Living with Climate Change in the East of England

Stage 1 Report: Guidance on Spatial Issues

Prepared for
Hertfordshire County Council
on behalf of the
East of England Regional Assembly
and
East of England
Sustainable Development Roundtable
by
Land Use Consultants
in association with
CAG Consultants
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APPENDICES

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1. INTRODUCTION TO THE SPATIAL STUDY

1.1. The issue of climate change has been of increasing concern for many years. It is now widely accepted in both scientific and political circles that climate change is happening, that human activity is contributing to it, and that the impacts are likely to be dramatic if not for this generation, then certainly for future ones. Accommodating the impacts of climate change is vital and this will require adaptation strategies.

1.2. In September 2002, the East of England Regional Assembly and Sustainable Development Roundtable appointed Land Use Consultants in association with CAG Consultants and SQW Ltd to undertake a study to provide authoritative guidance to enable the development of a range of policy initiatives and practical actions for regional adaptation to climate change.

1.3. This report provides guidance on adapting to climate change in spatial terms at the regional level, which makes up **Stage 1** of the study. This will be followed by **Stage 2** looking at local service provision. The aims and objectives of the study and the key stages are discussed below.

STUDY AIMS AND OBJECTIVES

1.4. The specific objectives of the study are to:

- Provide decision-makers in the East of England with a synthesis of evidence on the expected regional effects of climate change over the next century, this to include regional agencies, local authorities, business support organisations and where appropriate key businesses within the East of England;
- Identify appropriate measures to put in place in policies, strategies, and programmes to address the effects of these changes - when considering measures thought should be given to any potential conflicts with existing regional strategy/policy and the likely costs involved in undertaking such measures;
- Provide authoritative input to the process of producing draft Regional Planning Guidance (RPG) for the East of England and for the production or revision of other regional strategies;
- Identify local government services which would be affected by climate change, the degree to which adaptive measures could be taken, and how these might necessitate changes to service delivery for (each of) county, district and unitary services, and identify how this pattern might differ across the region;
- Identify practical and sustainable actions that can be started now, or in the short to medium term (10-20 years);

- Provide advice on ways of communicating the likely impacts of climate change to regional stakeholders and the wider public so as to raise awareness of the need, and support for, adaptation measures;
- Produce a reference work comprising a range of source materials capable of use by a wide range of audiences in the private, public and voluntary sectors, schools and by other learning groups and by the public at large on climate change in the Eastern Region; and
- Inform the development of the Sustainable Development Framework for the East of England through the identification of performance targets.

KEY STAGES OF WORK

1.5. Together the stages of the study address regional and more local level adaptation measures.

1.6. **Stage 1: Spatial Study**, has involved a scoping exercise and the production of this guidance on the key spatial decisions, and the strategies and actions required to address them. The method of approach to Stage 1 is outlined below.

1.7. **Stage 2: Local Service Provision**, will consider which services are likely to be affected by climate change; whether the effect is likely to be similar across the region as a whole; what opportunities might be afforded (e.g. promotion of environmental technologies, tourism, agricultural diversification etc.); the key decisions that will need to be made with respect to these effects and opportunities; and when these decisions will need to be made by (e.g. short term, medium term, long term).

1.8. **Stage 3: Final Report** will bring together the findings of the work carried out in the first two stages of the study. It will provide guidance for regional bodies, local government, the private sector, agencies, support groups and other service providers, on the local policy decisions, strategies and actions required to adapt to the effects of climate change and the likely threats and opportunities presented.

METHOD OF APPROACH TO STAGE 1

1.9. Stage 1 has involved the following tasks:

Task 1: Scoping Exercise and Inception Report

1.10. The findings of the scoping exercise were set out in an Inception Report, outlining the key issues to be covered by the study.

