sustainability northwest

Climate change in the Northwest and its impacts: a summary document

Compiled by

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On behalf of

The Northwest Climate Group

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The Northwest Climate Group is a partnership of public, private and NGO organisations. The Group works to ensure that consideration of climate change becomes a part of all decision-making processes to the benefit of society in the region and beyond. This will enable policy makers, businesses and individuals to better adapt to the impacts of climate change (adaptation), while ensuring that all within the region work to reduce the emissions that contribute to climate change (mitigation).

To achieve this mission, the Group will work to:

- educate and raise awareness of the causes of climate change, associated impacts, and opportunities for mitigation and adaptation;
- influence, guide and assist strategic decision-makers in public, private and voluntary sectors at local, regional and national level;
- help facilitate the delivery of high quality projects, both academic and practical.

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Purpose of the document

This document provides a summary of information concerning climate change in England's Northwest. It brings together material produced over recent years, to present a picture of what climate change will mean for the region. It is essential that we understand the impacts of climate change if we are to consider the actions required to address it.

There are four main sections to the document.

- Section 1 outlines the physical changes in climate that the region could see over the coming century;
- Section 2 discusses different socio-economic scenarios for the region;
- Section 3 discusses the contribution that the Northwest makes to climate change through its emissions of greenhouse gases;
- Section 4 outlines some of the physical and socio-economic impacts of this changing climate. Some of these are specific to the Northwest while others are general impacts that will affect the Northwest in similar ways to the rest of the UK.

Section 1: A changing climate

Global climate change

Since the industrial revolution, the concentrations of the greenhouse gases in the atmosphere have been increasing rapidly. Accompanying this increase, the climate of the Earth has been changing. The Earth's climate has previously undergone significant natural variations as a result of the planet's orbit and factors such as volcanic activity. However, the recent changes are recognised as resulting from human activities – largely the burning of fossil fuels. The changes that have been observed include[1]:

- Global temperatures have risen by about 0.6^{o}C since the beginning of the 20th century, with 0.4^{o}C of that warming occurring since the 1970s;
- The 10 warmest years since 1861 have all been since 1990, with 1998 the warmest, followed by 2002, 2003 and 2001;
- Concentrations of carbon dioxide (CO_2), the main greenhouse gas, have gone from around 280 parts per million (ppm) in 1700 to around 370 ppm today – an increase of over 30%. Using information from ice cores, it can be concluded that the current carbon dioxide concentrations have not been exceeded during the last 420,000 years and in all probability, not during the last 20 million years;
- Sea levels have risen by 10-25cm over the last 100 years;
- Glaciers are retreating across the globe, For example, at current rates of retreat, it is estimated that China could lose all its glaciers over the next 100 years, while Kilimanjaro has lost 85% of its ice over the last century, with the remaining not expected to last much more than a decade.

[1] For further information on global climate change see http://www.ipcc.ch; http://climatechange.unep.net/; http://www.metoffice.com/research/hadleycentre/.

A changing Northwest climate

As the global climate changes so does the climate of the Northwest. *Everybody has an Impact* (Shackley et al, 1998) outlines some of the changes that the Northwest has seen over recent decades, including:

- 0.4^{o}C rise in annual mean temperature at Manchester Airport between 1988 and 1997 (compared to the 1961-1990, 30 year average);
- 20% decrease in summer rainfall over the last century.
- Increased high intensity rainfall since the 1960s.
- Seasonal rainfall varying by as much as 15% from the average in the last 30 years.
- Sea level rise at Liverpool of around 6cm in the last 50 years.
- Increased flooding of some of the regions major rivers in the last few decades.

While historical records allow us to see the impacts that climate change is already having, understanding potential future impacts is more difficult. However, by considering different possible levels of greenhouse gas emissions, and through the development of sophisticated climate models, we are able to picture what climate change might look like during the coming century.

Future climate change

The starting points for considering future climate change are the emissions scenarios – different pictures of possible future greenhouse gas emissions. The UK Climate Impacts Programme (UKCIP) utilises four emission scenarios[2] summarised in the box below.

[2] These are based on the work of the Intergovernmental Panel on Climate Change (IPCC).

