



Campaign to Protect
Rural England

A CPRE Kent report

DRAFT

Tomorrow's Kent

Adapting to the challenge of climate change

- **Impacts of climate change on Kent**

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Foreword

Climate change over the coming decades and centuries represent is probably the biggest challenge that we, and our children, will face. Society, and government, is generally good and responding and adapting to immediate and short-term threats. We are less good at dealing with long term threats. This is partially due to leaders and managers prioritising immediate threats first, and partially due to how we approach risk management.

The biggest risk facing us all is that government does not adapt in the right way or at the right time. We are all willing to give some degree of freedom and wealth to government, business and the rule of law, on the unspoken understanding that our individual, and family, interests are best served by a collective approach and a common set of rules.

The danger with climate change is that government and the legal system will not protect us and even actively get in the way of us being protected. When that happens, the legitimacy of these institutions is undermined and people start taking the law into their own hands. An example could be those who feel disenfranchised from the flood management process and decide to build flood walls around their properties, even if it goes against planning regulations and even if it makes the flood situation worse for someone else.

When people are afraid, they become more selfish and less rational. The resultant breakdown in society often leads to a rise in crime and gang-activity. This is not some far-fetched 'Mad Max' scenario; it is a situation that occurred in Russia and Eastern Europe after the collapse of communism, and is rife in many areas of the world where government has failed: East Timor, Darfur, Ecuador, Somalia. It also happens in our own cities, like Manchester, south London and Liverpool, where those who do not see the legitimacy of the government, turn instead to violence and crime. A common response to such social unrest is a militarised police force, a centralised government and a controlled media but this often only increases the spiral of violence and distrust.

Hurricane Katrina, in 2005, is probably the best example of how quickly even a city in the world's richest country can collapse into climate chaos and struggle to recover. Both this and the economic turmoil of late 2008 were chilling reminders of how badly government can get it wrong.

Ultimately, climate change adaptation is a social problem. If we are to protect and improve the quality of life for individuals, families and communities, then we need to have the tools, the skills and the support to make our way in an increasingly uncertain world.

1 Introduction

1.1 About Kent

Kent is one of the most varied and distinctive of the English counties. Its landscape has been shaped by eons of natural processes and millennia of human activity.

As the most south-easterly spur of the British Isles, it is potentially the most vulnerable to the effects of climate change. Its geographical vulnerabilities are compounded by the pressures for economic and population growth in an already densely populated and congested county. Its role as the gateway between the UK and continental Europe also means that what happens in Kent could have much wider implications.

1.2 Past environmental changes

Climate change is not a new phenomenon, indeed the relative climatic stability of the last 10,000 years, often called the Holocene, is more of an anomaly in the context of the ice age cycles that have happened over the last 2-4 million year period, also known as the Quaternary.

Climate stability has been important because it allowed farmers to plant crops and raise livestock in the knowledge that more often than not they would achieve a surplus. Agricultural surpluses allowed complex societies to develop, survive and withstand shocks from other disasters, such as disease and conflict.

Kent has had a very dynamic environment. During the last glacial period, when sea-levels were much lower, the River Medway was a highland tributary of the Thames, which in turn was a tributary of the Rhine.

Dramatic changes have even occurred within the historic period: Thanet was a true island during the Roman and Jutish (pre-Norman) period and so too was the Isle of Oxney. Nearby Tenterden was effectively a coastal town with its docks at Small Hythe. The name means 'small landing place or haven', probably to differentiate it from the large port of Hythe to the east. Today both the Isle of Oxney and Tenterden are many miles inland behind the Romney Marsh.

Now it seems that our climate, and our environment, is on the move again. The problem is that our society, economy and transport have become more vulnerable to extreme weather, such as flooding and storms, and prolonged climate events, such as drought and ecological change.

1.3 Our goal

The Campaign to Protect Rural England (CPRE) is concerned with protecting and enhancing the quality of our urban and rural environments, and the quality of life for people today and for future generations.

The impacts of climate change, and our society's response, presents opportunities and threats that could dramatically change the quality of life for residents in Kent. Our goal is that the threats are foreseen and avoided, and the opportunities are taken for the benefit of all.

This challenge has the potential to dramatically change our society and economy. The choice we have is whether to play a role in shaping that future, or leaving circumstances to dictate their terms to us.

We want tomorrow's Kent to be a beautiful and diverse county that future generations can continue to enjoy as a place to live, work and visit. This means managing our natural resources wisely, having an open and democratic planning and political system, valuing the countryside for its own sake, respecting our historical and cultural legacy but not being afraid of change and innovation.

1.4 Methodology

This report draws on the rapidly growing body of scientific and policy literature and applies it to the Kent context. It is a dynamic area of research and political debate and so this report runs the risk of being quickly outdated. It was written ahead of the public release of the 2008 report of the UK Climate Impacts Programme (UKCIP), however it is understood that most of the broad conclusions are similar to the previous UKCIP02. However with a greater level of spatial resolution, which may have important implications for Kent. If necessary, an addendum to this report will be produced in early 2009.

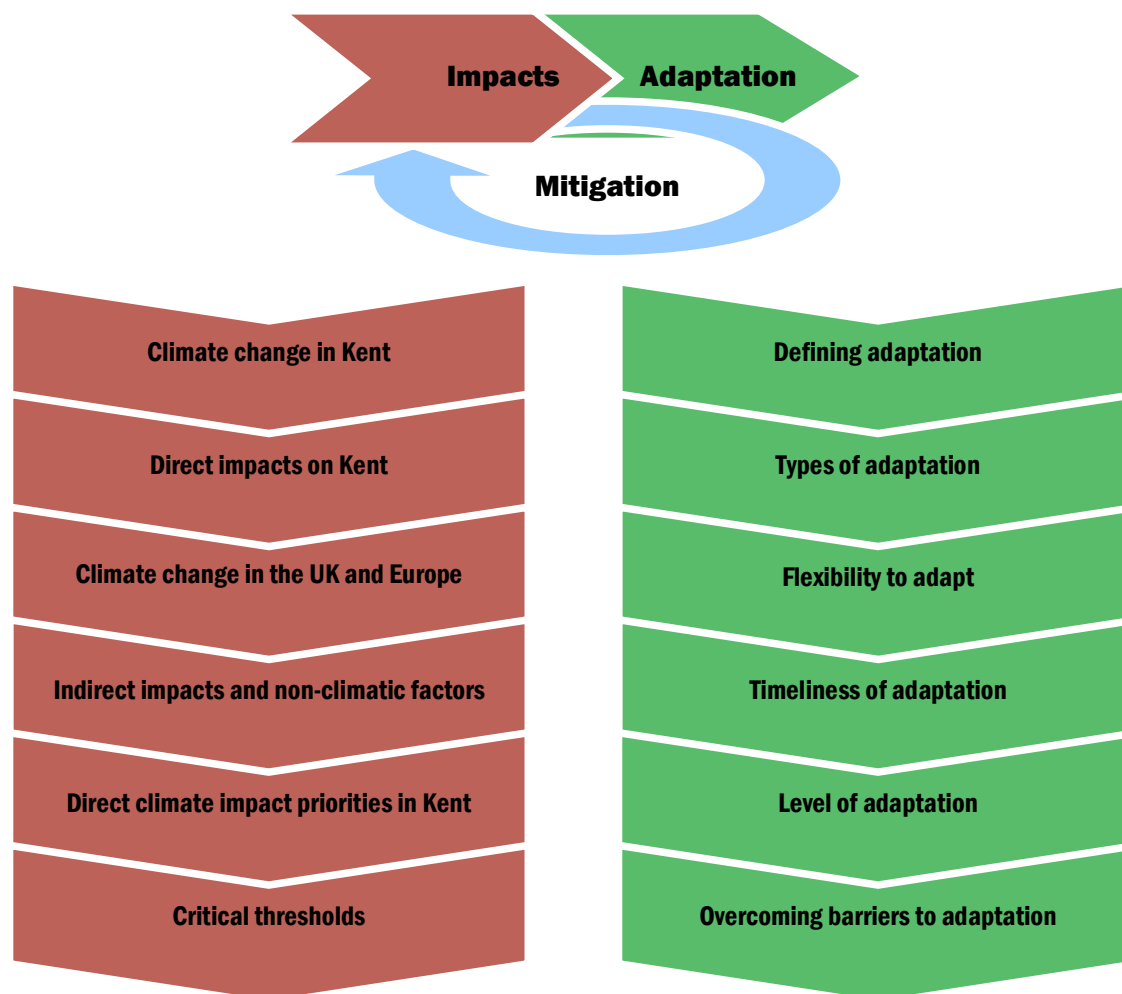
The main audience for this report comprises local authorities and other planning and delivery bodies in Kent. However, it is also written with the informed lay reader in mind.

The structure of this report has been influenced by three major sources:

1.4.1 The UKCIP Adaptation Toolkit

The Adaptation Toolkit is an online resource developed and provided by UKCIP¹.

Figure 1-1: Tomorrow's Kent – based on the UKCIP Adaptation Toolkit



¹ www.ukcip.gov.uk

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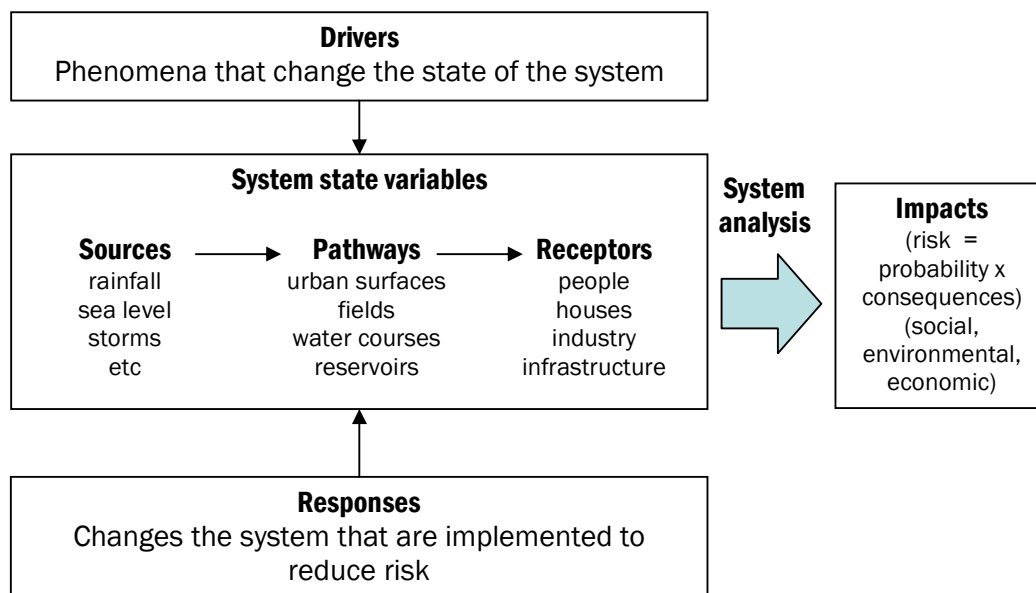
1.4.2 Foresight Future Flooding, produced by the government Foresight team and updated for the Pitt Review into the 2007 floods

The Foresight Future Flooding report was originally published in 2004 and has been influential in guiding government flood risk management policy. We think that other areas of climate change policy would benefit from a similar long term planning approach, particularly water quality and wastewater management, water resources, biodiversity, planning policy and building design.

The two structural elements used in this report are the Source-Pathway-Receptor (SPR) Framework (Figure 1-2) and the combined climate-change and socioeconomic scenarios, or storylines, adapted from IPCC scenarios (Figure 1-3).

With the complexity of the frameworks used it has not been possible to replicate the level of analytical work performed by their respective project teams, however they provide a solid foundation from which to explore and discuss the climate change issues in Kent.