Task 2: Literature Review and Data Analysis

1.11. There is a considerable amount of material built up through the work of the UK Climate Impacts Programme (UKCIP) and through other research, that details the potential impacts of climate change. Whilst some of this work is at the global or national scale, details are now being developed at the regional level, for example through the Regional Climate Change Impact Response Studies (REGIS) in East Anglia and Northwest England, and research by the Tyndall Centre at University of East Anglia (UEA). Our research sought to establish and confirm the impacts of climate change on the East of England, including:

(i) Changes affecting the whole region, where decisions will need to be made at the strategic level (e.g. distribution of development; infrastructure investment; etc.).

(ii) Changes affecting specific locations (e.g. the Coast, or the Fens).

(iii) Changes affecting the whole region where decisions will need to be made at the local level.

1.12. Stage 1 of the research has concentrated on (i) and (ii). Stage 2 will focus on (iii).

Task 3: Identifying Key Decisions to be made in Spatial Terms

1.13. Having identified the changes that are likely to affect the East of England at the regional level, and for specific broad locations, the consultancy team considered the following:

- Which of the changes are likely to require a spatial response;
- Which parts of the region (and, where relevant, economic sectors) these are likely to affect;
- What key decisions have to be made;
- Level of uncertainty and risk attached.

1.14. Particular attention was focused on the role of RPG14; however, this was not at the expense of longer-term decisions that may be of equal, if not greater, importance.

Task 4: Stakeholder Group Workshop

1.15. Having determined the issues and the questions, a workshop with the Stakeholder Group was held on 29 November to debate the way forward, with the aim of coming to consensus on the broad spatial decisions that have to be made. A list of attendees is given at **Appendix 5**. The project has been overseen by a Project Steering Group (**Appendix 4**).

1.16. Attendees took part in two workgroup sessions; the first looked at pressures and opportunities created by climate change and possible principles and adaptation strategies for responding to these. The second session looked at the implications of climate change for the RPG Options Consultation Document spatial scenarios.

1.17. The workshop proved to be a very useful and informative day, and many of the points raised in the workgroups and subsequent discussions have been used to develop this guidance on spatial issues.

Task 5: Guidance on Spatial Issues

1.18. Having undertaken data analysis and a literature review and consultation with a wide range of stakeholders. This document, reports on the spatial implications that are anticipated to result from the effects of climate change and provides guidance as to the key decisions that will need to be made in spatial terms and strategies and actions to see these implemented.

SOME KEY ISSUES UNDERPINNING THE GUIDANCE ON SPATIAL ISSUES

Adaptation versus mitigation

1.19. This study primarily seeks to provide guidance on adaptation strategies to enable the communities in the East of England to live with climate change. Whilst mitigation measures will play an important role in a long-term strategy to reduce our contributions to climate change, these are not the focus of this study.

Spatial guidance for regional level decisions

1.20. The study seeks to provide spatial guidance for regional level decisions, and as such makes broad recommendations to guide spatial development. However, local level measures (to be addressed in Stage 2), such as building design and management of flood risks, will play a very important role. They will have a major influence in dealing with the impacts of climate change on existing settlements. But they will be critical in the context of future new development, which may – in the light of wider sustainability considerations - be planned in areas, which are likely to be affected by the impacts of climate change.

Timescales

1.21. The study provides guidance for RPG and other strategies, but goes beyond the medium-term time scales of these strategies to provide guidance to the end of the century.

Scientific uncertainty and information availability

1.22. Good decision-making must be based on sound underlying information; however, information about climate change is relatively new and evolving, and information about the impacts of climate change is even less well established. Research studies, which are seeking to understand the potential impacts of climate change, are themselves subject to methodological uncertainties. Therefore, whilst this report is based on the best available information, the uncertainties inherent in planning for climate change must be recognised.

1.23. For some impacts very little information is available, particularly impacts based on the most up to date research into climate change. For example, flood risk is a major concern for the East of England, given its low-lying position and long coastline; however, there is very little available research to provide an indication of the actual extent of risk. Similarly more research is needed on the impacts of climate change on fluvial flooding. This guidance points to work that is being undertaken which will help to improve understanding of the potential impacts.