Box 1: Greenhouse gas emission scenarios

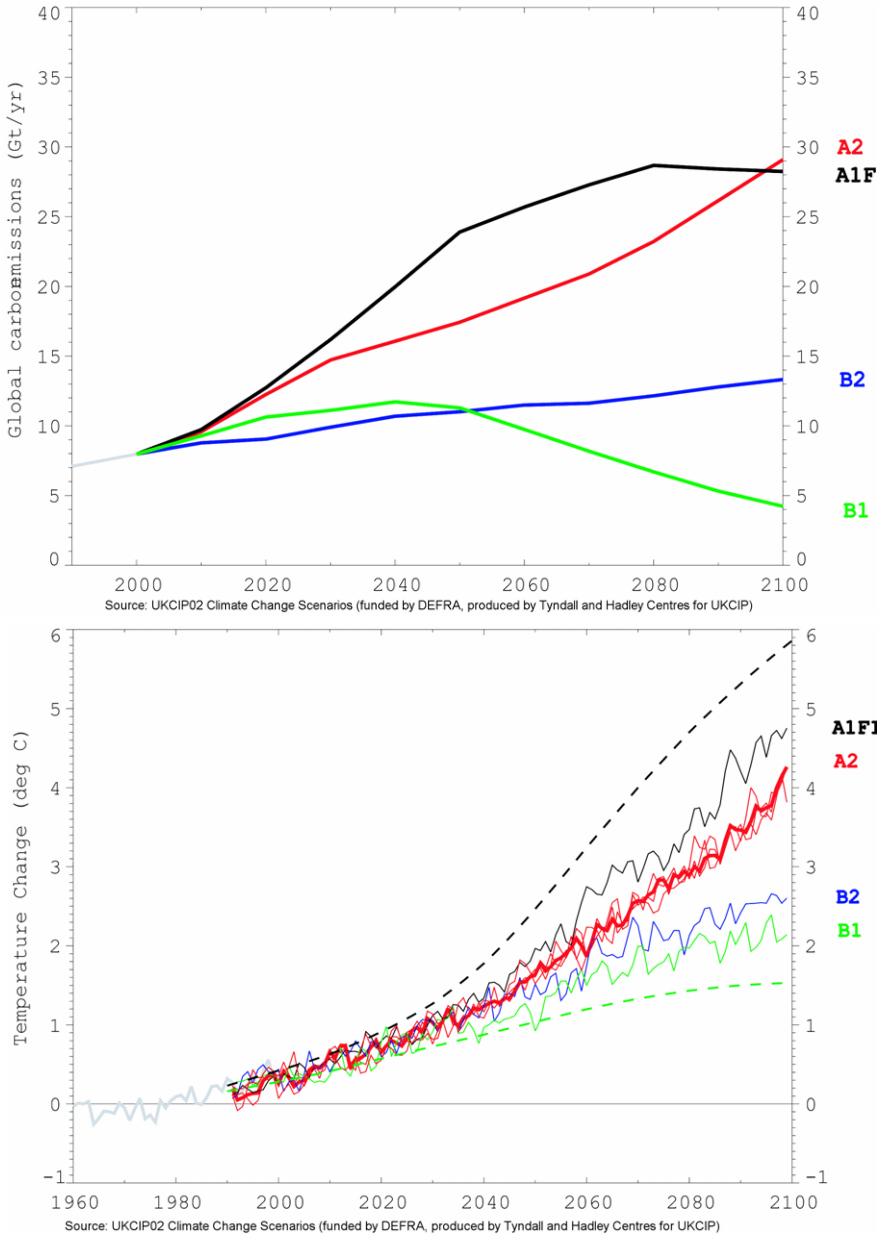
- High emissions (A1FI) – this reflects a world of very rapid economic growth, with a global population that peaks in the middle of the century and then declines. Market mechanisms continue to dominate and there is a rapid development and introduction of new technologies, but a continued reliance on fossil fuels. There is social, cultural and economic convergence between regions.
- Medium high emissions (A2) – this reflects a heterogeneous world with a continuously increasing global population. There is a regional focus to economic development and local identity remains strong. Technological change is slower and more fragmented than in the other scenarios.
- Medium low emissions (B2) – this reflects a world where the focus is on local solutions to economic, social and environmental sustainability. World population continues to grow but at a slower rate than the in the medium-high emissions scenario. Rates of economic growth are intermediate, while technological change is less rapid and diverse than in the high and low emission scenarios.
- Low emissions (B1) – this reflects a world with greater convergence between regions and global solutions to economic, social and environmental sustainability. Global population changes in a similar fashion to the high emissions scenario. Economic structures are transformed with rapid moves toward a service and information economy, reductions in materials intensity and the introduction of clean and resource efficient technologies.

In all of these scenarios it is assumed that no specific measures are taken to reduce greenhouse gas emissions.

Source: Hulme *et al*, 2002; and IPCC, 2000

Using information from these scenarios as inputs into climate models it is possible to investigate future changes in climate. Figure 1 below shows how these scenarios translate into global carbon dioxide emissions and average global temperature changes. Utilising these global changes, the United Kingdom Climate Impacts Programme (UKCIP) has presented likely climate changes across the UK (Hulme *et al*, 2002), allowing us to picture what climate change will mean for the Northwest region over the coming century.

Fig.1: Changes in global carbon dioxide emission and average temperatures under the different emissions scenarios



Summary of potential changes in the region

The changes for the Northwest are summarised in table 1 below. As with figure 1 above, the ranges in the values reflect the use of different emission scenarios, with high emissions corresponding to greater change.

Table 1: Climate changes in the Northwest

	2020s (2011-2040)	2050s (2041-2070)	2080s (2071-2100)
Change in average annual temperature	0 to 1^{O}C	1 to 3^{O}C	1 to 5^{O}C
Change in maximum summer temperature	0 to 2^{O}C	1 to 4^{O}C	2 to 6^{O}C
Change in summer rainfall	0 to 20% decrease	10 to 30% decrease	10 to 60% decrease
Change in winter rainfall	0 to 10% increase	0 to 20% increase	0 to 30% increase
Change in annual snowfall	10 to 30% decrease	30 to 60% decrease	40 to 100% decrease
Change in summer and autumn soil moisture content	Not available	Not available	20 to 50% decrease
Change in sea level	Not available	7 to 36cm	9 to 69cm

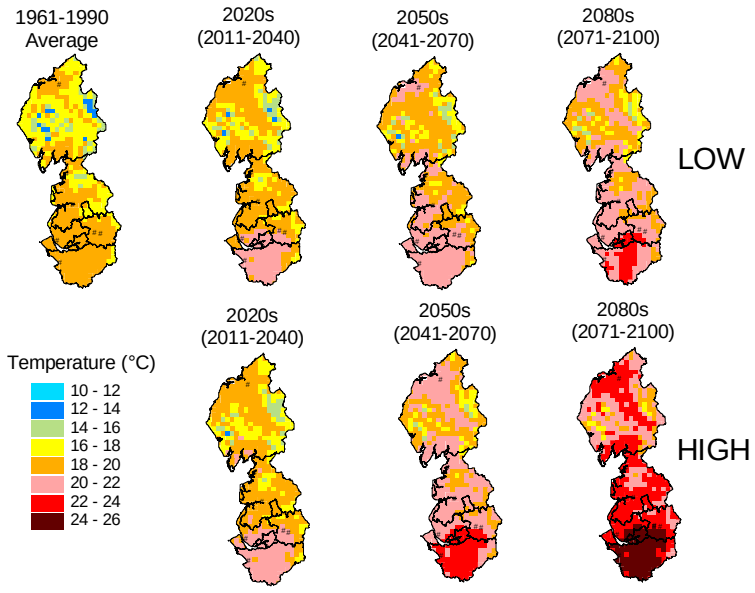
Source: adapted from CURE & Tyndall Centre North, 2003

In addition to overall regional changes, it is possible to look at what differences may result at a sub-regional level.

