best practice exchange with partners and to represent Highland issues	CEXO	BAC	Dec 2012	G	

THEME 2 – BUILD ON THE KNOWLEDGE BASE

Knowledge of potential climate change impacts and awareness of the need for action are crucial for adaptation. Researchers, policy makers and practitioners from different fields should jointly improve access to existing information on potential climate change impacts and adaptation that is easy to understand and targets the correct audience. Highland Council should seek to continually improve knowledge and understanding of climate change impacts and ensure this information is shared with relevant stakeholders. The Adaptation Strategy should therefore be viewed as a dynamic document that will evolve as our knowledge base increases.

	ACTION	Service	Action Type	Review Timescale	Status	Comment
2.1	Highlight the cost implications of weather related events and track related expenditure through appropriate cost coding.	FIN	DAA	Dec 2012	**P**	
2.2	Review Highland Council building and land estate and highlight the value at stake and the assets most vulnerable to climate impacts.	H&P	DAA	Dec 2012	**P**	
2.3	Carry out an inventory of Highland Watercourses.	TECS	DAA	July 2012	**G**	Underway by flood management team
2.4	Establish a flood monitoring/warning network and share data with SEPA and the public where appropriate.	TECS	DAA	Dec 2012	**G**	On target
2.5	Produce and regularly update a State of the Environment Report for Highland to provide a baseline from which to measure impacts.	P&D	DAA	Dec 2012	**P**	
2.6	Ensure the risks to Council service delivery from climate change impacts are reviewied by the SMT when corproate risks are reviewed.	FIN	BAC	August 2012	**G**	Takes place every 6 months.
2.7	**Emergency Planning Review**					
2.7.1	Review the location of emergency response centres. Consider more than one location and more than one access route to each location.	TECS	DAA	Dec 2012	**P**	Review – Through Emergency arrangements
2.7.2	Test emergency planning procedures under differing scenarios.	CEXO/ TECS	DAA	Dec 2012	**G**	Review – Through Emergency arrangements
2.7.3	Use the records of past emergency responses to help identify gaps and new actions to take forward.	TECS	DAA	Dec 2012	**P**	Review - Through Emergency arrangements
2.7.4	Identify staff with transferable skills to be utilised in an emergency.	TECS	DAA	Dec 2012	**P**	Review – Through Emergency arrangements

THEME 3 – INTEGRATE INTO POLICY						
Adaptation cannot be delivered in isolation, but should be embedded into existing policy and management structures and processes to make the key affected systems robust and resilient to climate change. Thus, existing decision-making processes, networks and instruments (e.g. policies, legislative frameworks) of affected sectors and organisations and at relevant levels of government should be reviewed and modified to adapt to climate change.						
	ACTION	**Service**	**Action Type**	**Review Timescale**	**Status**	**Comment**
3.1	Carry out risk assessment and include adaptation as a risk within Service Plans and review risk descriptions.	All	BAC	Dec 2012	**G**	Risk Assessment training underway in 2012, led by CEXO and mainstreaming of the approach supported by Finance (as risk lead).
3.2	'Include Climate Change Impacts and planned responses to impacts in Strategic Environmental Assessments of The Highland Council's Programmes, Plans and Strategies.'	All	BAC	July 2012	**G**	Guidance has been issued through SCCIP to assist in this.
3.3	Include Climate Change Adaptation in future Development Strategies.	P&D	BAC	July 2012	**G**	For example, following a climate change workshop adaptation issues have been acknowledged in the Highland Coastal Development Strategy 2009.
3.4	Climateproof plans, programmes and strategies; Project appraisals should also include Climate Change Impacts and sustainability assessments alongside other environmental, social and economic factors.	All	BAC	Dec 2012	**A**	All committee reports are screened for climate change and sustainability impacts but with mixed results to date. Effectiveness of such screening to monitored and guidance provided.
3.5	Identify climate-related budget pressures as part of revenues and Capital Planning budget process.	FIN	BAC	Dec 2012	**P**	
3.6	Review Building maintenance regimes in light of changing climatic effects.	H&P	DAA	Future	**P**	Will need to gather appropriate data before changes can be examined.
3.7	Include adaptation issues in the Council's procurement policy and procedures to ensure that these are secure from climate impacts and are sustainable.	FIN	DAA	Dec 2012	**P**	To be incorporated into the Sustainable Procurement Plan which is reviewed annually.

THEME 4 – EFFECTIVE COMMUNICATION

Knowledge of potential climate change impacts and awareness of the need for action are crucial for adaptation. Communication and transparent information are therefore essential. Personal communication should complement online information because face-to-face communication is thought to be more effective in stimulating action. Researchers, policy makers and practitioners from different fields should jointly improve access to existing information on potential climate change impacts and adaptation that is easy to understand and targets those at greatest risk.