Figure 1-2: Foresight SPR framework²



² adapted from p.8, Evans *et al.* (2008)

Figure 1-3: Foresight storylines



1.4.3 One Planet Living

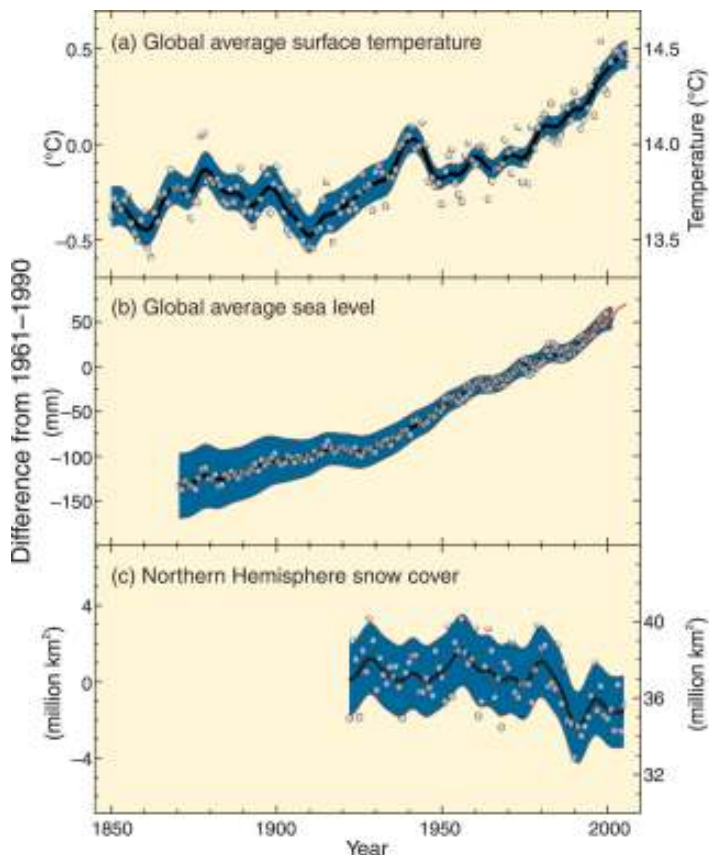
'One Planet Living' was developed by the World Wide Fund for Nature (WWF) as a way of planning future development to be within the ecological limits of the Earth. For example, if everyone alive today used resources in the same way that is typical for a person in Kent, we would need over three planets. This so-called 'ecological footprint' is clearly not sustainable and so any climate change adaptation that is proposed needs, at the very least, not to increase our footprint and should actively seek to reduce consumption and degradation of natural resources.

2 Climate change in Kent

2.1 Observed changes

Global and regional climate changes are well documented. Figure 2-1 shows how global temperatures and sea levels have been rising, and that snow in the northern hemisphere appears to be shrinking.

Figure 2-1: Global changes in temperature, sea level and northern hemisphere snow cover³



The UK Climate Impacts Programme (UKCIP) has compiled a comprehensive report on recorded changes across the UK⁴. Some changes relating to Kent can be identified. However, the report points out that because of high variability not many of the changes are statistically significant⁵. However, the change in mean daily temperature between 1914 and 2006 for the South East Region is 0.89 °C and this figure is reported as statistically significant to the 95% confidence level. Between seasons, the biggest change is in autumn which is now 1.25 °C warmer, on average, than at the beginning of the 20th century⁶.

The highest recorded temperature in the UK was 38.5 °C at Brogdale, near Faversham on 10 August 2003⁷.

One of the most complex changes is the decline in the average number of frost days per year between 1961 and 2006 (Figure 2-2). For the South East Region, the report claims we now experience 23.4 fewer days with air frost per year than in the 1960s⁸.

³ IPCC. (2008)

⁴ Jenkins *et al* (2007)

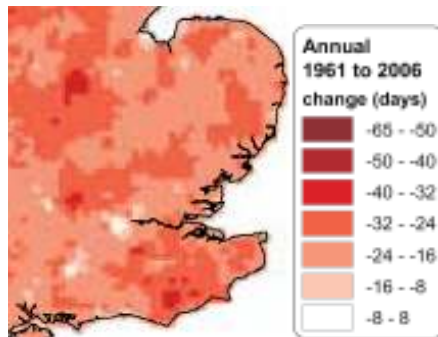
⁵ *Ibid.* p.25

⁶ *Ibid.* Table 2.2

⁷ Met Office: www.metoffice.gov.uk/climate/uk/extremes, accessed 29/08/08

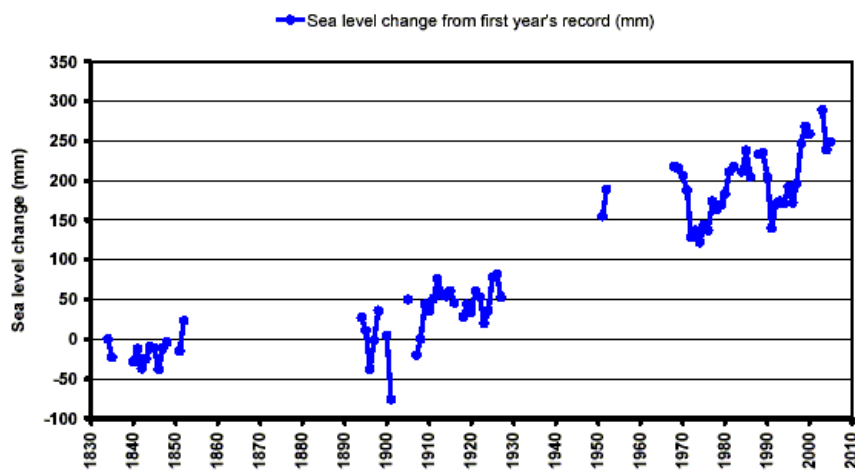
⁸ *Ibid.* Table 2.8

Figure 2-2: Change in annual days of air frost between 1961 and 2006⁹



Sea-level rise has been measured in most areas of the world, but the record from Sheerness (Figure 2-3) shows a rise of around 250 mm since the mid 1800s.

Figure 2-3: Recorded sea level rise at Sheerness¹⁰



2.2 Predicted changes

The UK Climate Impact Programme¹¹ is one of the main organisations looking at the how climate change is likely to affect the UK and what we can do about it. In 2002, they produced a series of scenarios for a coarse grid covering the country. From this is it possible to get some indication of the changes to come for the 2020s, 2050s and 2080s years under different green house gas emission scenarios for the square covering Kent¹². An update is due to be published at the end of 2008 and CPRE Kent will produce an update based on that new information.

Table 2-1: Predicted changes to Kent's climate

Temperature	Warmer throughout the year, particularly summer and autumn
	A slight increase in the diurnal temperature range in summer
	Kent may benefit from the cooling sea-breeze effects, relative to more inland areas of the South East.

⁹ Ibid. p59

¹⁰ Environment Agency (2008a)

¹¹ www.ukcip.org.uk

¹² A detailed summary is provided in Appendix 2. Updated scenarios are expected in 2008.

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Rain and snow	Progressively more winter rainfall by 2080 Progressively less summer rainfall by 2080 Little change in spring rainfall but a decrease in autumn A slight decrease in overall annual rainfall Not much change in winter snow by 2020 but potentially little or no snow occurring by 2050 or 2080. More intense rainfall events.
Soil moisture	A substantial decrease in soil moisture in summer and autumn A small decrease in annual and winter soil moisture content and no change in spring
Cloud cover	Decreasing in summer and autumn by 2050 and 2080 A slight increase in winter A slight decrease in spring by 2080
Wind speeds	Increasing winter wind speeds Slight increase in spring No change in summer Slight reduction in autumn
Season creep	The warmer temperatures, earlier in the year and for longer into the autumn, are extending the growing season so that by 2080 it could be warm enough for 40–100 extra days of plant growth per year (currently about 250 days/year) ¹³ . There is also evidence of changes in arrival and departure dates of migratory bird and marine species.

2.2.1 Sea level rise

As well as changes to weather patterns, there is strong evidence that sea levels have been rising and will continue to do so over the coming century. The dominant factor is the thermal expansion of seawater with rising atmospheric and sea temperatures.

The more well known factor is the melting of ice-caps. However, because ice is less dense than water (and hence floats) melting of the sea ice in the Arctic Ocean is unlikely to have a great effect. Of more concern are the major land-based ice-caps on Greenland and Antarctica. If the entire 2.85 million km³ of ice were to melt, it would lead to a global sea level rise of 7.2 m (23.6 ft.)¹⁴

There is a third factor which affects Kent and the southern England: the land is sinking¹⁵. Although the effect is only 0.5 mm/year¹⁶, in combination with climate change effects the risk of coastal flooding in Kent is increasing steadily.

¹³ p.2 *Climate Change Impacts - looking ahead for the South East*, South East Climate Change Partnership (Nov 2002)

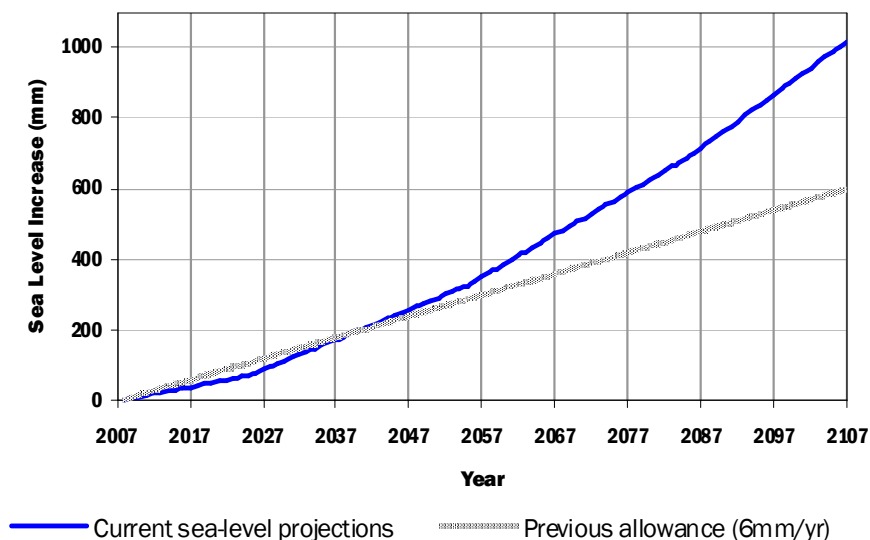
¹⁴ IPCC, 2001

¹⁵ The phenomenon is called 'isostatic rebound'. It occurs because the weight of the great ice caps of the last glacial age pushed down on the northern UK and when it melted, the UK began to tip back, like a very slow see-saw. The

Table 2-2: Projected sea level changes in the South East of England¹⁷

Regional isostatic subsidence (mm/yr)	Net Sea Level Rise relative to 1961-1990 (mm)					
	Low IPCC Emissions scenario			High IPCC Emissions scenario		
	2020s	2050s	2080s	2020s	2050s	2080s
0.5	60	110	140	160	400	740

Figure 2-4: Defra/UKCIP projected sea-level rise guidance (2007)



2.3 Uncertainties

The main sources of uncertainty are¹⁸:

2.3.1 Understanding of natural processes

Although there is growing evidence and scientific understanding of climate processes, there remain uncertainties about how the climate system will react and change over the coming decade. Of particular concern are a number of feedback processes that could accelerate the warming process. For example, the recorded melting of permafrost in Siberia¹⁹ is likely to release large quantities of methane which is 21 times more potent as a climate-forcing gas than carbon dioxide²⁰. Equally, there may be negative feedback mechanisms, associated with cloud cover or biological activity, which may help moderate the changes in ways that are currently neither fully understood nor modelled.

2.3.2 Natural variability

The Earth's climate is highly variable and chaotic in nature. Climatology and oceanography is increasing the understanding of many of these processes. However, for example, even though the effect that volcanic eruptions on climate may be better understood, we cannot know what eruptions will occur over the coming century.

rebound rates vary across the UK. The 0.5mm/year for the South East equates to a metre drop in land levels over the last 2,000 years.

¹⁶ "Updates to regional net sea-level change estimates for Great Britain" UKCIP (Feb 2007)

¹⁷ Table 2, "Updates to regional net sea-level change estimates for Great Britain" UKCIP (Feb 2007)

¹⁸ P.8, Greater London Authority (2008)

¹⁹ www.guardian.co.uk/climatechange/story/0,12374,1546824,00.html

²⁰ glossary.eea.europa.eu/EEAGlossary/C/carbon_dioxide_equivalent

2.3.3 Modelling and data

Computer models, however sophisticated, will always be crude representations of the real world and unable to capture the true complexity of our planet's climate system. Data are also imperfect due to limits in instrumentation capabilities and inconsistent spatial and temporal coverage across the globe.

2.3.4 Future emissions

The work of the IPCC indicates that how successful, or not, we are in cutting back global carbon emissions will have a major influence on how much adaptation we will need to do. It is possible that beyond 2 °C warming, globally, no amount of adaptation will preserve our current standard of living. However, even if emissions were to halted today, it is estimated that there is a 20 year lag in the climate system so that many changes are already unavoidable.

2.3.5 Scaling

Drawing conclusions about climate change impacts in a small area, like Kent, from global circulation models brings its own uncertainties. Kent has a diverse range of microclimate based on its topography, land cover and the fact that more than two thirds of county's perimeter is coastline.

2.3.6 Managing uncertainty

Despite these uncertainties in precisely what will happen and when, there is sufficient evidence, such as the UKCIP information, to give a strong steer on how we should be planning for the future.

The main way of working around the uncertainty is the use of scenarios to test different situations. For example, the Thames Estuary 2100 Project on future flood risk is using four scenarios²¹:

- Latest Government Guidance (+0.94 metres increase in water levels by 2100)
- UKCIP Medium-High scenario (+1.51m by 2100)
- TE2100 High + scenario (+2.6m by 2100)
- TE2100 High ++ scenario (+4.2m by 2100).

Under lower emission scenarios, sea level rise is much less, indicating that climate change mitigation can reduce the risk substantially, however, there is high confidence that sea levels will rise under all scenarios²².

2.4 Direct impacts on Kent

The climate changes identified above may bring about a number of positive and negative impacts that we will have to manage as individuals and as a society. While the types of impacts are relatively easy to identify, what is much harder to foresee is the likelihood the of impact occurring and its severity. Being able to do this would make it easier to prioritise investment and action.