Average maximum summer temperature

The maps below show changes across the region for the average summer maximum temperature, under both high and low emission scenarios.

Figure 2: Regional changes in average maximum summer temperature



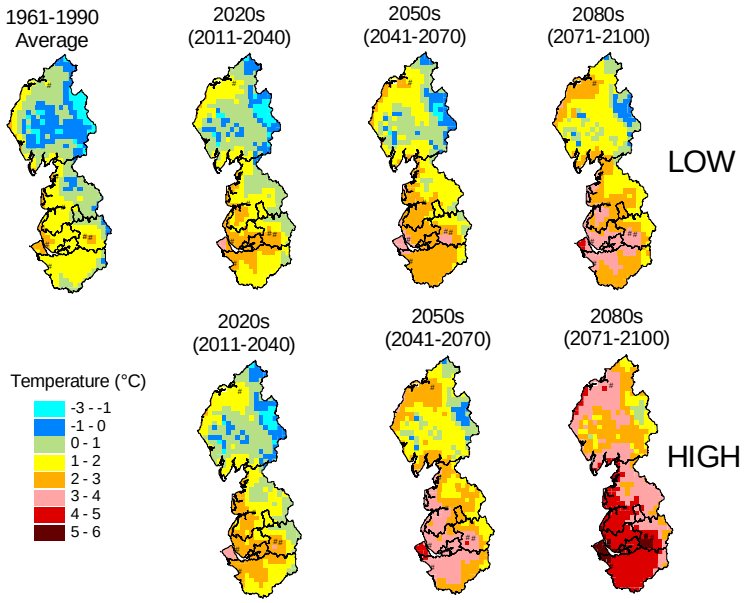
Source: McEvoy et al, 2004

There is a small increase in maximum summer temperature by the 2020s but relatively little difference between the high and low scenarios. This highlights that the majority of change over this period will result from emissions that have already been generated. The maps clearly show warming across the region, with parts of the south of the region seeing average maximum temperatures rising to between 24 and 26^{o}C. As a comparison, it is estimated that by the 2050s, Manchester could see peak summer temperatures similar to present day cities in Holland and Belgium, while by the 2080s, peak summer temperatures could be equivalent to Berlin, Frankfurt and Rome (CURE & Tyndall Centre North, 2003).

Average minimum winter temperature

As with the summer, the winter minimum temperature also rises across the region. This shows that even for the low scenario there are very few places in region with average minimum temperatures below freezing.

Figure 3: Regional changes in average minimum winter temperature

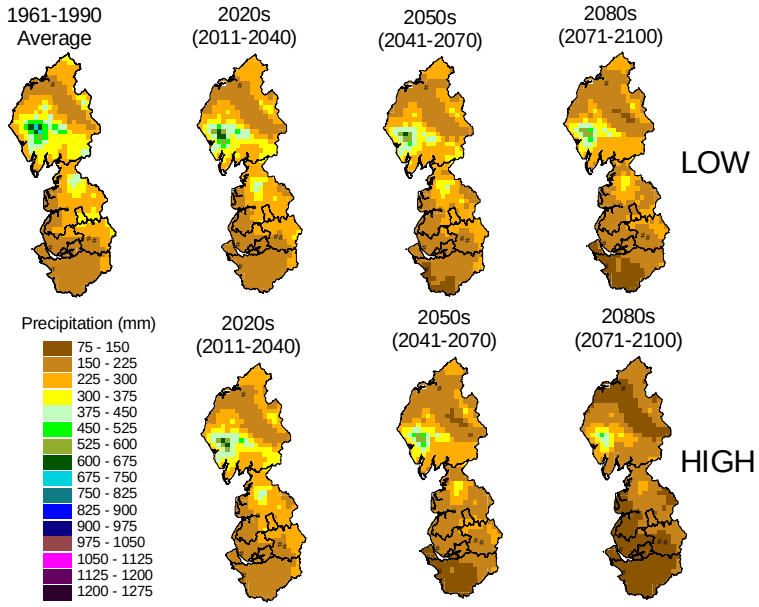


Source: McEvoy et al, 2004

Average summer rainfall

These maps show the average level of rainfall during the summer. As you can see throughout the region a decrease in summer rainfall is anticipated. Although these changes may not look that significant, if we take Cheshire in the south, by the 2080s (high scenario) there could be over a 60% reduction in rainfall. To help put these changes in context, average summer rainfall for Manchester is currently 210mm. In the dry year of 2003, Manchester received just 149mm. By the 2080s, for the high scenario, virtually every summer will be drier than the 2003 summer in Manchester (Cavan, 2004, presentation to the Climate Change and Visitor Economy Management Board).

Figure 4: Regional changes in average summer rainfall

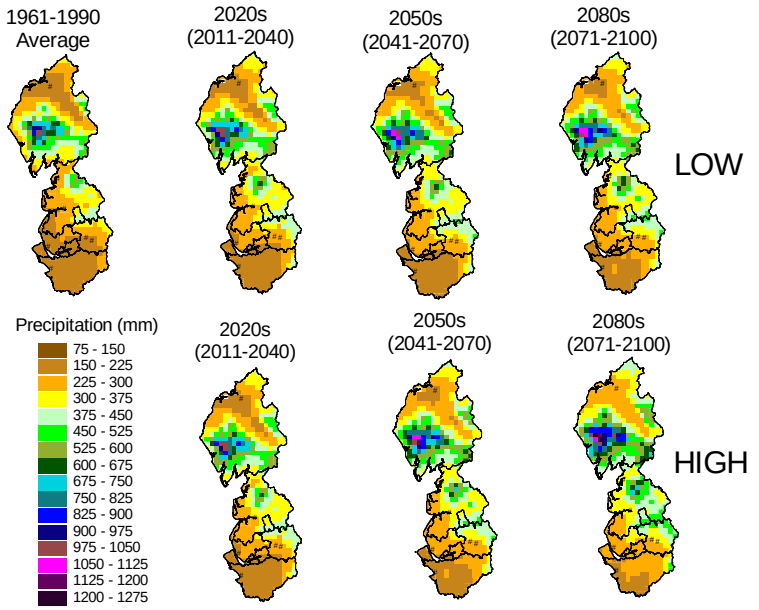


Source: McEvoy et al, 2004

Average winter rainfall

In contrast to the summer, these maps shows that winter rainfall is expected to increase.