1.24. Despite these uncertainties decisions still need to be made. The paragraphs below discuss the approach taken to handling climate change related risks and uncertainties in decision-making.

Risk, uncertainty and decision making

1.25. Whilst the scientific understanding of climate change and the likely impacts arising is improving all the time, there is inevitably significant uncertainty and attendant risks attached. A precautionary approach has been taken in preparing the guidance in order to reduce the risk of adverse impacts.

1.26. Decision making within the context of climate change inevitably means dealing with risk and uncertainty. In most instances we have a reasonable understanding about the consequences of particular climatic events e.g. we know the consequences of flooding. The uncertainty is related to the probability and severity of potential events.

1.27. This points to the necessity of making decisions that balance the risks of climate change impacts against other factors. Uncertainty could strongly impact on spatial decisions that primarily address issues or risks associated with present or future levels of climate variability, climate extremes and/ or future climate change that have major social, environmental or economic implications.

1.28. UKCIP is soon to publish its recommended decision making framework for dealing with risk and uncertainty in such instances.[1] The iterative decision making framework involves detailed risk assessments. UKCIP recommend users should investigate a wider range of climate change scenarios than are set out in the UKCIP02 scenarios report. UKCIP can provide advice on the use of scenarios.

1.29. Decision makers will need to be particularly aware of not making decisions that could constrain or reduce the effectiveness of future options for

[1] R. Willows and R. Connell, *Climate Adaptation: Risk, Uncertainty and Decision-Making.*

adaptation e.g. allowing housing developments in areas vulnerable to flooding, which might prevent effective flood management in the catchment in the future.

1.30. There will be decisions that can be made because they lead to significant benefits now, that are unrelated to climate change. These can be described as 'low or no-regrets' measures. For instance a decision to allow the sea to breach current sea defences might be justified now on the basis of creating new salt marsh habitats while in the long-term this might be a necessary adaptation to climate change.

The relationship between climate change perspectives and wider sustainability considerations

1.31. The guidance aims to provide a recommended spatial approach from one perspective only: that of climate change. Thus in terms of implementation, this approach is clearly – and necessarily - partial. Issues relating to climate change will need to be considered alongside a whole range of other factors pertaining to sustainability in the round. These being set out in the region's framework for sustainable development[2] (e.g. use of brownfield sites, imperatives for social and physical regeneration, high and stable levels of employment, etc.). It is quite possible that the conclusions deriving from a climate change perspective may run counter to many of those deriving from these other important considerations. Deciding upon the most sustainable approach taking all factors into account is the role of other strategies, particularly RPG14. Whilst this guidance will inform this process, from a climate change point of view, it is for techniques such as sustainability appraisal to take a broader perspective.

1.32. The UK Sustainable Development Strategy[3] contains ten guiding principles which should shape the development of sustainable policy, and are very useful when considering how to respond to the impacts of climate change:

- Putting people at the centre;
- Taking a long-term perspective;
- Taking account of costs and benefits;
- Creating an open and supportive economic system;
- Combating poverty and social exclusion;
- Respecting environmental limits;

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[2] East of England Regional Assembly and East of England Sustainable Development Round Table (October 2001) *Sustainable Development Framework for the East of England*.

[3] *A Better Quality of Life: A strategy for sustainable development in the UK*. May 1999.

- The precautionary principle;
- Using scientific knowledge;
- Transparency, information, participation and access to justice;
- Making the polluter pay.

1.33. Several of these principles are particularly important when considering how to integrate climate change responses into policy, for example, taking a long-term perspective, respecting environmental limits, and implementing the precautionary principle.