	ACTION	Service	Action Type	Review Timescale	Status	Comment
4.1	Maintain an up to date section on Climate Change Adaptation on the Highland Council website.	CEXO	DAA	Dec 2012	G	
4.2	Create a consistent corporate message used by Highland Council in communicating the impacts of climate change through the Carbon Management Plan Communictaion Plan.	CEXO	DAA	Dec 2012	G	Through Highland Council CMP Communication Plan.
4.3	Provide Training and Guidance to all Councillors.	CEXO	DAA	Dec 2012	G	One workshop to date. More scheduled
4.4	Disseminate information from Central Government down through Council Services and to Highland communities.	CEXO	BAC	Dec 2012	G	
4.5	Carry out workshops with community groups/ partner organisations to raise awareness and understanding, gather local knowledge, build on information base and build resilience.	CEXO/ TECS	BAC	Dec 2012	P	Could feature as topic for ward forums.
4.6	Training for Ward Managers and relevant staff to mirror climate change mitigation training.	CEXO	BAC	Dec 2012	P	To be aligned with training for Councillors.
4.7	Ensure debrief after weather events involves all relevant Council Services to improve communication and understanding and create linkages as with communities and other stakeholders.	TECS	DAA	July 2012	P	Emergency Planning team.
4.8	Ensure effective dissemination of climate change adaptation message to Highland Schools.	CEXO/ ECS	BAC	Dec 2012	P	Eco School and School Global Footprint projects will assist with dissemination of this message.

THEME 5 – COOPERATE WITH STAKEHOLDERS

Relevant stakeholders need to be brought together to identify the most appropriate forms of adaptation. Analysing the capacity of stakeholders to cope with and adapt to climatic events is fundamental to characterising current and possible future vulnerability. Understanding the role of stakeholders in the decision-making process will assist in the implementation of adaptation policies. Successful adaptation will require partnership working across Services and Sectors.

	ACTION	Service	Action Type	Review Timescale	Status	Comment
5.1	Clarify the roles of the different stakeholders/partners in Highland through the work of the Highland Environment Forum.	P&D	BAC	December2012	**P**	
5.2	Maximise complementarity between Highland Council policies and that of other organisations and seek out where new policies can be aligned.	P&D	BAC	March 2013	**P**	Through Community Planning Partners and Highland Environment Forum.
5.3	Prepare Local Flood Risk Management Plans in consultation with stakeholders and neighbouring LA's to supplement the National Plans prepared by SEPA.	TECS	DAA	Dec 2015	**P**	To be programmed. Deadline Dec 2015
5.4	Explore Secondment Opportunities between Highland organisations to share knowledge, experience and skills and further understanding of the key roles.	P&D	BAC	Future	**P**	
5.5	Develop a Community Adaptation Action Plan and use process to encourage other local communities to become more self-reliant and build resilience to the effects of climate change.	CEXO/ TECS	DAA	Oct 2012	**G**	Pilot project underway with Scottish Natural heritage
5.6	Identifying the capacity for woodland expansion in suitable riparian (river bank) areas over Highland.	P&D	DAA		**G**	Woodland strategy.
5.7	Through the Highland Biodiversity Partnership, producing a report on the degree of habitat fragmentation within Highland and how this will impact on key species.	P&D	DAA	Dec 2012	**P**	
5.8	Map the vulnerable sectors and communities in Highland.	CEXO/ SW	DAA	March 2013	**P**	Adapt IT (carefirst) to assist in identifying vulnerable people.
5.9	Seek to engage with new stakeholders out with current partnership e.g Utility companies, Insurance providers and Scottish Water.	CEXO	BAC	June 2013	**P**	

FURTHER READING

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Below is a list of resources and publications used in the formation in this Adaptation Strategy:

Adaptation Scotland
www.adaptationscotland.org.uk

UK Climate Impacts Programme (UKCIP)
www.ukcip.org.uk

UK Climate Projections 2009 (UKCP09)
www.ukclimateprojections.defra.gov.uk

The Met Office
www.metoffice.gov.uk

Clim-ATIC
www.clim-atic.org

An Online Handbook of Climate Trends in Scotland
www.climatetrendshandbook.sccip.org.uk

Scottish Road Network Landslips Study (2005)
www.scotland.gov.uk/Publications/2005/07/08131738/17395

Scottish Road Network Climate Change Study (2005)
www.scotland.gov.uk/Publications/2005/07/08131510/15117

Highland Council Local Climate Impact Profile (2011)
www.highland.gov.uk/yourenvironment/sustainabledevelopment/climatechange

The Intergovernmental Panel on Climate Change Fourth Assessment Report
www.ipcc.ch/publications_and_data/publications_and_data_reports.htm#1

RSPB Climate Change, wildlife and adaptation: 20 tough questions, 20 rough answers.
http://www.rspb.org.uk/Images/climatechange20questions_tcm9-170121.pdf

RSPB Helping Nature to Help Us: Scotland's biodiversity and the challenge of climate change.
http://www.rspb.org.uk/Images/Final%20Final%20Scottish%20Climate%20A4%20booklet_tcm9-184696.pdf

Public Bodies Climate Change Duties: Putting them Into Practice
http://www.scotland.gov.uk/climatechange/publicsector

Defra UK Climate Change Risk Assessment
http://www.defra.gov.uk/environment/climate/adaptation/ccra/index.htm

Marine climate Change impacts Partnership Report Card 2011
http://www.mccip.org.uk/annual-report-card.aspx

Present and Future Sea Levels: Scottish Natural Heritage
http://www.snh.gov.uk/about-scotlands-nature/rocks-soils-and-landforms/coasts/sea-levels/

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