Figure 5: Regional changes in average winter rainfall



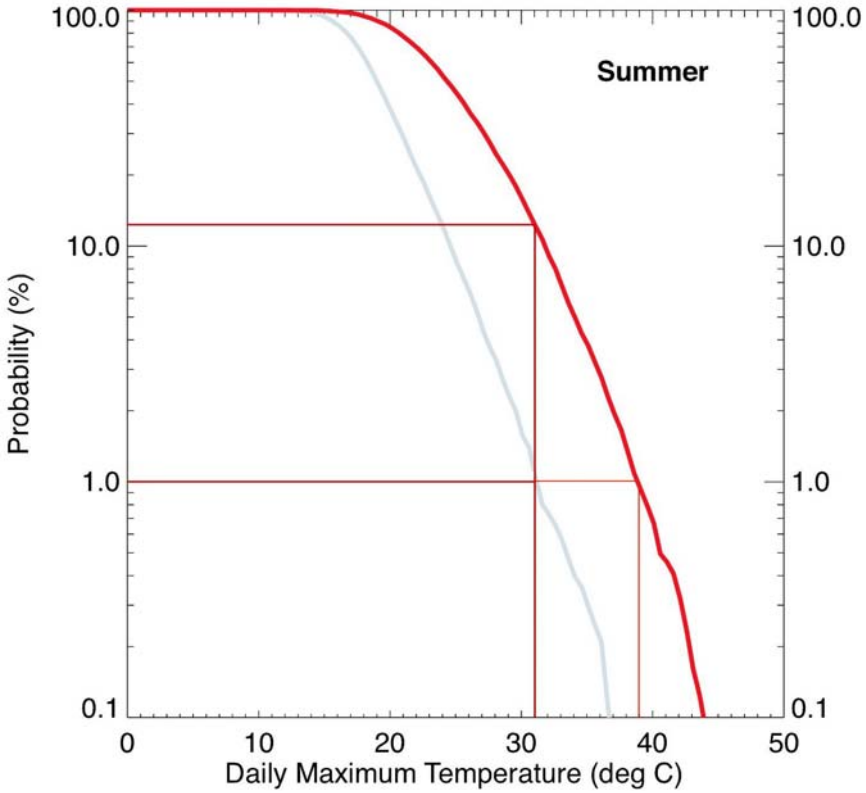
Source: McEvoy et al, 2004

Extreme events

In addition to changes in average temperatures, climate change will bring more extremes in weather. Figure 6 below is for the Central England Temperature region, which roughly covers a triangular area enclosed by Manchester Bristol and London, but the picture is likely to be similar for the Northwest. The grey line shows current probabilities of various summer daily maximum temperatures being reached. At present there is a 1% chance, about 1 day every summer, of temperatures reaching 31^{o}C.

The red line reflects changes under the medium high emissions scenario. Under this scenario 31^{o}C is reached for around 11 days every summer by the 2080s, while there is a 1% chance of the temperature reaching 39^{o}C, exceeding the current maximum temperature record for the UK.

Figure 6: Probability of certain summer daily maximum temperatures



Source: adapted from Hulme *et al*, 2002

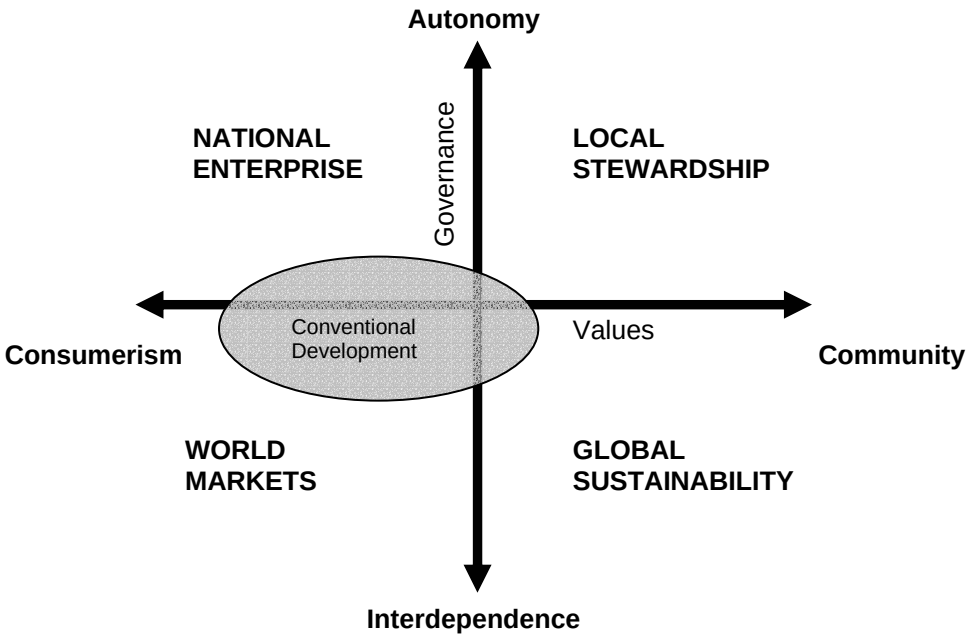
For the UK as a whole, other changes will include:

- An increase in the number of very warm summer months (such as August 1995, when the average temperature was 3.4^{O}C above normal);
- An increase in days with heavy rainfall;
- Very wet winters could occur almost once a decade by the 2080s;
- The number of depressions moving across the UK from North Atlantic (particularly in winter) is predicted to increase leading to the possibility of more storms.