Figure 2-5 is an illustration from the IPCC fourth round assessment showing that if global temperatures are allowed to rise then the impacts will become increasingly severe. For this reason, international efforts are focused on reducing carbon emissions so that global temperatures do not rise by more than 2 °C over the next century.

²¹ Environment Agency (<http://te2100.environment-agency.gov.uk/Registered/Content.aspx?pid=3>, accessed 13 June 2008)

²² p.14, Evans *et al.* (2008)

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Table 2-3 is an assessment of what the climate changes identified in Table 2-1 and Table 2-2 may mean for Kent. No attempt has been made to assess how these impacts relate to changes in global temperature, but such detailed work may be necessary for those authorities who need make decisions based on critical thresholds (see Section 2.8)

Figure 2-5: Global impacts of climate change²³

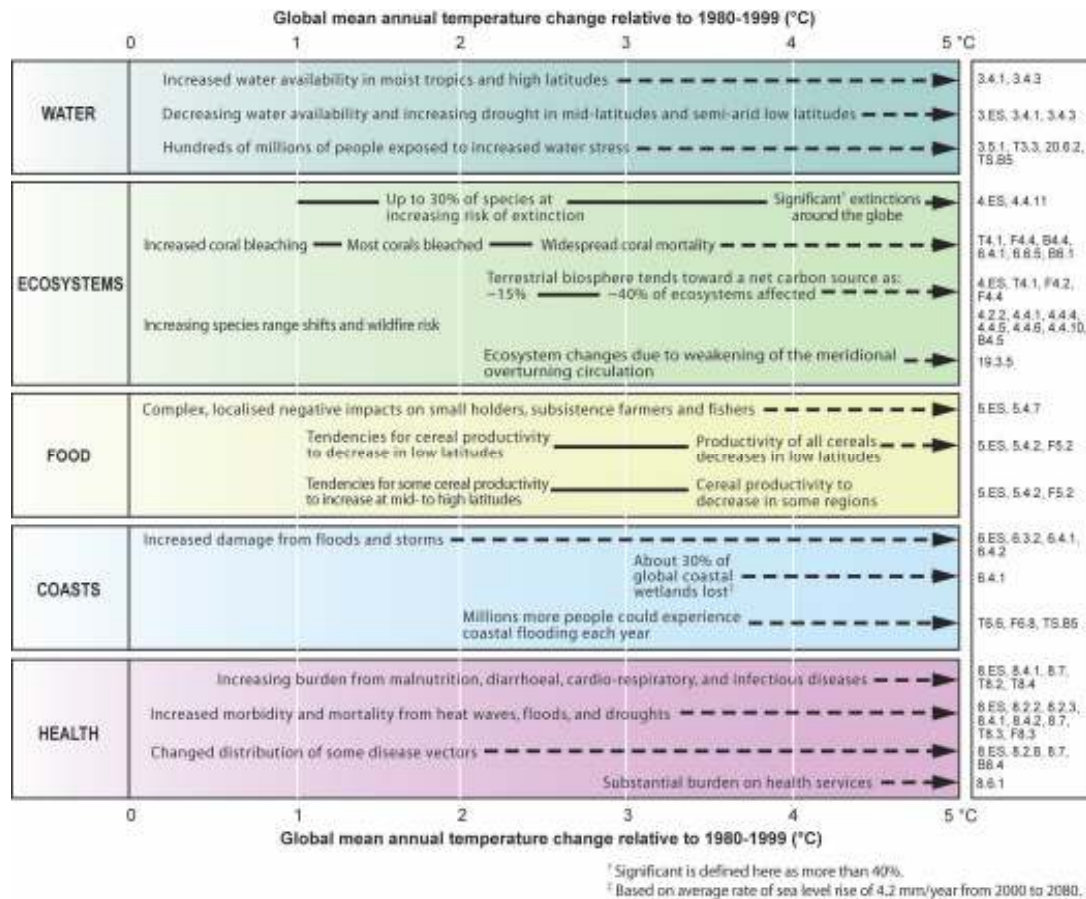


Table 2-3: Potential climate change impacts in Kent²⁴

Change	Negative impacts	Positive opportunities
Warmer, particularly summer and autumn	More health problems from more cases of food poisoning, heat exhaustion, dehydration and poor air quality (principally ozone).	More Mediterranean-like summers could boost tourism in the county, both domestically and from continental Europe.
	Uncomfortably high temperatures in buildings and likely to reduce worker productivity, worsen behaviour of school children, and create more disturbed sleep patterns leading to more mental and physical health problems.	Warmer winters likely reduce cold-related deaths and fuel-poverty problems, but this benefit maybe offset by escalating energy prices.
	Public transport less comfortable.	Reduced frost related damage to buildings. Fewer frozen pipes.

²³ IPCC 2008 (<http://www.ipcc.ch/graphics/graphics/syr/fig3-6.jpg>)

²⁴ Various sources, but primarily adapted from West, C.C. and Gawith, M.J. (Eds.) (2005) and KCC (2006a)

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Change	Negative impacts	Positive opportunities
	Transport disruption from heat-buckled rails, melting asphalt on roads and overheating vehicle engines.	More favourable conditions more new crops, such as grapes, leading to expansion of Wine industry ²⁵ .
	Increased fire risk, particularly heathland on the High Weald and the Ashdown Forest in East Sussex.	
	Fewer frosts may affect some native species, like apples, and allow more pest species to survive through the winter.	
	Increase dust levels in the air, causing nuisance and respiratory problems.	
	Increased summer energy demand for cooling systems	
Wetter Winters	Increased flood risk to life, damage to property and disruption to daily life and economic activity in winter.	Groundwater recharge may be sustained, but this is dependent on other factors such as rainfall intensity, soil moisture and vegetation growing seasons.
	Could increase damp problems, particularly in old buildings.	
	More cliff activity and collapse	
	More field water-logging or land drainage costs.	
Drier summers	Reduced water resource availability in a county that is already water-stressed.	Better weather for walking and cycling to reduce car-dependency and obesity. Also create a healthier, more active outdoor culture (with precautions against the increased risk of skin cancer).
	Increased water demand, particularly from domestic gardens, swimming pools, agriculture, golf courses and other irrigated green spaces.	
	Reduced summer river flows and poor water quality could adversely effect (1) the recreational navigation, and tourism value, of the River Medway and the lower Great Stour; (2) Recreational angling on Kent's rivers and fishing lakes.	

²⁵ However, research by Imperial College suggests that conditions in southern England maybe too hot for vines by 2080 (http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_27-5-2008-11-11-43?newsid=37054, viewed 27/05/2008)

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Change	Negative impacts	Positive opportunities
Reduced snowfall	Less groundwater recharge from snow melt.	Less disruption of transport and schools from snow. Less expenditure on road gritting and snow ploughs
More intense rainfall events	Increased flood risk to life, damage to property and disruption to daily life and economic activity at any time of year.	
	More intense rainfall events more likely to cause soil erosion and movement of debris, leading to more frequent blockage of drains and channels. This may in turn cause more localised flooding problems and increase maintenance costs.	
	More likely to cause sewer flooding, emergency overflow releases from wastewater treatment works, or wash off of harmful chemicals from land into rivers and other water bodies, causing pollution incidents	
Decrease in soil moisture	Shrinkage of Wealden and Gault clays leading to subsidence and damage to foundations of buildings and roads. Increased risk of water supply pipe/foul sewer damage and leakage.	
	Reduced groundwater recharge in autumn/early winter.	
Less cloud cover in summer and autumn	Greater incidence of sunburn and skin cancer.	Less cloud cover, particularly in spring and summer could make solar energy systems more viable.
	Increased evaporative water loss from ponds and reservoirs, like Bewl Water and Bough Beech.	
Higher winter wind speeds	Great storminess likely to increase disruption to ferry and port services, increasing delays and Operation Stack frequency. Sheltering effects of breakwaters and Quays reduced at Kent's ports, requiring expensive enhancements.	Higher winter wind speeds could increase wind power performance, however this may not occur if wind speed/direction is more 'gusty'.
Season creep – longer growing seasons	Loss of native species, habitats and landscapes. However there is opportunity to encourage colonisation of species from France and southern Europe.	Longer growing season may boost crop yields

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Change	Negative impacts	Positive opportunities
	(Re)Introduction of pests and diseases that may affect people (malaria), livestock (blue-tongue), crops and wildlife. New, or more active, pests may also threaten the integrity of historic buildings, collections and designed landscapes.	Wildlife habitats may adapt and provide ecological space for European species under threat elsewhere, thus helping to conserve Europe's overall biodiversity.
	Changes in vegetation patterns may threaten visibility and integrity of archaeological remains and historic landscapes ²⁶ .	
Sea level rise	Saline intrusion into coastal Chalk and gravel aquifers, particularly around Thanet, Dover and on Romney Marsh	
	Sea level rise and increased storminess is very likely to increase coastal flood risk. This will lead to either increasingly expensive and intrusive flood defences, or a conflict between competing land uses as land is given over to the sea.	
	Coastal squeeze – loss of amenity beaches and foreshore habitats, such as dunes, tidal mudflats and saltmarshes	
	Increased coastal erosion – loss of land, building and habitats.	

2.5 Climate change in the UK and Europe

This report focuses of necessity on the county of Kent. However it is still essential to have an appreciation of the wider context in the UK and Europe. Predictions provided for those levels indicate that Kent may suffer from higher temperatures and more water shortages earlier and harder than elsewhere in the UK.

However, on a European scale, Figure 2-6 and Figure 2-7 indicate that the UK in general will be far less affected from changes in temperature and rainfall than the rest of Europe. Both of these figures show annual means and thus hide different seasonal changes, for example the UKCIP predictions for wetter winters and drier summers, which may balance out over the course of the year but still cause serious problems.

It would appear that the UK is being largely protected the currents and airstreams of the North Atlantic. Meanwhile, southern Europe appears to be facing serious challenges to its already water-stressed condition.

What may be concluded is that the *indirect* impacts of the climate change, discussed in Section 2.6 may have more serious implications for the UK than the *direct* impacts.

²⁶ English Heritage (2008)

Figure 2-6: Change in mean annual temperature by 2100²⁷

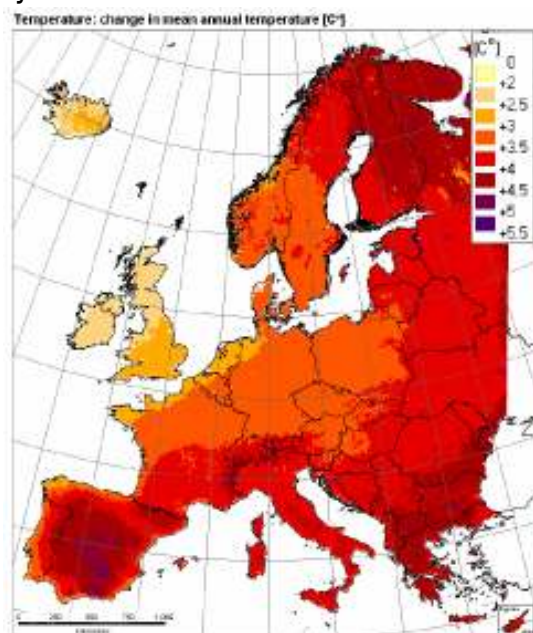
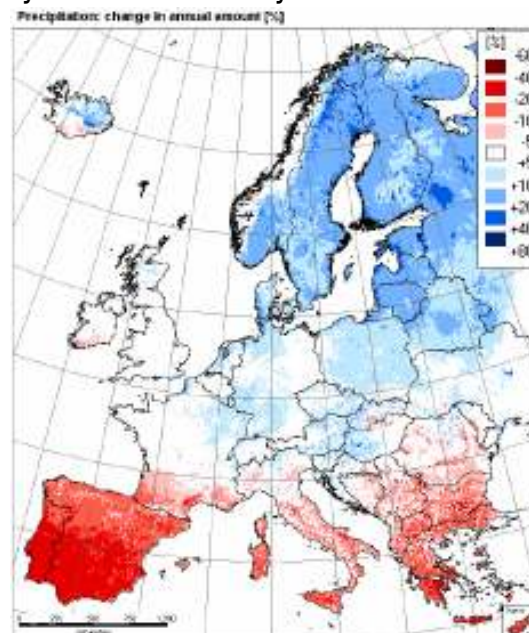


Figure 2-7: Change in mean annual precipitation by the end of this century



2.6 Indirect impacts and non-climatic factors

Climate change is a global phenomenon and the effects are likely to be much more severe in other areas of the world, as discussed above. It is likely that these indirect impacts will have greater social and economic impacts than the direct impacts on Kent. These and other challenges that interact with climate change to varying degrees²⁸ are summarised below:

2.6.1 Biodiversity

Approximately 20 – 30 % of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 – 2.5 °C²⁹. Even with no warming, the rate of species and habitat loss worldwide is disastrous and accelerating in response to economic and population growth: WWF's Living Planet Index tracks the populations of nearly 4,000 species and it has shown a decline by nearly 27% between 1970 and 2005³⁰.