STRUCTURE OF THIS REPORT

1.34. The remainder of this report is structured into the following sections:

- **Section 2: Climate change in the East of England** provides background on global climate change, and presents data from the UKCIP on climate changes in the East of England region.
- **Section 3: Climate change impacts** discusses the key climate change impacts facing the East of England, the main driving forces causing the impacts and where these impacts are likely to occur in spatial terms.
- **Section 4: Spatial guidance** presents a discussion on the issues facing the East of England, which will need to be considered when preparing adaptation strategies. It sets out a range of principles and adaptation measures, that could be applied, in order to live with climate change in the East of England and considers what these mean in spatial terms and the implications for the Spatial Scenarios, in the RPG 14 Options Consultation Document, as well as other strategies.

2. CLIMATE CHANGE IN THE EAST OF ENGLAND

2.1. One of the biggest challenges of addressing climate change is that it inevitably requires decision-makers to deal with risk and uncertainty given that it is not possible to give firm predictions on future climate. Not only is it difficult to predict what changes will occur to the climate and what impacts these will bring, but that the changes and impacts are likely to vary depending upon our ability and willingness to control the emissions which are causing climate change.

2.2. It is important to recognise that much of the change in the climate over the next 30 to 40 years has already been determined by historic emissions and because of the inertia in the climate system. We are likely; therefore, to have to adapt to some degree of climate change however much future emissions are reduced.

Global climate change

2.3. Global temperature has risen by about 0.6°C since the beginning of the twentieth century, with about 0.4°C of this warming occurring since the 1970s. 1998 was the single warmest year in the 142-year global instrumental record and 2001 was the third warmest (**Figure 2.1**). This warming could have been due to a number of causes, some human in origin and some natural. It is known that the Earth's climate changes substantially between an ice age and an inter-glacial period, but these changes occur over time-scales of a thousand years or more. The Earth's climate also varies naturally as a result of interactions between the ocean and the atmosphere, which causes variations in the climate from year-to-year, from decade-to-decade and from century-to-century. Reconstructions of Northern Hemisphere climate over the past 1,000 years reveal such variability. The warming observed over the past 100 years is larger than these natural variations in climate, suggesting that the recent rise in temperature cannot be solely due to natural variability of the climate system.

2.4. So what is causing the warming? There is new and stronger evidence to show that most of the warming observed over the last 50 years is attributable to human activities[4]. *Climate Change Scenarios for the United Kingdom* (Hulme et al., 2002) indicates that this change cannot be accounted for by natural variability alone. Modelling of natural factors, such as changes in the energy output of the sun and explosive volcanoes, shows that these factors can only explain some of the decade-to-decade changes in the climate. For example, warming during the early twentieth century, but not the warming observed over the last 40 to 50 years (**Figure 2.2a**).

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[4] IPCC, 2001: Climate Change 2001: Synthesis Report. A contribution of Working Groups I, II and II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.

2.5. Over the last one to two hundred years, human activities have also affected climate. Increased concentrations of greenhouse gases such as carbon dioxide, methane and low level ozone, trap more energy in the lower atmosphere and thus warm the climate. Changes in such human factors were used to drive a model, which shows that the recent rise in temperatures is well replicated (**Figure 2.2b**). When both human and natural factors are put together, the model produces a good simulation of global temperature over a 140-year period (**Figure 2.2c**). This provides evidence that humans are playing a major role in causing recent global climate change.

Climate change in the East of England

2.6. For the purposes of this study, use has been made of the UKCIP02 climate change scenarios[5] to provide an understanding of the changes that could potentially be experienced in the East of England. The scenarios reflect a range of possible future emissions, based on results from a set of experiments using the most advanced climate modelling capabilities. The actual level of emissions and hence climate change will depend on actions taken globally to limit emissions (or otherwise).

2.7. For this study the 'Low Emissions' and 'High Emissions' scenarios have been considered, as they provide a good range of potential climate changes:

- Low Emissions (increase in global temperature of 2.0^{o}C by the 2080s);
- High Emissions (increase in global temperature of 3.9^{o}C by the 2080s).