Section 2: Socio-economic scenarios

In addition to changing climate, the social and economic situation is unlikely to remain static over the coming century. To enable consideration of these changes socio-economic scenarios have been developed, portraying different pictures of how the world may develop. Drawing on work by the IPCC and the UK Foresight Programme, UKCIP has developed one such set of scenarios to use when considering climate change (UK Climate Impacts Programme, 2000). The scenarios are structured around a governance/values framework.

Figure 7: Four socio-economic scenarios for the UK



At the two ends of the 'values' axis are consumerism, representing a more individualistic outlook, and community. The 'governance' axis varies from strong global interdependence, through to more national autonomy. Within each scenario, consideration is given to demography and settlement patterns, composition and rate of economic growth, and the rate and direction of technological change. The scenarios are summarised in the box below.

Box 2: Socio-economic scenarios

National Enterprise – Private consumption and personal freedom are central objectives and there is little concern for social equity or the environment. State intervention is limited except to protect prevailing interests at the national and regional level. Economic growth is low in general, with the South East and London seeing the highest growth rates. The population increases slowly and average household is stable. Planning controls are weakened and there is a presumption in favour of new developments. Private transport continues to dominate with little investment in alternatives.

Local Stewardship – Social values encourage co-operation and regional development and there is a strong emphasis on equity, social inclusion and democratic values. Conservation of resources and the natural environment are strong policy objectives. Economic growth is relatively slow but is more evenly spread across the regions. The population is stable and household numbers decline slightly. Planning controls are tight with growth focused on existing urban areas. Demand for transport overall is significantly lower.

World Market – Private consumption and material well-being are overriding concerns and the market is seen as best able to deliver on this goals. The nation state is weaker with some powers transferred to the EU level, while there is limited devolution of other responsibilities to the more local level. Economic growth is rapid but income distribution widens. Population growth is slow but people are increasingly mobile and there is a higher rate of immigration from outside Europe and significant rates of migration within the UK, with the population of London and the South East continuing to grow. The planning system is weak. Growth of traffic continues and new roads built to accommodate this.

Global Sustainability – Communitarian and internationalist social values predominate and there is broad consensus over the goal of maintaining and enhancing social equity and environmental quality. International cooperation is seen as key to achieving this and global governance is strong with some loss of power at the national level. Economic growth continues along present lines, with commercial and social/environmental objectives balanced. Household numbers grow at present rates and more even development reduces migration within the UK. Strong planning controls prevent development in green belts. Investments are made in public transport and eco-efficient cars reduce the negative impacts of traffic

From: UKCIP, 2000, pp.23-53

These scenarios were developed to reflect a national picture and subsequent work has endeavoured to 'regionalise' them. Work in the REGIS[3] project focused on two particular scenarios, global sustainability and regional enterprise (from national enterprise), and what they would mean at the regional level. Work with stakeholders led to a change in the regional enterprise scenario compared to the scenarios originally developed. While national enterprise had been an inward looking, low investment scenario, regional enterprise was reconceptualised as economically bullish with an innovative, economically strong region. For the different scenarios, the picture for the Northwest was seen as:

- Regional Enterprise – There will growth in the region but it will be just below the national average and a high-technology, service based economy will develop. Some agriculture, such as dairy and horticulture will flourish, while

[3] Regional Climate Change Impacts and Response Studies in East England and North West England.

hill-farming will struggle, although will be aided regionally to preserve a way of life and help with landscape conservation and tourist activities in Northern Lancashire and Cumbria. Population migration from the region will level off. Cumbria will see a net migration, particularly of elderly people, and will also see an increased demand for tourism. Some coastal areas will see managed realignment (Solway Firth and around Morecombe Bay) but the onus will be on protecting already developed areas of coastline. Pressures for coastal development will grow in certain areas. Development will increase in certain areas of the region (Warrington, south Cheshire, south Wirral, City of Manchester, southern Greater Manchester, Preston, Kendal, the Eden Valley);

- Global Sustainability – Agriculture will be transformed as subsidy payments become geared towards sustainable production, with an emphasis on low-intensity farming in the uplands. There will be little new coastal development with the focus on better planning of existing developed and urban sites. Generally there would be a greater awareness amongst citizens of the region of the environmental impact of everyday actions, and involvement in environmental organisations and campaigns would be much higher. Demand side management and leakage reduction will mean that the region may be able to export excess water resources to other regions. The levels of CO_2 emissions in the region will be reduced significantly. Consideration of biodiversity will be high and may impact on decisions of priorities for protection of coastline. Managed realignment will be a larger part of coastal management but local consensus will be sought on this kind of issue.

Work under REGIS2, a follow up to the original REGIS work, and other projects is currently taking this work on regional scenarios forward.

Section 3: Greenhouse Gas Emissions in the Northwest

Carbon Counting (Mander *et al*, 2000) represented the first effort at detailing the levels of greenhouse emissions from the Northwest. This took a 'top-down' approach, taking national figures and breaking these down using regional indicators. Following on from this, the Greenhouse Gas Inventory for the North West Region project (GRIP) provides a more complete picture of regional greenhouse gas emissions. Utilising a bottom-up approach where possible, using data about all sources in the study area, GRIP is currently a unique resource and offers us detailed understanding of the emissions profile of the region. Table 2 below shows emissions of $C0_2$ (Thousand tonnes) due to energy use in different sectors.

For comparison, the NW covers 11% of the UK landmass; accounts for 11.66% of UK households; 11% of the UK population; NW GDP per capita is £11,273 compared to the UK average of £15,788; the NW has 11.27% of cars registered in the UK.