2.6.2 Globalisation

Globalisation offers opportunities in being able to move food, resources and information around the world to improve international responses to major disasters, such as the Asian tsunami of 2005 or the recent Australian drought. However, these arguable benefits may be more than offset by the lengthening of supply chains that has led to wealthy countries exporting their environmental damage to developing countries where natural resources are exploited, and to China where the majority of consumer goods are manufactured. Free-market mechanisms have been successful in expanding globalisation, but they fail in the long term because essential human values, such as environmental quality and social justice, are not reflected in market prices. Free-market advocates say that the answer is create new markets for these 'externalities',

²⁷ Commission of European Communities (2007) based on IPCC SRES scenario A2. The projected climate impacts are estimated for 2071-2100 relative to 1961-1990. The maps are based on DMI/PRUDENCE data (<http://prudence.dmi.dk>), and processed by JRC within the JRC funded PESETA study (<http://peseta.jrc.es>)

²⁸ The Strategy Unit (2008)

²⁹ Commission of European Communities (2007)

³⁰ P.1, WWF (2008)

so that the price signals ref;³¹. However, industry will be reluctant to take on any costs that they don't have to because it reduces their competitiveness. The only way to overcome this is either through regulation, which is notoriously difficult to enforce internationally, or from customer demand. Fair Trade products are an example of the latter, however they will always likely to remain niche markets because the majority of consumers demand least cost.

Globalised transport systems also have major impacts on greenhouse gas emissions, quality of life and local economies. Kent suffers especially from freight traffic passing through on the motorway network, particularly when disruptions lead to Operation Stack. Growth in air travel has consistently threatened the tranquillity of Kent with expansion proposals at Lydd, Manston, Cliffe/Thames Estuary as well as the impact of flight paths into the London airports, principally Gatwick.

2.6.3 Technological change

While the rate of technological change in information and computing technologies has been unprecedented in the last decade, many other areas have failed to deliver the solutions promised by their advocates. Nowhere is this more noticeable than in the energy sector:

- Despite massive investment and public subsidies, nuclear power has failed to address the concerns over waste disposal, and now has questionable fuel security³².
- Nuclear fusion still remains a distant prospect.
- Renewable energy technologies are attracting greater investment but they are often create the dilemma of being most effective in areas that are ecologically sensitive (e.g. a tidal barrier across the Severn estuary) or have a high landscape value (e.g. wind turbines in the Welsh and Scottish highlands)
- The most recent proposed panacea has been biofuels but these have been blighted by uncertain carbon savings and a conflict with food agriculture at a time when population and food consumption are increasing and the area of productive land is falling³³. However, some biomass solutions, like woodchip boilers and algal biofuel, offer some interesting opportunities.

The growing demand for fuel and food has lead to calls for research and investment into Genetically Modified (GM) crops. GM faces widespread public scepticism and opposition, which may be based on a suspicion that it may create more problems than it solves. However, the EU is under pressure from the World Trade Organisation to drop its current ban on GM foods on the grounds that it amounts to protectionism against non-EU produce³⁴.

2.6.4 Economic growth and competitiveness in Kent and the UK

Our economic growth model is based on the desirability of infinite growth. Economic output is a function of:

- population;
- productivity per head (competitiveness); and
- quantity and value of material resources passed through the economy from extraction and harvest from the environment, to disposal back to the environment.

³¹ www.adamsmith.org/blog/environment/common-error-no.-43-20080223951/ (viewed 14/03/2008)

³² Sustainable Development Commission (Mar 2006), The role of nuclear power in a low carbon economy - Paper 8: Uranium resource availability

³³ National Farmers' Union (2008)

³⁴ <http://news.bbc.co.uk/1/hi/world/europe/7182793.stm>

Economic *growth* is needed because personal, business and government spending is largely based on the use of debt to get future benefits today. This model only works as long as future income is greater than the debt repayments, plus interest costs. If not then individuals, businesses and governments can slip into debt spirals that lead to payment defaults, bankruptcy and, for governments, cut backs in public spending and economic recession. The UK government's debt in March 2008 was £43billion³⁵, therefore short-term economic growth is a top political priority so that this debt can be serviced and public services maintained, even if this is at the expense of social, environmental and long-term economic goals.

The situation has been made worse by economic instability triggered by the 'credit-crunch' in the US housing market and rapidly escalating oil and grain costs. This has pushed UK government priorities further towards short-term economic interests as the only real political priority³⁶.

It is this short-termism that presents some of the biggest challenges to mitigating and adapting to climate change and why there has been conflicting policy and so little action from all levels of government and business, beyond some well-intentioned, but weak rhetoric.

2.6.5 Population growth, migration and demographic change

The world population in 2008 stands at over 6.5 billion and is projected to rise to 9.2 billion by 2050³⁷. The UK population is currently around 61 million³⁸ and is projected to reach 71 million by 2031³⁹. This means that if, as a country, we need to reduce our national carbon emissions by 80% then, individually we have to reduce our carbon emission by closer to 90% because of the greater population contributing to the national emissions.

When considering climate change adaptation as a global issue it is worth putting the situation in Kent in a global context. It is the poorest areas of the world that will suffer hardest and be least able to adapt to changes in sea-level, rainfall and temperature.

46% of the world's population (3 billion individuals) are under the age of 25 and at increasing risk from disease, conflict, natural disasters⁴⁰. Climate change, and resultant poverty and conflict, will undermine the efforts to meet the UN Millennium Goals (see Box 2.1):

Box 2.1 - UN Millennium Goals

By 2015, all United Nations Member States have pledged to:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

³⁵ <http://news.bbc.co.uk/1/hi/business/7291687.stm> (viewed 14/03/2008)

³⁶ This is reflected in the 2008 government consultation document '*Prosperous Places: Taking Forward the Review of Sub National Economic Development and Regeneration*' which seeks to merge the regional spatial strategies and regional economic strategies and migrate planning powers away from regional assemblies to the regional economic development agencies.

³⁷ <http://esa.un.org/unpp/> (viewed 03/09/2008)

³⁸ <http://www.statistics.gov.uk/cci/nugget.asp?id=6> (viewed 03/09/2008)

³⁹ <http://www.statistics.gov.uk/cci/nugget.asp?id=1352> (viewed 03/09/2008)

⁴⁰ P.18 UNICEF (Dec 2007), *Climate Change and Children*, New York

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The impact is likely to be greatest in the tropical regions of the world where population pressures are strong and social and economic stability is often weak. Africa is projected to account for 38% of global population growth to 2020⁴¹. 75 million people in Africa may be exposed to more water stress in 2020 than they are today⁴².

This is likely to trigger large scale migration into Europe and this threat has been identified by EU foreign ministers⁴³. There is some evidence that this is already happening with 191 million migrants globally, compared to 76 million in 1960⁴⁴. In the UK, Kent is likely to be the county most affected by this issue, with ever increasing security at the county's ports and the Channel Tunnel and pressure for 'Sangatte'-type reception centres on both sides of the channel. Polls show that immigration is a concern among the British public⁴⁵, even if the problem more perceived than real.

Therefore, it is critical to appreciate that future social and security problems in Kent will need an international response to tackle the Millennium Goals if we are to manage the challenge of immigration and associated rise of far-right political groups and violence, as has been seen in the recent Italian elections⁴⁶.

2.6.6 International security

Figure 2-8 below shows areas of the world where climate change could exacerbate instability and add to the stress on already fragile economies, environments and political systems. This could have implications to the UK and Kent in terms of:

- Increased demand on armed services for peace-keeping and humanitarian operations;
- Increased numbers of refugees arriving in Kent;
- Increased terrorist threat.

Terrorism will increase because the poorer countries who are most affected by climate change will have few military resources other than a large, young, unemployed, under-educated population that will be vulnerable to any ideology that promises a better future or revenge against richer nations or ruling classes. Recent experience in Iraq, Afghanistan, Somalia, Palestine/Israel, Lebanon, Columbia, Darfur and Sri Lanka has shown that even highly trained, well resourced military forces can be rendered largely ineffective in what is termed 'asymmetric warfare.' In these cases, it is often the civilian population that suffers the most, from both sides, which makes building trust and developing diplomatic solutions slow and often ineffective.

Climate change is being recognised increasingly by military analysts as a 'threat multiplier' and a serious national security threat in its own right⁴⁷.

⁴¹ P.25, The Strategy Unit (2008), *Realising Britain's Potential: Future Strategic Challenges for Britain*

⁴² P.4 UNICEF (Dec 2007), *Climate Change and Children*, New York

⁴³ <http://www.telegraph.co.uk/news/uknews/1581231/Eco-migration-threat-to-UK-of-climate-change.html> (viewed 27/05/2008)

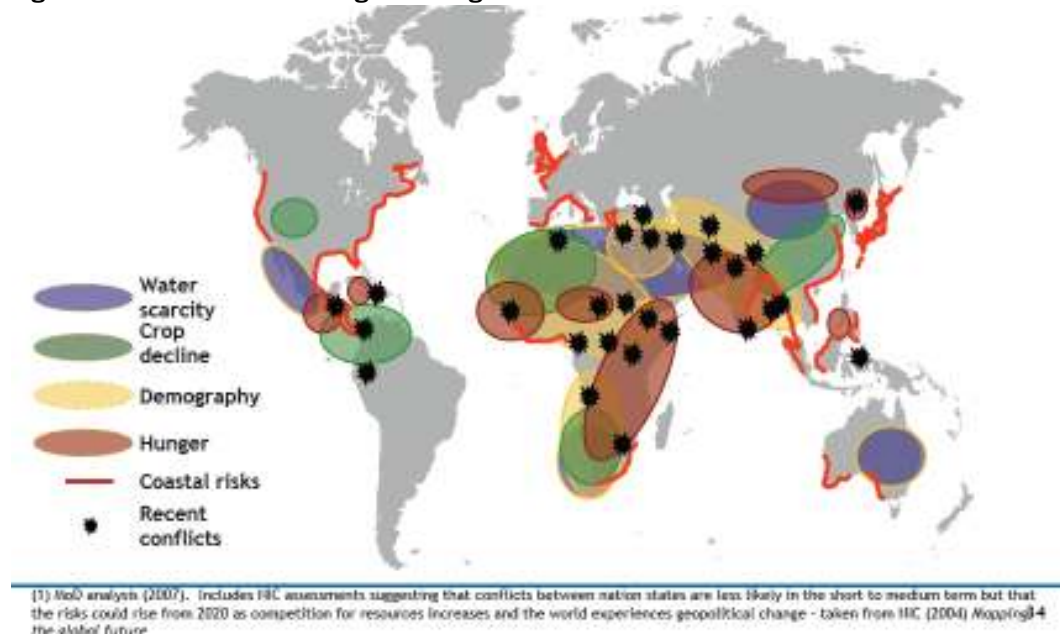
⁴⁴ The Strategy Unit (2008)

⁴⁵ <http://news.bbc.co.uk/1/hi/uk/7352125.stm> (viewed 03/09/2008)

⁴⁶ <http://news.bbc.co.uk/1/hi/world/europe/7404616.stm> (viewed 27/05/2008)

⁴⁷ Dupont. (2008)

Figure 2-8: Global climate change challenges⁴⁸



2.6.7 Social exclusion and inequality

Adapting to climate change is likely to require a major cultural shift in our values and behaviour. Getting the message out and including everyone in the adaptation process is critical, but may be difficult to achieve with many hard to reach social groups, such as Gypsies and Travellers or sink estates in the poorer areas of Thanet and Medway. In the context of buildings, water management and coastal management, it is often these groups that are most at risk, due to low literacy or lack of English, lack of access and trust in internet and other information services, poor housing quality, lack of finances and poor skills.

Therefore housing associations, registered social landlords, social, adult and traveller services have a vital role to play in helping individuals and communities participate in the climate change adaptation process.

2.6.8 Crime

Crime has generally been falling in the UK⁴⁹. However there is some anecdotal evidence to suggest that escalating fuel costs are leading to increased fuel theft, particularly from domestic oil tanks in isolated rural areas⁵⁰. Kent also suffers from extensive fly-tipping of domestic and commercial waste, often linked to organised crime. Crime is likely to be an unintended consequence of other 'green' or 'carbon' taxes that are likely to be needed to encourage climate change mitigation because faced with a new cost, individuals and businesses will be tempted to cheat.

2.6.9 Public Services

The quality of public services dominates the political agenda at all levels. This can often lead to short-term political thinking to be able to survive the next election, at the expense of long term gains.

⁴⁸ The Strategy Unit (2008)

⁴⁹ <http://news.bbc.co.uk/1/hi/uk/7511758.stm> (viewed 03/09/2008)

⁵⁰ <http://news.bbc.co.uk/1/hi/england/gloucestershire/7433274.stm> (viewed 03/09/2008)

2.6.10 Governance and democracy

As discussed later in this report, there are different ways that our society can adapt to climate change. There is a risk of governance either becoming authoritarian, in restricting personal freedom, or too libertarian, thus worsening social inequalities. However, climate change is only one of many factors that will shape the future of our governance.