2.8. Even if global emissions of carbon dioxide eventually fall below today's level, as assumed in the UK Climate Impacts Programme 02 Low Emissions scenario (the Low Emissions scenario assumes an atmospheric CO^2 concentration of 525ppm by the 2080s), the future rate of global warming over the present century may be about four times that experienced during the twentieth century. If the emissions rate increases to approximately four times today's level – the High Emissions scenario – the future warming rate may be about eight times that experienced during the twentieth century.

2.9. The UKCIP02 study uses these scenarios to provide information on a range of climate change variables. These are grouped into seasonal changes, daily changes and changes in extreme events and marine and coastal changes.

2.10. The UKCIP02 scenarios present UK wide data at a 50km resolution. It is therefore possible to see the range of changes that might take place in the East of England. The data is also presented in three 30-year time periods centred on the 2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100).

[5] Hulme M et al. (2002), *Climate change scenarios for the United Kingdom: The UKCIP02 Scientific Report*, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

The changes in climate for each of these periods are calculated as the changes in 30-year average, with respect to the model simulated climate of the baseline period, 1961-1990. A summary of some key changes facing the East of England is provided below.

Temperature changes

2.11. The East of England region will get warmer under all the scenarios, to some degree. These changes are summarised in **Table 2.1a**. Temperature increases will be greatest in summer under the High Emissions scenario. By the 2080s we may see increases of up to 5°C. Under the Low Emissions scenario, there will still be increases in summer temperatures of between 2 and 3°C. Changes in average annual temperature are shown in **Figure 2.3**. The number of 'extremely warm' days[6] in summer will also increase.

2.12. Temperature changes will lead to a lengthening of the thermal growing season[7], of up to 100 days under the High Emissions scenario by the 2080s. It is important to note however, that this definition is dependent only on temperature and does not take account of water availability nor day-length and will not necessarily lead to year round plant growth. The number of heating degree days - which relate daily temperature to the demand for energy to heat buildings and to maintain a comfortable minimum temperature[8] will also be affected by temperature changes and will see a decrease. Conversely the number of cooling degree days- which relate daily

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[6] Extremely warm days have been defined using the 90th percentile daily-average temperature modelled for the baseline period 1961-1990, i.e. the daily average temperature which is exceeded, on average, on 10% of days.

[7] Thermal growing season - the length of the thermal growing season is defined as the longest period within a year that satisfies the twin requirements of: (i) beginning at the start of a period when daily-average temperature is greater than 5.5C for five consecutive days; and (ii) ending on the day prior to the first subsequent period when daily-average temperature is less than 5.5C for five consecutive days.

[8] Heating degree days - The number of heating degree days in a year gives an indication of the amount of time, and by how much, the temperature is below a given baseline. HDD are important because organisations have a legal obligation to maintain a minimum temperature in a building. The method used by UKCIP is that adopted by the Met. Office. The baseline standard is a daily-average temperature, Tmean - usually estimated as the average of the minimum and maximum temperatures for that day - of 15.5C. Therefore, HDD=15.5 - Tmean, and is summed for all days in a year, ignoring negative values. For example, if Tmean on one day is 10.5C, then there are 5 heating degree-days for that day. The formula for HDD is correct for cases when both the maximum and minimum are below the base. If this is not the case, various weighted increments are used to correct the basic equation.

temperature to the demand for energy to cool buildings and to maintain a comfortable maximum temperature[9] - will see an increase.

Table 2.1a: Key climate changes in the East of England (under low and High Emissions scenarios) by the 2080s – temperature related.