Table 2: Emissions of CO_2 by sector

	UK CO_2 emissions (thousand tonnes)	NW CO_2 emissions (thousand tonnes)	% of UK emissions (for that sector)	% of regional total emissions
Domestic	133,802.67	18,506.67	13.83	29.73
Industrial	97,177.84	13,787.43	14.19	22.15
Services	58,445.15	6,148.31	10.52	9.88
Energy transformation	39,948.80	3,781.05	10.82	6.07
Energy Industry use	45,370.78	2,959.39	6.52	4.75
Fugitive emissions	20,258.24	1,751.01	8.64	2.81
Other	9,507.55	1,116.17	11.74	1.79
Transport	128,134.07	14,189.54	11.07	22.8
TOTAL	527,645.10	62,239.56	11.80	

Source: adapted from Carney (2005)

The table shows that emissions as result of energy use in the industrial and domestic sectors are relatively high compared to national figures. For domestic emissions households in the Northwest emit, on average, 6.2tCO_2Eqv[4], compared to a national average of 5.4tCO_2Eqv. This is despite the above average levels of fuel poverty in the region, and is likely to reflect the age and quality of the housing stock

Other sources of CO_2 emissions, from industrial processes, waste and agriculture are comparatively small. However, of the other greenhouse gases, it is worth noting that the Northwest accounts for just over 30% of national emissions of Hydroflourocarbons (HFCs) as a result of production facilities in the region.

Section 4: Physical, Social and Economic Impacts of Climate Change in the Northwest

The following section details some of the possible impacts of climate change. Where information exists these are discussed specifically to the region. In other cases the discussion focuses on impacts in the UK.

Physical Impacts

Flooding

With projected sea level rises, increased winter rainfall, and increased intensity of this rainfall, it is unsurprising that one of the most significant projected impacts of climate change is flooding. This has been discussed in a number of reports, the most recent being the Foresight, *Future Flooding* study (Evans *et al*, 2004). Table 3 below summarises the changes that this study predicts for the NW under different

[4] In addition to CO_2, methane, nitrous oxide, fluorocarbons and sulphur hexafluoride are considered as greenhouse gases. Each of these gases has a different global warming strength and conversion factors are used in order that all emissions can be considered in one figure. This is then referred to as Carbon Dioxide Equivalent (CO_2Eqv).

scenarios. The scenarios used for this study link climate and socio-economic change, with high emission linked to world markets (WM), medium-high emissions linked to National Enterprise (NE), medium low linked with Local Sustainability (LS) and low emissions linked with Global Sustainability (GS). These figures assume no additional improvement in flood defences.

Table 3: Summary of flooding issues for the Northwest[5]

Year	2000	WM 2080s	NE 2080s	LS 2080s	GS 2080s
Annual Probability of flooding	2%	10%	9%	9%	8%
Number of people living within the indicative flood plain	400,000	450,000	450,000	400,000	400,000
Number of people at 'high' risk[6]	200,000	325,000	375,000	310,000	290,000
Expected annual damage (residential and commercial)	£125 million	£2,500 million	£1,300 million	£150 million	£350 million
Distribution of economic risk – upland floodplains	£50 million	£850 million	£450 million	£60 million	£120 million
Distribution of economic risk – lowland floodplain	£25 million	£350 million	£150 million	£25 million	£50million
Distribution of economic risk – coastal floodplains	£50 million	£1,300 million	£700 million	£75 million	£180million
Expected annual damage - agriculture	£0.75 million	£1.25 million	£2.75 million	£5 million	£3 million
Social Flood Vulnerability Index[7]	Medium	Medium	Medium	High	Medium

Source: adapted from Evans *et al* (2004)

These figures do not include the risks from urban flooding, which are not broken down by region. As an indication of the increased risk and associated costs, the

[5] The numbers have been extrapolated from graphs and are indicative only.
[6] High risk is an annual probability greater than 1 in 75
[7] The 'Social Vulnerability Index' takes account of indicators of financial deprivation (such as unemployment, car and house ownership, and overcrowding) and social characteristics (such as the long-term sick, single parents and the elderly). This then translates into a 5 point scale of vulnerability, from low to high (Tapsell et al, 2002)

number of properties at risk of a 1 in 10 year flood event in England and Wales is seen as increasing from 81,700 properties today to 380,000 properties under the WM scenario; 340,000 properties under NE; 320,000 properties under LS; and 300,000 properties under GS.

Other work has also focused on flood risks in the region. Using predicted sea level rises, the REGIS study calculated that by the 2020s for the Low emissions scenario, what is currently a 1 in 100 year flooding event would occur once every 68 years. For the same time period and the High scenario the event would occur on average once every 21 years. By the 2080s for the high scenario, a 1 in 100 year flooding event would be an annual occurrence. Some areas, such as around Blackpool, have flood defences designed to cope with a 1 in 200 year event, however, under the 2050 high emissions scenario what is now a 1 in 200 year event would become a 1 in 10 year event. Overall, flooding events would lead to the loss of 7% of arable agriculture land in the NW (Holman I P and Loveland PJ (eds), 2001).

The *Future Flooding* report also proposed a portfolio of measures to alleviate the increased risk. Even if these measures were implemented, there would still be a doubling or tripling of the annual probability of flooding. However, as shown in table 3 above, this is an improvement compared to the 4 to 5 times increase in probability if no action is taken beyond maintaining current standards. The report estimates costs of these measures for the Northwest to vary from just over £1bn (for GS scenario) to £4bn (for NE scenario).

Biodiversity

Observations have shown that the behaviour of flora and fauna is changing as the climate changes. Over the last century the thermal growing season has lengthened by almost one month. The earlier onset of spring and later onset of winter has been directly observable with, for example:

- the four earliest dates for leafing of oak trees being in the last decade[8];
- The average first flowering date of 385 British plant species has advanced by 4.5 days during the past decade compared with the previous four decades. (Fitter and Fitter, 2002);
- Toads, frogs and newts are spawning earlier (Sparks et al, 2004).

Other effects that have been seen as average temperatures have increased include:

- The range of some butterflies is expanding northwards, for example the Comma butterfly has expanded Northwards to colonise almost one third of the UK since 1982[9];
- The northward margins for many birds has moved northwards by around 19km (Thomas and Lennon, 1999).