2.7 Direct climate impact priorities in Kent

Climate change will affect almost every aspect of our lives, to varying degree. Because it is such an overarching issue, this report will focus on key areas that were identified as the top priorities by delegates at the *Tomorrow's Kent* conference on 1 February 2008 in relation to *direct* climate impacts:

- Building Design & Planning
- Water management
- Coastal management

2.7.1 Building Design & Planning

Kent has great range of housing and building heritage that spans centuries. In the South East, 95% of buildings were built before 1995, 40% before 1945 and 20% before 1918⁵¹.

The factors that determined their design are complex and policy for future building is constantly evolving. Government policy is for major housing growth in Kent over the next 20 years, at least. Therefore there are two main aspects for consideration:

New buildings need consider both climate change mitigation and adaptation over their probable life spans (at least 50 years, more commonly 100-plus). Design and policy considerations go beyond the building itself and need to consider the setting, with the opportunities and risks that it brings.

Existing buildings may need to be altered by their owners to maintain their habitability. This will require flexible planning policies and public access to information to allow informed decision-making.

Table 2-4: Building Design & Planning Drivers

Driver Group	Driver	Source / Pathway/ Receptor	Explanation
Climate Change	Precipitation	Source	Changes in short duration precipitation – amount, intensity, duration, location, seasonality and clustering, snowfall.
	Temperature	Source	Influenced by ambient air temperature and exposure to direct sunlight. Temperature and its variability affects heating and cooling, and hence affects comfort and energy demand.
	Storminess/Wind speeds	Source	Changes in duration, strength, direction and 'gustiness' of winds will affect ongoing building maintenance and risk of storm damage to the building fabric, contents or adjacent property (e.g. roof tiles falling onto a parked car).
	Floodwater	Source	Floodwater, from any source, entering the home and causing disruption and damage.
Building structure	Roof	Pathway	Primary protection against precipitation, including snow and hail, and insulation between interior and exterior temperature differences.
	Exterior Walls	Pathway	Protection against precipitation and exterior and interior temperature differences.
	Windows & Doors	Pathway	Access for occupants, light and ventilation. Also influences heat transfer in and out of the building.

⁵¹ p.19, Three Regions Climate Change Group (2008)

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Driver Group	Driver	Source / Pathway/ Receptor	Explanation
	Foundations	Pathway	The stable base on which the building stands. May be impacted by subsidence or heave and shrink of any surrounding clays. The level of the foundation slab can affect the flood risk to the building.
	Interior resilience	Pathway	The time, cost and effort required to recover from a flood or storm.
Setting	Impermeable curtilage, driveway, yard, paths, decking, car parks	Pathway	Impermeable areas around the building may increase flood risk to the building, or to neighbours. May also reflect heat into a building.
	Adjacent buildings/urban area	Pathway	May block light/create shade. May create an urban heat island effect. May be a pathway for roof/drainage/flood water into the building or its curtilage.
	Adjacent open space/water bodies countryside	Pathway/ Receptor	May be a source of flood risk to the building. Vegetation and water features may create a cooler microclimate.
	Adjacent trees and planting	Pathway	Trees can block light/provide shade. Root systems may impact building foundations over time.
	Underlying soil/geology	Pathway/ Receptor	Underlying groundwater or soil saturation may be a source of flooding, or may have the capacity to act as a soakaway to absorb roof and surface drainage. Soil properties will also affect gardening and its water demands.
Infrastructure	Water supply	Pathway	Vulnerability to problems with the wider public water supply network, particularly during a period of drought.
	Foul sewerage	Pathway	The vulnerability to flooding and pollution damage from the foul drainage network. Older properties are often on combined sewers which include stormwater runoff, which increase risk of sewer flooding. Misconnections of roof guttering down-pipes into the foul sewer are also a common problem.
	Surface drainage	Pathway	The vulnerability to flooding and pollution from a blockage or surcharging of surface drainage network.
	Roads and pavements	Pathway	In intense downpours, road drainage can be blocked or surcharged and the roads and pavements act as uncontrolled water channels. This may be an unanticipated flood risk for the building. Extreme summer heat can melt asphalt, though unlikely to stop vehicular access.
	Infrastructure impacts	Receptor	The flood or pollution impact the building may have on the services to which it is connected (sewers, drains, roads etc). Private or water company surface drains that transfer stormwater to soakaway or a watercourse with little or no treatment.
Government	Planning policy	Pathway	From national legislation and Policy Position Statements (PPS) to Regional Spatial Strategy (RSS) policies and Local Development Framework (LDF) policies which affect both new buildings and alterations to existing ones.
	Taxation & Grants	Pathway	Common tools to attempt to change the direct of behaviour or market forces. Can help or hinder 'auto-adaptation' to climate change.
	Public spending	Receptor	Government spending priorities will influence climate change adaptation of government buildings and land, which may in turn help stimulate emerging markets in climate change adaptation.
Human Behaviour	Water use	Pathway	The water efficiency of buildings and their occupants will influence wider water resource planning and adaptation.
	Heating, cooling and appliance use	Pathway	Maintaining comfortable temperatures within buildings will influence the seasonality and amount of energy demand and hence influence wider energy generation planning.
	Building occupancy and use	Pathway	How a building is used will affect the risk that climate change poses to its occupants.
	Maintenance	Pathway	The effectiveness of adaptation measures included in buildings will only be as effective as long as they are robust and well maintained. This will depend on a range of

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Driver Group	Driver	Source / Pathway/ Receptor	Explanation
			behaviour, knowledge and financial factors.
	Enjoyment and health of the occupants	Receptor	Physical and mental health benefits or impacts of the building design, materials and use.
	Public attitudes and expectations	Receptor	Determines preferences for styles of risk management, and likely to vary in different areas and over time. At one extreme will be highly self-sufficient building where the occupants have the ability, and responsibility, to cope with extreme events. At the other is a highly connected building that is largely dependent on external services, infrastructure and skills for coping with flooding, water shortages and extreme heat.
Socio-economics	Contents and property	Receptor	Accounting for the cost of flood or storm damage to households.
	Social impacts	Receptor	Effects on neighbours and wider community, e.g. transference of flood risk, nuisance, inspiring positive social change.
	Urban impacts	Receptor	The type, layout of building and resulting densities of development, building form and nature of land use, all affect the climate-related damage costs. Hence, in future adaptation may affect not just individual design but wider urban design and land use planning policies.
	Historic heritage & landscape	Receptor	Protecting historical assets, local building materials and architecture, streetscapes and landscapes for the benefit of current and future generations.
	Science, engineering and technology	Receptor	The level and type of investment in science, engineering and technology will strongly influence the ability to use natural resources, labour and capital to achieve more for less. They are determined primarily by worldview and influence all aspects of building design and construction.
Environmental quality	Biodiversity	Receptor	Effects on wildlife, creation or loss of important habitats and biodiversity.
	Pollution	Receptor	Increasing, or decreasing, risk of air, water or land contamination.

2.7.2 Water management

Water management in Kent has been a contentious in relation to the growth plans for Kent and climate change will exacerbate these policy conflicts:

- 80% of Kent's public water supply comes from groundwater, which is already stressed and vulnerable to saline intrusion and changes to rainfall patterns and loss of regular snow melt that might reduce aquifer recharge;
- Kent's rivers are ecologically sensitive and vulnerable to pollution and low flows:
 - The River Darent dried up in its middle reaches during the 1989-1991 drought. Bankside augmentation wells installed in the mid 1990s provide only limited relief.
 - The River Great Stour downstream of Ashford is a high quality chalk river that is vulnerable to low flows, and poor water quality from upstream wastewater treatment works and agricultural runoff.
 - The Little Stour and Dour are vulnerable to low flows and have been the subject of water company and Environment Agency investigations and Alleviation of Low Flow (ALF) schemes.
 - The marshes and mudflats of the Swale owe some of their rich biodiversity to chalk-fed springs and streams coming from the lee slope of the North Downs.

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- Thousands of homes in Kent are at risk of flooding from numerous sources. Even minor flood events can disrupt other infrastructure, such as gas mains⁵² or electricity substations⁵³. Existing flood defences, such as the Leigh Barrier, will need continual performance reviews and periodic upgrades to maintain the same standard of service.

2.7.3 Coastal management

Together, Kent and Medway have the one of the longest and most varied coastlines in the UK:

- 1200km² land at risk in Kent⁵⁴.
- 44,000 properties are at risk from Coastal Flooding in Kent⁵⁵ in more than thirteen coastal towns and numerous villages and rural dwellings. The number and level of risk will increase with climate change and coastal housing development, like the Thames Gateway.
- Kent's saltmarshes are rich habitats supporting a large number of invertebrate and bird species, many of which are found only in these habitats⁵⁶. Much of the North Kent marshes are protected under EU Habitats Directive regulations as Special Protection Areas (SPA) or Special Areas of Conservation (SAC), as well as under the UN Ramsar convention on wetlands.
- 57% of Grade 1 agricultural land is below the 5 metre contour⁵⁷.
- Accelerated cliff erosion on Thanet and around Dover could threaten homes, historic assets and roads, such as the A20 at Shakespeare Cliff, and railways, such as the Dover to Folkestone Railway⁵⁸.
- A number of important historic features and buildings are at risk, including:
 - Paleolithic deposits of national and European significance related to the earliest occupation of North West Europe up to about 700,000 years ago⁵⁹.
 - Shornemead Fort, Gravesend
 - Cliff Fort, Hoo Peninsula
 - Hoo Fort, Medway Estuary
 - Chatham Historic Dockyard
 - Garrison Point and Sheerness Harbour
 - Reculver Roman Fort and St Mary's Church (remains of)
 - St Augustines Well and traditional landing place of Hengest and Horsa, and St Augustine
 - Sandown Castle (remains of)
 - Shakespeare Cliff
 - Royal Military Canal
 - Chantry Fort, Gravesend
 - Thames and Medway Canal, Gravesend
 - Darnet Fort, Medway Estuary
 - Upnor Castle, Medway Estuary
 - Temple Manor, Rochester
 - Whitstable Harbour
 - Richborough Roman Fort and Amphitheatre
 - Sandwich Harbour
 - Deal Castle
 - Hythe and Dymchurch Martello Towers and Dymchurch Redoubt
- A number of critical infrastructure sites are at risk of being inundated, or cut off, including:
 - Littlebrook power station, Dartford
 - Isle of Grain power station, Hoo Peninsula
 - Thamesport/Isle of Grain oil terminal, Hoo Peninsula
 - Kingsnorth power station, Hoo Peninsula

⁵² BBC (May 2008), *Homes lose gas after pipe floods* (<http://news.bbc.co.uk/1/hi/england/kent/7421932.stm>, viewed 27 May 2008)

⁵³ ref – Pitt review?

⁵⁴ Ibid.

⁵⁵ Environment Agency (2008)

⁵⁶ Möller *et al* (1999)

⁵⁷ National Farmers' Union (2008)

⁵⁸ Box 3, KCC (2006a)

⁵⁹ English Heritage (2006)

- Motney Hill wastewater treatment works
- Rushenden wastewater treatment works
- Richborough wastewater treatment works
- Port of Dover
- Dungeness power station
- Sheerness Docks
- Port of Ramsgate
- Weatherlees wastewater treatment works
- Port of Folkestone
- Lydd and Hythe Ranges

2.8 Critical thresholds

The final element of describing climate impacts is the concept of 'critical thresholds'. This is the level of a given impact beyond which damage is done. Defining such thresholds is fraught with difficulty; for example, what is the air temperature threshold that will make fish stocks in Kent's lakes and rivers vulnerable to mass fish kills? This will depend on a complex web of factors relating to dissolved oxygen, chemical quality and dilution, abstraction and water demand, and increased evaporation. Other thresholds, such as the melting point of road asphalt may be more easily defined.

Thresholds, and indicators of success, should ideally be measurements of receptors from the tables above, as they represent the values, or objectives, that we are trying to achieve for a better society. However, some of these, like happiness, are either intangible or are related to a wider range of factors than climate. Hence it will be necessary to measure indicators relating to sources and pathways.

In most cases, existing legal limits will act as indicators and critical thresholds. However further work is needed by government and Kent County Council to collate and cross check critical thresholds for climate change in the UK, and Kent.

It is important to have an idea of what these critical thresholds are so that right adaptive action can be taken at the right time and in the right degree to avoid crossing those boundaries. Some examples are given in Appendix 7.3.

2.9 Impacts Summary

The available evidence points to major changes in how the climate of our county is likely to behave over the coming century. The main areas of concern can be summarised as:

- More uncertain rainfall, leading to more flooding and more water shortages;
- Warmer temperatures throughout the year, leading to less snow, more evaporation, changes to wildlife and problems with summer overheating;
- Increasing sea-levels and more storminess putting large areas of Kent's coastline at risk.