Variable	Summary of changes	
	Low Emissions scenario	**High Emissions scenario**
Seasonal temperature	• Annual warming by the 2080s of between 2-2.5°C • Summer temperature increases between 2-3°C	• Annual warming by the 2080s of between 3.5-4.5°C • Summer temperature increases of up to 5°C
Temperature extremes	• Number of 'extremely' warm days increases, especially in summer and autumn (an increase of up to 14 'extremely' warm days in summer) • Number of very cold days decreases, especially in winter	• Number of 'extremely warm' days increases, especially in summer and autumn (an increase of up to 30 'extremely' warm days in summer) • Number of very cold days decreases, especially in winter
Thermal growing season	• Increases by between 45 and 55 days	• Increases by up to 100 days
Heating degree days (an indication of the amount of time, and by how much, the temperature is below a given baseline)	• Decreases in heating degree days of between 20-25%[10]	• Decreases in heating degree days of between 40 and 45%[11]

9 Cooling degree days – Cooling degree days perform a similar function to HDD. There is no officially designated base temperature; in the UKCIP study, 22C has been used on the basis of building energy management practice. Thus, CDD=Tmean−22 which is summed for all days in the year, ignoring negative values. The formula holds when both the maximum and minimum temperatures are above 22C; in other cases weighted increments are used.
10 Compared to a baseline for the south of England of 2100−2300 HDD/year– this baseline is not available for the East of England, but the south of England baseline still gives a rough indication of the magnitude of the increase.
11 As previous.

Variable	Summary of changes	
	Low Emissions scenario	High Emissions scenario
Cooling degree days (which relate daily temperature to the demand for energy to cool buildings and to maintain a comfortable maximum temperature)	• Increases in cooling degree days of between 40 and 150 days[12]	• Increases in cooling degree days of between 80 and 200 days[13]

Precipitation changes

2.13. Rainfall patterns will change, with summers getting drier and winters wetter, leading to a slight decrease in annual rainfall. The frequency of 'intense' precipitation events in winter will increase[14], although they will decrease in frequency in summer. Soil moisture, which is a product of rainfall and evaporation, is set to decrease in summer and autumn under the High and Low Emissions scenarios, and will also decrease in winter under the High Emissions scenario. These changes are summarised in **Table 2.1b**. Percentage changes in average winter and summer precipitation are shown in **Figures 2.4** and **2.5**.

Table 2.1b: Key climate changes in the East of England (under Low and High Emissions scenarios) by the 2080s – precipitation related

Variable	Summary of changes	
	Low Emissions scenario	High Emissions scenario

[12] Compared to a baseline of 310–330 CDD/year days in the south of England – this baseline is not available for the East of England, but the south of England baseline still gives a rough indication of the magnitude of the increase.
[13] As previous.
[14] A measure of change in intense rainfall days per season is derived from quantile analysis. This method allows the definition of 'intense' to vary across the country. For example, under baseline conditions, an intense winter day's precipitation is between 35 and 45 mm in northwest Scotland, but only about 20 mm in southeast England.

Variable	Summary of changes	
	Low Emissions scenario	High Emissions scenario
Seasonal precipitation	• Wetter winters, between 10-20% wetter • Drier summers, between 20-30% drier • Drier overall annually, between 0 and 10%	• Wetter winters, between 25-35% wetter • Drier summers, between 40-60% drier • Drier overall annually between 0 and 10%
Precipitation intensity	• Increases in winter (around 0.25-0.75 more days of 'intense' rainfall in winter)	• Increases in winter (around 0.75-1.25 more days of 'intense' rainfall in winter)
Soil moisture	• Decreases in summer and autumn soil moisture of between 10-30%	• Decreases in summer and autumn soil moisture of between 30-50% • Up to 10% drier under the High Emissions scenario in parts of the region in winter

Changes in sea level

2.14. Regional changes in sea level are likely to occur. The sea level in the East of England is predicted to rise due to three factors: isostatic subsidence (on-going readjustment of the land to the de-glaciation that followed the last ice age – as a result much of southern Britain is sinking whilst much of northern Britain is rising relative to the sea) and climate-induced glacial melting and thermal expansion of ocean water. In the East of England a sea level rise of between 22cm and 82cm is predicted to occur, depending on the emissions scenario used.