Work has been undertaken to better understand how species distribution may change as a result of climate change. The REGIS study found that the main impacts of climate change on biodiversity will be in the uplands of the Pennines and the Lake District (montane Arctic-Alpine habitats). In these habitats, all species modelled in the study were negatively affected by climate change as the space with a climate suitable for them declined (Holman and Loveland, 2001). Even under the low

[8] See http://www.phenology.org.uk/
[9] See above

emissions scenario, one species, the small mountain ringlet butterfly, was seen to lose all its suitable climate space by the 2050s. In other environments, biodiversity was not seen as being significantly affected. However, some sensitive species in blanket and raised bogs and salt marshes are likely to lose out under climate change. Species of arctic fish that are found in some lakes in Cumbria are also likely to be lost. Because of the large tidal range in the Northwest, saltmarshes are less susceptible to sea-level rise than in other areas (e.g. East Anglia).

Health

The possible effects of climate change on health are numerous. It is estimated that the heatwave in August 2003 caused over 20,000 excess deaths in Western and Southern Europe (European Environment Agency, 2004), with around 2,000 extra deaths in England and Wales. In one particular hot spell in London during this period, deaths of people over the age of 75 rose by 60% (NHS, 2004). High night-time temperatures, which prevent people from cooling down, are of particular concern. These problems can be exacerbated in urban areas due to 'heat island' effects[10], with research showing that the annual mean temperature in cities can be 0.5-3^{o}C higher than surrounding rural areas (Gill et al, 2004). It should be noted that the current heat island effect observed in urban areas in the Northwest is not as significant as, for example, that seen in London (CURE & Tyndall Centre North). While higher temperatures may result in greater numbers of summer deaths, increased winter temperatures will help reduce the number of cold-related deaths by up to 20,000 nationally (DoH, 2002).

Increased summer temperatures could lead to increased amounts of low level ozone building up in urban areas. High levels of ozone can cause eye irritation and respiratory problems – particularly in people who already have respiratory complaints (e.g. asthma)[11].

With an increase in temperature it is predicted that cases of food poisoning in the UK will increase, potentially by up to 10,000 cases every year by 2050[12] (DoH, 2002). The two main factors behind such an increase are that warmer weather presents better conditions for the multiplication of bacteria, and offers more opportunities for people to cook on barbecues.

Although it is difficult to predict it is thought that in addition to warmer temperatures, it is also possible that we will have more sunshine. As conditions become more favourable we are likely to see an increase in outdoor activities enhancing the possible exposure to ultraviolet radiation from the sun. This could contribute to an increase in the incidence of skin cancers.

The 2002 DoH report argued that in the UK, while indigenous malaria could become re-established in some areas it was unlikely to cause many problems. However, increases in global incidences of malaria would be likely to result in more travellers developing the disease. The report also found that tick-borne diseases were not likely

[10] Urban areas are often warmer than the surrounding countryside, a phenomenon known as the heat island effect. It is the result of a number of factors including: slower cooling at night; greater absorption of heat in building materials; decrease in wind speeds; and heat released from human activities (Gill, 2004)

[11] See http://www.advisorybodies.doh.gov.uk/comeap/statementsreports/airpol9.htm

[12] This is against a current background of 100,000 cases a year

to increase. It recognises that monitoring of other vector borne diseases such as West Nile Virus will be important.

Given what has been said earlier, one area of importance regarding health is the impact of flooding. While consideration of the financial impacts of flooding is relatively easy to undertake, the non-monetary effects on people are harder to study. Deaths from flooding events in Western Europe have decreased considerably over the last 30 years, despite there being more flooding events (EEA, 2004). However, research is increasingly showing that it is the psychological impacts of flooding that are the greatest problem (Reacher et al, 2004; Tapsell et al 2002; Ohl and Tapsell, 2000; Health Protection Agency, 2003). One issue is the different levels of vulnerability that people have to flooding events, depending on issues such as their economic situation, health, age, single parent status etc.

Water

Climate change will cause problems for water supply as warmer drier summers increase demand and decrease availability. A heavy reliance on reservoirs to supply water to the NW could be problematic if there are consecutive dry years. Meanwhile there will be limited scope for increased summer abstraction from rivers in the region. As a number of dams reach the end of their life, there may be a need to build new dams closer to major towns and cities. In addition to water supply, there will also be problems with water quality as: the warmer climate increase cases of algal bloom, which can be toxic; sea level rises lead to increased risk of saline intrusion into coastal aquifers; and low flow rates of rivers increases the concentration of pollutants (CURE & Tyndall Centre North, 2003).

Transport

A recent report by the Department for Transport (2004) highlighted a number of issues that climate change raises for transport infrastructure.

- Highways
    - Increased flood risk from rivers, the sea and from inadequate drainage;
    - Deterioration of infrastructure, including: risk of subsidence and heave as a result of wetter winters and drier summers; risk to tall structures from increased incidents of high winds; more rapid deterioration of concrete resulting from higher summer temperatures and from driving rain; melting of asphalt surfaces causing subsidence and loss of grip on roads;
    - Road safety issues as a result of more extreme weather;
    - Issues around the management of landscape and biodiversity on land owned by the Highways Agency.
- Railways
    - Increased flooding could cause major disruption, particularly as it is often difficult to bypass affected areas. In some coastal areas where flooding becomes more frequent it may become necessary to consider moving the railway lines (managed retreat). Swollen rivers, which may not flood, may still cause problems for the structural safety of bridges;
    - Heavy rain will cause increased problems from landslips and collapses, while drier summers will exacerbate subsidence;

    - Extreme weather will make driving conditions more difficult, increasing the possibility of signal warnings being missed by drivers;
    - Changing seasons may affect work that is ongoing to manage the risk of disruption from fallen leaves;
    - Higher summer temperatures may cause rail buckling, requiring speed restrictions (as seen in 2003).
- Aviation
    - Subsidence, flooding and drainage are likely to be the main issues facing airports.

Impacts on economic sectors

Forestry

Productivity of forestry in the NW is likely to rise, particularly in comparison with the South of the country. For example, in the NW (and NE) yield of beech is expected to increase by the 2050s under both high and low scenarios, while it will decrease under both scenarios in most other regions. In general the longer growing season will see earlier budburst and, while frost damage would be reduced overall, late frosts could be particularly damaging if the buds are appearing early. Drier summers could lead to drought problems, while wetter winters could result in root damage in waterlogged soils and decreased stability. This could be particularly problematic if accompanied by an increase in the number of winter storms. Conditions may also result in increased pest problems.