Many, if not most, areas of the UK will suffer from similar problems. However there are a number of features that makes Kent particularly vulnerable:

- A long coastline with large areas of low-lying land which are important habitats, farmland and in some cases, development areas.
- A large and changing population.
- A diverse economy with areas of both affluence and poverty.
- A large amount of critical transport and energy infrastructure which is important not just for the county but for the UK as a whole.

In a European, or global, context, the impacts of climate change on Kent appear relatively minor and so it may well be the indirect impacts of climate change on world economics, politics and migration patterns that have a greater effect on the county and its people.

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While the situation is serious, it is worth considering that Jared Diamond in his book, *Collapse; how societies choose to fail or survive*, identified five factors that have contributed to the collapse of past societies, like Easter Island, the Maya and the Greenland Norse:

- Environmental damage.
- Climate change.
- Hostile neighbours.
- Friendly trade partners.
- Society's response to environmental problems.

In the past it has often taken a combination of these five factors to bring about the collapse and disappearance of a society. While in some ways our society is quite vulnerable, modern communications, scientific research, environmental and social activism and globalised trade systems do give hope, although some of these factors have done much to create new problems in their attempts to solve old ones.

3 Adaptation

3.1 Defining 'adaptation'

The Stern Report defines the objective of adaptation as being:

*“to reduce the vulnerability to climatic change and variability, thereby reducing their negative impacts. It should also enhance the capability to capture any benefits of climate change.”*⁶⁰

Stern identifies adaptation as crucial but makes the following points:

- We need to deal with the unavoidable impacts of climate change which are going to happen however our carbon emissions change from now on;
- We will need to adapt to the changes to reduce their negative impact, however adaptation on its own cannot solve the whole problem of climate change;
- There are limits on what human adaptation can achieve. This is, in part, because there are limits to how quickly other species and ecosystems can adapt;
- Adaptation will generally provide local benefits without long time lags. Some of this change will happen autonomously as individuals and organisations make their own decisions and actions. However, the most vulnerable in our society are the least equipped to make adaptations on their own;
- Adaptation is complex and many constraints will have to be overcome. Government needs to provide policy, economic and institutional support to the private sector and civil society.
- Studies suggest that the benefits of adaptation are likely to outweigh the costs to many climate-sensitive sectors of the economy, however quantitative information is limited.

In the context of Kent, Stern gives a clear indication that work on adaptation can be done at the local level and that bodies like SEEDA, Kent County Council, Medway Council and the other government authorities have the ability to create the right conditions for individuals and organisations to plan and act to adapt to climate change.

3.2 Adaptation strategies

3.2.1 Types of adaptation

There are two strands to adaptation, and within them various types of strategy, summarised in Table 3-1 below.

⁶⁰ pp.405, STERN REVIEW: *The Economic of Climate Change*, HM Treasury (2007)

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Table 3-1: Types of adaptation strategy⁶¹

Strategy	Component	Description
Building adaptive capacity to create the right conditions for organisations and individuals to plan and take action. This is done by providing the right tools and information (such as found on the UKCIP website) and a favourable regulatory and institutional environment to allow action to happen.	<i>Climate change risk assessment in long and medium term planning</i>	Organisations that adopt risk assessment will be more flexible and better able to cope with climate risks.
	<i>Research</i>	Use research to better understand climate risks and performance of adaptation options.
	<i>Monitoring</i>	(a) monitoring how climate change and its impacts are developing (b) evaluating society's responses to those changes.
	<i>Information supply, education, awareness-raising</i>	Providing more and better information on what is happening and how to adapt.
Taking action to reduce vulnerability to climate risks and exploit opportunities	<i>Contingency planning</i>	Strategic planning for low probability, high consequence events.
	<i>Diversification or bet-hedging</i>	Relying on a diversity of, say, water resources, to reduce vulnerability to extreme events.
	<i>Insurance</i>	A financial tool to enable those affected to recover quickly.
	<i>Defend and manage</i>	Technological, engineering or behavioural solutions to prevent climate events doing harm.
	<i>Change of use</i>	Anticipatory or reactive. Includes planning responses, with or without technical measures
	<i>Retreat and abandon</i>	Acknowledging that an asset, such as coastal land, may be uneconomic or unfeasible to defend indefinitely.
	<i>Safety factors, climate headroom, buffering measures</i>	Not using natural resources to their maximum economic potential, or over-engineering technical solutions, to allow for extreme weather events.

The draft London Adaptation Strategy⁶² expresses this slightly differently through a hierarchy of increasingly reactive measures:

- **Prevent:** actions to reduce the probability of an impact.
- **Prepare:** actions taken to better understand the risk/opportunity before the change happens and plan an effective response.
- **Respond:** actions taken in response to an event to limit the harm done.
- **Recover:** actions taken after the event to return to normal as quickly and cost-effectively as possible.

Some adaptation will occur without government intervention. This may be due to market signals making adaptation financially attractive, or because organisations or individuals take a principled stand.

However, relying on individual adaptation may be unnecessarily expensive or create unnecessary conflict between competing interests. This is where more collective and long-term policy decisions and investment is needed, for example, more restrictive planning around floodplains to take into account likely increases in the frequency of major floods.

⁶¹ Adapted from p. 405, *STERN Review: The Economics of Climate Change*, HM Treasury (2007) and *Typology of Adaptation Strategies* (UKCIP, www.ukcip.org.uk/resources/tools/wizard/resources_main.asp?res_id=7)

⁶² P.xii Greater London Authority (2008)

Hence it is important to identify those elements of our society, economy and environment that have the flexibility to adapt quickly to climate changes, and those that do not and therefore require more forward planning. Tension is likely to occur when trying to differentiate the two because there will be those that want to get on and take action, and those who think that further investigation, planning and adaptive capacity building is required, just in case the wrong decision is made.

We also need to ensure adaptation does not itself exacerbate existing problems or undermine efforts to mitigate climate change by reducing carbon emissions. For example, flood walls can have a large carbon footprint because manufacture of concrete produces a tonne of carbon dioxide for each tonne of cement produced⁶³, and they can make erosion/flooding worse elsewhere, thus moving the problem rather than solving it.

3.2.2 Storylines

The government's Foresight programme used four socio-economic scenarios, or 'storylines' based on the axes of Governance and Values that were combined with emissions scenarios from high to low (Figure 1-3/Figure 3-1). This approach is useful because some ways of adapting to climate change will be easier, or harder, to implement depending on the values of our future society, locally in Kent, nationally in the UK and even globally.

Figure 3-1; Foresight 'storyline' carbon emission scenarios

National Enterprise (Medium-High emissions)	Local Stewardship (Medium-Low emissions)
World Markets (High emissions)	Global Sustainability (Low emissions)

Both World Markets and National Enterprise scenarios lead to continued emissions that is likely to push global temperatures beyond the 2 degree change and a high risk of going beyond 4 degrees in which runaway climate change becomes a real possibility⁶⁴. Neither scenario is likely to achieve a sufficiently low ecological footprint for One Planet Living to be achieved. For this reason, both World Markets and National Enterprise have been discounted from further consideration.

It could be argued that our society has developed from a form of Local Stewardship, through National Enterprise and we are currently a World Market society. A common strand in environmentalism is the movement to a kind of 'enlightened peasant' Local Stewardship. However, from where we are today, it seems that making the transition towards Global Sustainability is the most likely and desirable, although it brings the danger of an authoritarian bureaucracy that values stability of a whole society over the human rights of an individual person.

The central tension, or choice, between the viable scenarios, Local Stewardship and Global Sustainability, is whether decision-making and action is best conducted at the local scale via a bottom-up approach, or a more centralised top-down governance. The reality is likely to be a combination of the two. However, all cases require a big cultural shift away from the current economic model of globalisation that promotes consumerism as defining social goal⁶⁵.

⁶³ The main chemical reaction in cement production is heating calcium carbonate (CaCO₃) to create Lime (CaCO) and CO₂

⁶⁴ <http://www.guardian.co.uk/environment/2008/aug/06/climatechange.scienceofclimatechange> (viewed 03/09/2008)

⁶⁵ Porritt. (2008)

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Table 3-2: Foresight Socioeconomic 'Storylines'

	Local Stewardship	National Enterprise	World Markets	Global Sustainability
Carbon emissions	Medium-Low	Medium-High	High	Low
Income	Low	Medium-low	High	Medium-high
Social Values	Localist, co-operative	Nationalist, individualist	Internationalist, libertarian	Internationalist, communitarian
Governance	Strong, local, participative	Weak, national, closed	Weak, dispersed, consultative	Strong, co-ordinated, consultative
Role of policy	Interventionist, social and environmental	State-centred, market regulation to protect key sectors	Minimal, enabling markets	Corporatist, political, social and environmental goals
Economic development	Low growth, low innovation, modular and sustainable	Medium-low growth, low maintenance innovation, economy	High growth, high innovation, capital productivity	Medium-high growth, high innovation, resource productivity
Fast-growing sectors	Small-scale manufacturing, food and organic farming, local services	Private health and education, domestic and personal services, tourism, retailing, defence	Health & leisure, media & information, financial services, biotechnology, nanotechnology	Education and training, large systems engineering, new and renewable energy, Information services
Declining sectors	Retailing, tourism, financial services	Public services, civil engineering	Manufacturing, agriculture	Fossil-fuel energy, traditional manufacturing
Unemployment	Medium-low (high voluntary sector)	Medium-high	Medium-low	Low
Equity	Strong improvement	Decline	Strong decline	Improvement

3.2.3 Storylines and adaptation

The table below illustrates how the two different socio-economic storylines may affect society's response to climate change impacts. They are intended to represent two extreme directions that a future society may take.

Table 3-3: Scenario responses to climate change impacts

Strategy	Component	Global Sustainability	Local Stewardship
Build adaptive capacity	<i>Climate change risk assessment in long and medium term planning</i>	A global approach to monitoring and research allows early detection and analysis of problems. Allows uncertainties to be reduced sufficiently for medium and long term plans to be made with confidence.	Risk assessment only done when there is sufficient evidence in the local area. Long term planning is limited by large uncertainties of future impacts.
	<i>Research</i>	Large investment in international research teams and co-ordination between universities, governments, NGO and private sector. Emphasis on computer modelling and macro-policy recommendations.	Small scale ecological and social research with an emphasis on fieldwork and community surveys.
	<i>Monitoring</i>	Emphasis on large scale monitoring with particular reliance on satellite technology.	Dense network of observations and observers, involving a large portion of the public. Coverage will be patchy.
	<i>Information supply, education, awareness-raising</i>	Emphasis on broadcasting information and use of mass media and large scale marketing campaigns and updating education curricula. Debate is encouraged through the media.	Information shared among the community and actively debated in a way that includes the majority of the community in understanding the risks and deciding on action, or inaction. Information shared between localities in an informal basis.

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Strategy	Component	Global Sustainability	Local Stewardship
Action to reduce vulnerability to climate risks and exploit opportunities	<i>Contingency planning</i>	A co-ordinated hierarchy of strategies and plans. Pressure for consistency may create plans that suit no-one.	Small scale plans tailored to local conditions and needs. Quality of such plans likely to be inconsistent. Opportunities missed for sharing knowledge and resources.
	<i>Diversification or bet-hedging</i>	Reliance on large scale networks move resources around swiftly and effectively during extreme events, like floods or droughts.	Emphasis on self-sufficiency of households and communities. Opportunities missed for sharing knowledge and resources.
	<i>Insurance</i>	Highly developed insurance markets able to provide good coverage.	Poorly developed capital markets will hinder the coverage than insurance can provide.
	<i>Defend and manage</i>	Professional schemes incorporating the latest technology, methods and lessons learned from around the world.	Community based schemes that draw on local knowledge, skills and manpower to build and maintain. Lower financial cost but higher time costs. Effectiveness dependent on local resources available, knowledge and skills.
	<i>Change of use</i>	Hierarchy of plans and policies to allow change of use may be so dependent on demonstrating fairness and consistency that it may create a very slow, expensive process.	Localised decision making allows rapid adaptation, if consensus can be reached. Wide variation in policy and practice between geographic areas.
	<i>Retreat and abandon</i>	Large scale strategic decisions on costs and benefits of defending or retreating. Long term decisions may not be sensitive to short term local needs.	Community support for those affected, unless whole area is affected, which may lead to unmanaged migration. Lack of ability to make tough decisions may put whole community at risk.
	<i>Safety factors, climate headroom, buffering measures</i>	Determined by centralised consensus and enforced by a regulatory authority.	Largely led by social pressures which may or may not be rational.

Two further scenarios have been considered in this report:

- **Do Nothing:** this assumes that there is no government intervention in climate change policy at any level.
- **Business-as-usual:** this assumes that policies continue on their present course.

3.3 General barriers to adaptation

3.3.1 Approaching uncertainty and perception of risk

Even with the published research provided by the IPCC and UKCIP, the impacts of climate change are still highly uncertain, particularly at a local scale like a county or a borough. The risk to life and property posed by climate change are just a few among many issues, such as politics, the economy, commodity prices, crime and social trends.

Different individuals, companies, governmental and non-governmental bodies will assess risk differently and respond differently. Research in the south east shows that while 58% of Small-Medium Enterprises (SMEs) feel that climate change will have some impact on their business it is rarely a top priority.⁶⁶

3.3.2 Lack of awareness and education

The risk posed by climate change is poorly understood and barely recognised in Kent. Therefore it is vital that there is a much greater level of awareness of the risks and consequences.

⁶⁶ Norrington and Underwood (2008)

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There is some ongoing action. For example, the Environment Agency raises awareness of flood risk through the promotion of their Floodline service to those properties in a known flood risk area. However, they have found that uptake still remains low and are asking for Floodline to be an 'opt-out' service rather than a voluntary 'opt-in' and this was supported by the Pitt Review⁶⁷.

However, local authorities should be doing more, particularly when it comes to their Local Development Framework policies and individual planning application decisions. This will require training and awareness raising among councillors, council officers, applicants and planning consultants.

While the quality of information being provided is important, who it comes from and how it is delivered is also vital because if the source is not trusted then the information will be ignored.

3.3.3 Inter-generational equity vs. immediate need

The most widely used definition of 'sustainable development' is: 'meets the needs of the present without compromising the ability of future generations to meet their own needs'⁶⁸. The term has been widely used and abused over the last twenty years. However what is most striking is that the UK government definition refers to maintaining high levels of stable economic growth and in many government documents Sustainable Development and Sustained Economic Growth are synonymous. This makes the bold assumption that economic growth today will not harm the interests of future generations. That climate change is largely a product of economic growth shows that this is not the case. For economic growth to be truly sustainable it needs to be decoupled from carbon emissions and non-renewable use of natural resources. Whilst some economies, such as the UK, appear to have been making progress in this direction, the reality is that most polluting manufacturing industries has been outsourced to China and India where lower environmental and labour standards means that the products can be made cheaper than in Europe.

It has been estimated that at least a quarter of China's carbon emissions can be attributed to the manufacture of products for consumption in Europe and America⁶⁹. In addition, China is investing heavily in African regimes, like Zimbabwe, to procure minerals, timber and other resources at least-cost and with little or no regard or benefit to the local society, economy or environment⁷⁰.

Because of the outsourcing of manufacture and natural resource extraction from Kent, the county has, by in large, managed to retain a lot of its character and environmental quality. Indeed, the closure of manufacturing in much of Kent has enabled some improvements to water quality and air quality. But by exporting much of our ecological footprint we are much less aware of it, what impact it has and responsibility we have to minimise it.

The primary political argument for economic growth is job creation, which is seen as the best, indeed only, way of tackling poverty and maintaining a stable society. While this has undoubtedly been successful, this driving economic paradigm takes no account of finite limits to natural resources or natural processes. This has led to massive depletion of the global natural capital worldwide.

If we do not reduce our consumption of resources to fit the One Planet Living constraints, then future generations will be poorer than us, have to face tougher climate challenges and have fewer resources with which to adapt.

⁶⁷ ES.100, p. xxxii Pitt (2008)

⁶⁸ Commonly attributed to the Brundtland Report: Our Common Future (1987)

⁶⁹ <http://news.bbc.co.uk/1/hi/uk/7052115.stm> (viewed 03/09/2008)

⁷⁰ http://www.royalafricansociety.org/index.php?option=com_content&task=view&id=368&Itemid=70 (viewed 03/09/2008)

3.3.4 Directing market forces

The fastest, most effective way of delivering climate change adaptation will be through market forces pushing the uptake of information, technology and enabling individuals and organisations to look after themselves. However, even the Confederation of British Industry (CBI) acknowledges that the full range of public policies will need to be deployed to create the right incentives⁷¹. Some barriers, such as taxation or regulation, may need to be removed or refocused. The danger in doing this is that this often creates unforeseen consequences that may make the situation worse rather than better.

For example, Landfill Tax was designed to implement the 'polluter pays' principle so that those who create waste have to pay for its proper disposal or recycling. An unintended consequence has been the dramatic increase in flytipping in the Kent countryside as unscrupulous operators seek to dodge their responsibilities and make unlawful profit.

3.3.5 Mismatch between those who bear the costs and those who receives the benefits

Many adaptation measures cost more to implement than continuing with existing practices. This is likely to present a barrier, particularly in the construction industry where the developer who is exposed to the additional cost does not benefit, unless the cost of the adaptation measure can be passed onto the customer. For this to happen, the house-buyer needs to be sufficiently aware of climate issues and value the additional benefits of the added measures enough to pay that premium. However, climate-proofing is unlikely to ever be the deciding factor in a house-buying decision, therefore there won't be the market signal to demonstrate that there is demand for these measures, even if there is.

There are likely to be other instances where the party that bears the cost of adaptation is not the primary beneficiary. For example, putting in drainage that stops storm water from your property flooding your neighbour. On a larger scale, a housebuilder may have to give up developable land for a detention pond that provides flood protection to not just his development but also an adjacent one, or a development that has not yet been built.

Another example is the slow adoption of green roof technology. They are able to reduce storm runoff, act as effective insulation and reduce air pollution. A barrier to their adoption is that many of their benefits are accrued by the wider society and not necessarily the building owner, with the exception of the insulation effect. For example, it has been estimated that greening 10% of the roofs in Chicago would reduce public health spending by \$31 million to \$118 million per year⁷².

In these instances there needs to be a fair system of regulation, tariffs, tax-breaks or claw-back mechanisms, otherwise development won't go ahead or would do so with a compromised, poorly performing solution. This is a common situation with Sustainable Drainage Systems (SUDS) across large development areas like Ashford where each developer has implemented their own solution, creating a disorganised, unconnected patchwork of greenspaces and drainage systems. The masterplanning, Green-Blue Grid work and SUDS strategy has helped overcome this by creating clear ground rules.

3.3.6 Conflicts between mitigation and adaptation

The principal focus of adaptation is the control and reduction of risk to health, life and property. With such aims it will be tempting, in many cases, to use energy-intensive engineering solutions that can deliver results with a high degree of control and certainty. However, the associated carbon emissions are likely to undermine mitigation efforts to reduce atmospheric carbon dioxide and reduce severity of the climate changes that we will have to adapt to.

⁷¹ p.2, CBI (2007)

⁷² Clark *et al* (undated)

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Even if the energy is supplied from renewable sources, there is an opportunity cost in that energy not being put to uses that produce more valuable social and economic outputs.

For example, water companies in Kent are looking to increasing more energy intensive solutions, such as desalination, effluent re-use and water transfer pipelines to meet the growing demand and the reduced certainty of supply.

As the volume of wastewater increases, and river flows decrease, so wastewater treatment is becoming more energy intensive to ensure that the final effluent meets the standards set by the Environment Agency.

It has also been suggested that land management schemes for river basin protection, for example the use of land for water storage to alleviate flooding, may have implications for emissions of greenhouse gases⁷³.

⁷³ EEA 2007a

4 Conclusion

4.1 Summary of UKCIP 2002 Climate Change Scenarios.

Update of 2050 and 2080 forecasts and implications for the 2° C critical threshold; possibly with an emphasis on the more direct negative impacts: (air quality, public health, infrastructure failures, fire risk, pests, air conditioning, water resources and environmental quality storm intensities and localised flooding, sea level rise, coastal erosion etc) Kent expected to suffer higher temperature increases and more severe drought episodes than elsewhere in U.K.

4.2 Indirect effects

UK expected to be less affected than elsewhere in Europe but need to address the consequences of more profound changes taking place in many other parts of the world; most of these arising from, or exacerbated by, population growth. e.g. –

- depletion of natural resources (incl water supplies)
- deforestation
- desertification
- reduction in cereal based food production in favour of grazing or bio-fuels; both perceived as more profitable
- loss of biodiversity and species extinction
- continuing emphasis on fossil fuels and nuclear power
- growth in air travel (mainly leisure) generated by advantageous fuel subsidies and tax breaks.

As a result the UK and Kent face the prospect of increasing levels of immigration by refugees from the most severely affected regions. The pressures from population expansion are further augmented by what appears to be a universal commitment to economic growth as an unalloyed benefit; hence the continuing adherence to true market values, notwithstanding that these are almost totally at odds with the criteria defining economic, environmental and social sustainability. (Ref to later discussion of “Foresight” scenarios as the framework for assessing different options for addressing climate change)

The question then arises as to whether these two opposing philosophies can be reconciled by adopting a free-market response to environmental challenges (as employed in recent rainforest conservation initiatives based on carbon trading)

4.3 CPRE Priorities

CPRE has identified 3 aspects which should, in our view, be given priority attention in the strategy for adapting-to and mitigating the impact of climate change in Kent:-

- Building Design and Planning
- Water Management
- Coastal Management

4.3.1 Building Design and Planning.

All of the forecast changes in rainfall, temperature and wind speed will impact to varying degrees on most aspects of a building's design and construction, as well as on the setting, infrastructure and essential services (Table 2.4). Many of the aspects (drivers) relate to the quality of life and security of the occupants, and to the efficiency of the buildings as elements of a viable community plan. And the plan must be sufficiently robust and flexible to accommodate all of the significant climate shifts anticipated during the design life of the development, and also deliver the requisite improvements in emission levels within the target date.

4.3.2 Water Resource Management.

Key issues for Kent, associated with the impact on the balance of water resources:-

- decreasing effective rainfall,
- increasing public supply demand,
- increasing drought frequency and severity,
- additional stress on surface and groundwater resources,
- further depletion of river flows, water table levels and wetland storage,
- greater urgency for implementation of EWFD and Habitats Directive for restoring sustainable abstractions and improving environmental quality of the County's rivers and wetlands,
- increased cost to the community in maintaining levels of service for public supply and security of supplies for direct abstraction (including agriculture and horticulture)
- in extreme cases, additional constraints on further increases in the use of water for irrigation – with implications for the rural economy.
- an overall increase in the cost of development and management of new sources of supply for public distribution.
- greater urgency for implementation of water efficiency measures.

4.3.3 River Flood Management.

Depending on the rate of increase in greenhouse gas emission levels, we must expect to see a corresponding increase in the frequency and magnitude of storm events, with an accompanying expansion of the indicative flood plain areas. This has implications for future housing development in locations on or close-to the borders of major floodplains; which must add urgency to the need for the incorporation of SUDS and other drainage regulation facilities as a pre-condition for the grant of planning consents.

Recent experience from the north midlands has also highlighted what may in future prove to be the even-greater threat to power supplies, communications and emergency services.

4.3.4 Coastal Management.

If we take this as comprising measures to protect against or alleviate storm-tide flooding and coastal erosion, our concerns for any area facing either of these threats would primarily centre on the more vulnerable communities and designated conservation areas. The continuing increase in land values might now also justify a review of earlier assessments of agricultural areas that may

have resulted in relatively unfavourable cost/benefit ratings for purposes of special protection measures.

4.4 Adaptation.

The Stern Report recognises the need for early action to adapt to climate change and, where practicable, ameliorate its negative impact. We should, at the same time, exploit any opportunities to derive benefit from the changes. By and large; any action on these lines would be carried through as local initiatives, albeit within the context of National, Regional or County strategies.

An adaptation strategy would therefore need to have the scope and resilience to:-

- plan and prepare for events,
- respond effectively in minimising the impact,
- follow up with the necessary recovery and remedial measures.

In the long term, the strategy must also accommodate the effect of any future acceleration of the forecast changes; those which could, for example, bring increasingly severe droughts or greater frequency and magnitude of flood events.

Use of the Foresight Scenarios helps to define the range of political / economic regimes, usually represented by four different profiles (Ref Table 3.2), any one of which is likely to obtain at anytime in the future. Each can be distinguished by a characteristic relative level of greenhouse gas emissions:-

- World Market (high gge): A free market, minimal regulation regime allowing maximum economic growth and individual freedom.
- National Enterprise (med-high gge): State-centred and protectionist with a high priority on national prosperity.
- Local Stewardship (med-low gge): Selective intervention but with regional devolution and a strong environmental and conservation agenda.
- Global Sustainability (low gge): International perspective with a focus on UN millennium goals.

Governance in the UK is essentially 'World Market'; environmentally high risk and unlikely to carry through or even support an effective climate-change management programme. The current administration clearly regards sustainable development as broadly synonymous with sustained economic growth, and fails to acknowledge the latter as the key driver, accelerating global warming and the depletion of natural resources. It undermines the principal of sustainability by serving the needs of the present, to the detriment of future generations. As evidence, we see the continuation of a housing programme for Thames Gateway and Ashford which as yet makes no provision for resource or energy efficiency, or any coherent initiatives on urban flood alleviation.

A move to a 'National Enterprise' regime would similarly fail to constrain emission levels to within the 2° C growth threshold. This therefore leaves us with two choices, assuming of course that 'doing nothing' is not an option. Neither should we rest content with the current regime with its impressive agenda of environmental objectives but with little evidence as yet of any progress toward effective delivery. We seem therefore to have little alternative to a major cultural shift away from consumer-driven high growth and towards a programme combining the essential elements of Local Stewardship and Global Sustainability. Having said this, it can also be argued that a good outcome could be achieved by exploiting the instincts serving national and individual material interests, but which at the same time could prove affective in reconciling the competing

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goals of growth and sustainability. The rainforest carbon trading experiments could provide one such approach, focusing on financial rewards rather than penalties. (Give greed a chance?)