It is also important to consider the effect that forestry could have on greenhouse gas emissions, with increased tree cover absorbing greater amounts of carbon dioxide. Forestry can also be used to help alleviate the impacts of climate change, such as flooding and erosion (Broadmeadow, 2004).

Agriculture

Analysis of agriculture for the REGIS project found that yields of arable crops increase under the 2050s Low scenario, with lower increases under the high scenario. Grass yields show an opposite trend, with high yields under the high scenario. The analysis finds that there is likely to be little overall change in the distribution of cropping in the NW under climate change if the socio-economic situation remains similar to today. However, both the global sustainability and regional enterprise scenarios see a large increase in arable cropping due to a decrease in competitiveness of dairy farming. The warmer climate will mean that sugar beet can be more widely grown and there would be a case for a processing factory in the south of the region. Potatoes show a similar trend to sugar beet. The need for irrigation is low and this is likely to remain the case. Even under the high scenario irrigation levels will only be 6mm/ha/year[13]. Areas of farmed grass remain the same under similar economic conditions but reduce under the regional enterprise scenario (Holman I P and Loveland PJ (eds), 2001).

[13] This compares to predicted levels of 30mm/ha/year in East Anglia.

Construction

The changing climate will affect design and build of new buildings and the retrofit of existing buildings. A number of impacts on buildings may be exacerbated by climate change including: subsidence; increased pressures on building materials affecting lifespan; possible increased wind damage; and risks from flooding. Increased amounts and intensity of winter rainfall may contribute to a greater number of delays in the construction process, which would have to be factored into discussions on timetables (Vivian, 2004). In many cases, the higher temperatures will lead to consideration of the use of air conditioning which could lead to between 10-16% increase in energy used for cooling by 2050. Natural ventilation could be utilised effectively in the Northwest, with studies showing that the use of best practice natural ventilation and green design could, for the 2050s, reduce the number of hours where working conditions would be outside of established comfort levels from 182 (9% of working time) to 32 (1.5% of working time) (Cure & Tyndall Centre North, 2003).

Insurance

Climate change brings both challenges and opportunities to the insurance industry. Table 4 below summarises the anticipated increased levels of property claims for 2050[14].

Table 4: Changes in property claims

	Today		2050	
	Annual Average	Extreme Year	Annual Average	Extreme Year
Subsidence	£300 million	£600 million	£600 million	£1,200 million
Storm	£400 million	£2,500 million	£800 million	£7,500 million
Inland flood	£400 million	£1,500 million	£800 million	£4,500 million
Coastal flood		£5,000 million		£40,000 million (London affected)

Source: Dlugolecki, 2004

After the floods of 2000, the Insurance industry worked closely with the Government to ensure that, in general, coverage was not withheld from property owners. The result was an agreement that the industry would:

- Continue offering cover to properties in flood risk areas as standard where they were protected to a 1 in 75 year standard;
- Will maintain cover for properties where defence improvements to give a 1 in 75 year standard are planned to be completed before 2007;
- Will look at, on a case by case basis, properties that are not protected to a 1 in 75 year standard and where there are no plans to improve the level of protection but will not guarantee cover.

Given the earlier discussion on increased probability of flooding, and in particular the possible increase in the number of properties at risk of a 1 in 10 year event from 81,700 today up to a maximum of 380,000 (nationally), significant increased protection will be required to reduce risk to the required 1 in 75 year standard. Other issues, such as termite damage, that have not previously been covered by insurers could rise in importance.

[14] These assume no socio-economic change and no change in government policy

Utilities

Because of the location of many energy generation facilities, close to water for cooling, flooding is in many cases the biggest threat. Given the operating timescales for the utility infrastructure, future climate change will need to be an important consideration for any new facilities. Storms present difficulties due to impacts on overhead cables. As has been mentioned previously, increased variability in water supply will provide problems. Droughts are likely to become more frequent, while increased intensity of rainfall in the winter will cause difficulties in the management of waste water.

There will be increased opportunities around the use of renewable energy in the region, particularly related to wind, which is a major Northwest resource. Current debates on the use of nuclear power to alleviate CO_2 emissions may have implications for the industry in the region.

Tourism and Leisure – the visitor economy

It is anticipated that climate change will bring opportunities for increased visitor numbers to the region as the tourist season is extended. However, this will have to be managed to ensure that any damage to the environment that climate change may bring is not exacerbated by increases in the numbers of visitors. The impacts of climate change on the visitor economy of the region are being examined in an ongoing project funded by Defra, the NWDA and the Environment Agency. Further details on this project are available at http://www.snw.org.uk/tourism.

Chemicals

The impact of climate change on the chemical industry is likely to be small (Shackley et al, 2004). Costs may increase as a result of increased need for cooling in summer, and the industry will be affected by increases in floods and storms.

Other business

The main impacts on businesses will result from flooding, reduced winter heating costs and increased summer cooling costs. Impacts on the transport infrastructure will have knock on effects on distribution of goods, while a changing climate may well bring changing markets, regionally, nationally and internationally.

Concluding remarks

This document has presented a summary of work that examines the likely climate change that the region will experience over the coming century and the impacts that will be associated with this. While there are risks, there are also opportunities, and understanding what these may be is the first step in taking action. Efforts are required to reduce the level of greenhouse emissions from the region and to ensure that organisations recognise the effect that climate change could have on their operations. It is essential that these issues become a central consideration in the decision-making processes of organisations in the region.

Further information

For further information on approaches to reducing greenhouse gas emissions see:

- The Carbon Trust – www.thecarbontrust.org.uk; and
- The Energy Saving Trust – www.est.org.uk

For information on understanding the impacts that climate change could have on your organisations, and what can be done to address these see:

- The United Kingdom Climate Impacts Programme – www.ukcip.org.uk

For information on the Northwest Climate group, contact Steven Glynn (email: s.glynn@snw.org.uk; tel: 0161 834 8834)

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