5 Glossary

Term	Acronym	Description
Catchment Abstraction Management Strategy	CAMS	
Catchment Flood Management Plan	CFMP	
Green House Gases	GHG	Gases that influence the global climate by a process called "radiative forcing". Carbon Dioxide (CO ₂) is the most significant gas in terms of volume emitted, however other gases, such as methane (CH ₄), nitrous oxide (N ₂ O) have a much greater warming effect. Some gases and particulates have negative warming effect, such as Sulphur Dioxide (SO ₂), which is principally emitted by volcanoes.
Local Development Framework	LDF	Replaces the former Local Plan and is intended to be a much broader collection of planning documents that include social, economic and environmental objectives.
Non-governmental Organisation	NGO	Non-profit organisation, either a charity or social enterprise. Includes lobby groups, campaigning organisations (like CPRE), think tanks, conservation, health and social bodies.
Precipitation		Rain, snow, hail, sleet, dew
Regional Spatial Strategy	RSS	For Kent, this is the South East Plan, which will supersede the Kent & Medway Structure Plan (2006) when it is finally adopted.
Shoreline Management Plan	SMP	
Source-Pathway-Receptor framework	SPR	
Section 106	S106	The provision within planning permission process for local authorities to get developers to contribute money from their scheme towards public infrastructure

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7 Appendices

7.1 Observed Climate changes

Table 7-1: Observed changes in Kent

Parameter	Season	Period	Value	Period	Value	Change	Variation across Kent
Mean Temperature	Spring	1961-1990	6-10 °C	1971-2000	8-10 °C	+0.3 – +0.5 °C	Colder at high elevations: the top the North Downs, Greensand Ridge and High Weald
	Summer		14-18 °C		14-18 °C	+0.3 – +0.5 °C	Warmer on North Kent coast and along the Royal Military Canal/inland areas of Romney Marsh
	Autumn		10-12 °C		10-12 °C	+0 – +0.2 °C	Little variation
	Winter		2-6 °C		4-6 °C	+0.4 – +0.7 °C	Colder at high elevations: the top the North Downs, Greensand Ridge and High Weald
	Annual		8-12 °C		8-12 °C	+0.3 – +0.4 °C	Warmer on North Kent coast and Romney Marsh
Maximum Temperature	Spring	1961-1990	12-14 °C	1971-2000	12-14 °C	+0.3 – +0.5 °C	Cooler in the high East Kent North Downs
	Summer		18-22 °C		20-22 °C	+0.3 – +0.5 °C	Cooler on the North Downs ridge
	Autumn		14-16 °C		14-16 °C	0 – +0.1 °C	Cooler on the North Downs ridge
	Winter		6-8 °C		6-8 °C	+0.5 – +0.7 °C	Little variation
	Annual		12-14 °C		12-16 °C	+0.3 – +0.5 °C	Warmer around Dartford/Gravesend and the Low Weald
Minimum Temperature	Spring	1961-1990	2-6 °C	1971-2000	2-6 °C	+0.3 – +0.5 °C	Cooler in inland West Kent
	Summer		10-12 °C		10-14 °C	+0.1 – +0.5 °C	Little variation in 1961-1990 but becoming hotter on North Kent coast and Romney Marsh during 1971-2000
	Autumn		6-8 °C		6-8 °C	0 – +0.3 °C	Little variation
	Winter		0-2 °C		0-4 °C	+0.3 – +0.7 °C	Little variation in 1961-1990 but becoming warmer around the coast during 1971-2000
	Annual		4-8 °C		4-8 °C	+0.1 – +0.5 °C	Cooler in inland West Kent and East Kent North Downs
Days of Air Frost	Annual	1961-1990	50–70	1971-2000	30-70	-10 – -4	1961-2006 changes show a wide variation in changes across the county, probably dependent on elevation, topography and exposure to warm marine wind.
Precipitation	Spring	1961-1990	100 – 180mm	1971-2000	100 – 180mm	-5 – +5	More on the North Downs ridge

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Parameter	Season	Period	Value	Period	Value	Change	Variation across Kent
	Summer		100 – 180mm		100 – 180mm	-10 – +5	Less precipitation on Thanet between 61-90 and 71-00
	Autumn		180 – 350mm		180 – 350mm	-5 – +10	More on East Kent North Downs, less on the Hoo Peninsula and Sheppey. Small increase in West Kent between 61-90 and 71-00
	Winter		180 – 260mm		180 – 260mm	-5 – +5	Less on Romney Marsh, North Kent coast and the Medway valley around Aylesford
	Annual		450 – 1000mm		450 – 1000mm	-5 – +5	More on the North Downs and High Weald

7.2 Predicted Changes

Table 7-2: UKCIP02 project changes in Kent⁷⁴

Climate Parameter	Season	Low Emissions			High Emissions		
		2020s	2050s	2080s	2020s	2050s	2080s
Temperature (change °C) annual and seasonal means	Annual	1.0	2.0	2.5	1.5	2.5	4.5
	Winter	1.0	1.5	2.0	1.0	2.0	3.5
	Spring	1.0	1.5	2.0	1.0	2.5	3.5
	Summer	1.5	2.0	3.0	1.5	3.5	5.0
	Autumn	1.5	2.0	3.0	1.5	3.0	5.0
Precipitation (% change) annual and seasonal means	Annual	0	0	-10%	0	-10%	-10%
	Winter	+10%	+15%	+20%	+10%	+20%	+30%
	Spring	0	0	0	0	0	+10%
	Summer	-20%	-30%	-30%	-20%	-40%	-60%
	Autumn	-10%	-10%	-10%	-10%	-20%	-20%
Diurnal temperature range (change °C)	Annual	+0.2	+0.2	+0.2	+0.2	+0.4	+0.4
	Winter	0	0	0	0	0	0
	Spring	0	0	0	0	0	+0.4
	Summer	+0.2	+0.4	+0.4	+0.4	+0.6	+1.0
	Autumn	+0.2	+0.2	+0.4	+0.2	+0.4	+0.4
Soil moisture content (% change)	Annual	0	-10%	-10%	0	-10%	-20%
	Winter	-10%	-10%	-10%	-10%	-10%	-10%
	Spring	0	0	0	0	0	0
	Summer	0	0	-20%	0	-30%	-40%
	Autumn	0	-20%	-30%	0	-30%	-50%

⁷⁴ Interpreted from “http://www.ukcip.org.uk/scenarios/ukcip02/maps/seasonal_changes.asp”

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Climate Parameter	Season	Low Emissions			High Emissions		
		2020s	2050s	2080s	2020s	2050s	2080s
Average winter snowfall (% change)	Winter	0	-50%	-70%	0	-70%	-99%
Cloud cover (% change)	Annual	-3%	-3%	-6%	-3%	-6%	-6%
	Winter	0	0	+3%	0	+3%	+3%
	Spring	0	0	-3%	0	-3%	-6%
	Summer	-6%	-6%	-9%	-6%	-9%	-15%
	Autumn	-3%	-3%	-6%	-3%	-6%	-9%
Daily mean wind speed (% change)	Annual	+3%	+3%	+3%	+3%	+3%	+5%
	Winter	+3%	+5%	+5%	+3%	+7%	+11%
	Spring	+3%	+3%	+3%	+3%	+3%	+3%
	Summer	0	0	0	0	0	+3%
	Autumn	0	-3%	-3%	0	-3%	-5%

7.3 Critical Thresholds

Table 7-3: Building design & planning critical thresholds

Driver Group	Driver	SPR Class	Critical Threshold(s)	Indicator
Climate Change	Precipitation	Source	Overloading of building's gutters and drains Empty rainwater tanks	local rainfall records
	Temperature	Source	Risk of heat-related illness	No. of days with temperature >30 °C?
	Storminess/Wind speeds	Source	Damage to building fabric	local wind records
	Floodwater	Source	Floodwater entering building	
Building structure	Roof	Pathway	Damage	Insurance claims
	Exterior Walls	Pathway	Damage	Insurance claims
	Windows & Doors	Pathway	Damage	Insurance claims
	Foundations	Pathway	Damage	Insurance claims
Setting	Impermeable curtilage: driveway, yard, paths, decking, car parks	Pathway	Building, or neighbours, suffer from surface flooding	Percentage impermeability of curtilage
	Adjacent buildings/urban area	Pathway	Risk of heat-related illness	No. of days with temperature >30 °C?
	Adjacent open space, water bodies, countryside	Pathway/Receptor	Flood risk greater than 1-in-100 years (1%)	Environment Agency flood maps
	Adjacent trees and planting	Pathway	?	?
	Underlying soil/geology	Pathway/Receptor	Groundwater flooding occurs	Records of past events and groundwater levels
Infrastructure	Water supply	Pathway	Potable water supply cut off	Hosepipe bans, Non-essential use bans, drought orders
	Foul sewerage	Pathway	Foul sewer connection cut off	Water company records
	Surface drainage	Pathway	Surface drainage connection cut off	Water company records
	Roads and pavements	Pathway	Floodwater entering building from roads Melting asphalt that prevents use of road or pavement	Local authority records
	Infrastructure impacts	Receptor	Any impacts that can be traced back to the building	Local authority records
Human Behaviour	Water use	Pathway	?	Per capita water use + leakage
	Heating, cooling and appliance use	Pathway	?	Per capita energy demand
	Building occupancy and use	Pathway	?	?
	Maintenance	Pathway	Building system (e.g. drainage) no longer working	?
	Enjoyment and health of the occupants	Receptor	No. of heat related deaths/illnesses No. of flood/pollution related deaths/illnesses No. cases of depression or other psychological disorders	NHS records
	Public attitudes and expectations	Receptor	Public unwilling to co-operate or actively campaigns against measures	various
Socio-	Contents and property	Receptor	Damage	Insurance claims

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Driver Group	Driver	SPR Class	Critical Threshold(s)	Indicator
economics	Social impacts	Receptor	Social breakdown	Crime statistics Poverty statistics Education statistics Nuisance reports
	Urban impacts	Receptor	Building or area no long viable for occupation	Planning and demolition records
	Historic heritage & landscape	Receptor	Permanent loss of a historic or landscape asset	Historic buildings registers Landscape assessments
	Science, engineering and technology	Receptor	?	?
Environmental quality	Biodiversity	Receptor	Loss of species and key habitats	Kent Biodiversity Action Plan (BAP) and wildlife survey data
	Pollution	Receptor	Harmful pollution events	Environment Agency pollution incident inventory and routine monitoring data NHS records

7.4 The Nottingham Declaration on Climate Change

7.4.1 Text

We acknowledge that

- Evidence shows that climate change is occurring.
- Climate change will continue to have far reaching effects on the UK's people and places, economy, society and environment.

We welcome the

- Social, economic and environmental benefits which come from combating climate change.
- Emissions targets agreed by central government and the programme for delivering change, as set out in the UK Climate Change Programme.

• Opportunity for local government to lead the response at a local level, encouraging and helping local residents, local businesses and other organisations - to reduce their energy costs, to reduce congestion, to adapt to the impacts of climate change, to improve the local environment and to deal with fuel poverty in our communities.

• Endorsement of this declaration by central government.

We commit our Council from this date to

- Work with central government to contribute, at a local level, to the delivery of the UK Climate Change Programme, the Kyoto Protocol and the target for carbon dioxide reduction by 2010.
- Participate in local and regional networks for support.
- Within the next two years develop plans with our partners and local communities to progressively address the causes and the impacts of climate change, according to our local priorities, securing maximum benefit for our communities.
- Publicly declare, within appropriate plans and strategies, the commitment to achieve a significant reduction of greenhouse gas emissions from our own authority's operations, especially energy sourcing and use, travel and transport, waste production and disposal and the purchasing of goods and services.
- Assess the risk associated with climate change and the implications for our services and our communities of climate change impacts and adapt accordingly.
- Encourage all sectors in our local community to take the opportunity to adapt to the impacts of climate change, to reduce their own greenhouse gas emissions and to make public their commitment to action.
- Monitor the progress of our plans against the actions needed and publish the result.

Council acknowledges the increasing impact that climate change will have on our community during the 21st century and commits to tackling the causes and effects of a changing climate on our city/county/borough/district.

Version: NDCC Revised Version 8/8/2006

7.4.2 Kent signatories

Council	Date Signed
Kent County Council	2001
Medway Unitary Authority	14 November 2006
Ashford Borough Council	11 January 2007
Tunbridge Wells Borough Council	9 February 2007
Shepway District Council	20 June 2007
Sevenoaks District Council	8 October 2007
Swale Borough Council	21 November 2007
Canterbury City Council	signed
Maidstone Borough Council	signed
Tonbridge & Malling Borough Council	signed
Dartford Borough Council	
Dover District Council	
Gravesham District Council	