2.15. Extreme sea levels due to storm surges are expected to increase in size and frequency. The data shows that simulated changes in the 50-year return period water levels, taking into account possible increased storminess, increased sea level and vertical land movements, are by 2080 between 1 and 1.4 m higher than experienced currently in the East of England. However, there are high levels of uncertainty associated with these predictions due to the assumptions used in the modelling. The regional model used in the UKCIP02 scenarios cannot produce simulations of surge height directly. Instead atmospheric winds and pressures have been used to drive a separate high resolution (30km) model with an ocean component. Different patterns and magnitude of change in surge height would be produced by using changes in climate extracted from another model, or by applying them to a higher resolution (12km) surge model. Earlier modelling work using a 12km surge model found the 50-year return period surge height off South East England to be much less. Figures relating to frequency and size of storm surges is presented in **Table 2.1c** below, and in **Figure 2.6 a and b**.

Table 2.1c: Key climate changes in the East of England (under Low and High emissions scenarios) by the 2080s – sea level

Variable	Summary of changes	
	Low Emissions scenario	**High Emissions scenario**
Sea level change	• Net sea level rise of approximately 22 cm (taking into account the effects of vertical land movement)	• Net sea level rise of approximately 82 cm (taking into account the effects of vertical land movement)
Extreme sea levels (storm surges)	• 50 year return surge height will increase by up to 1 m • Present 'once-in-50-year' storm surge will occur once every 10 years • Although high level of uncertainty in these predictions	• 50 year return surge height will increase by up to 1.4 m • Present 'once-in-50-year' storm surge will occur more often than once per year • Although high level of uncertainty in these predictions

Seasonality and variability

2.16. The East of England will also see changes in seasonality and variability. Seasonality is a measure of seasonal difference, for example between summer and winter. Seasonality will increase in terms of precipitation and temperature. Inter-annual variability provides an indication of the variation in seasonal temperature or precipitation that can be expected to occur from year-to-year as the climate warms. In the East of England, summer and autumn temperatures will become more variable as will winter and spring precipitation. Understanding the likelihood of experiencing anomalous seasonal temperatures and precipitations together can be useful. For example, the occurrence of high temperatures in a summer of low precipitation enhances drought conditions, while a warm and wet winter can result in building and flood damage. Winter depressions will also become more frequent leading to possible increased storminess, although there is a relatively low level of confidence associated with this result. Similarly winter wind speeds may increase somewhat, but there is, again, a high level of uncertainly associated with this result.

Table 2.1d: Key climate changes in the East of England (under Low and High Emissions scenarios) by the 2080s – seasonality and variability

Variable	Summary of changes
Seasonality	• Precipitation: greater contrast between summer (drier) and winter (wetter) seasons • Temperature: summers warm more than winters

Variable	Summary of changes
Variability	• Years as warm as 1999 (1.2°C warmer than average) become very common • Summers as dry as 1995 (37% drier than average) become very common • Winter and spring precipitation becomes more variable • Summer and autumn temperatures become more variable
Storm tracks	• Winter depressions become more frequent leading to possible increased storminess, but high uncertainty in this result
Windiness	• Slightly stronger winds (up to 10% stronger) may be experienced during winter, but again, high uncertainty in this result.

In summary, the East of England will experience:

- Hotter drier summers; milder wetter winters
- Significant decrease in soil moisture content
- Extreme high temperatures more frequent
- Extreme winter precipitation more frequent
- Increase in thermal growing season
- Net sea level rise and increase in sea storm surge height.

3. CLIMATE CHANGE IMPACTS

CLIMATE CHANGE IMPACTS WITH A SPATIAL DIMENSION

3.1. Changes in climate variables will result in climate change impacts. The focus of this study is to identify and address those impacts, which have a spatial dimension. Stage 1 is concentrating on those impacts that will affect the whole region and will require decisions to be made at the strategic level (e.g. distribution of development, infrastructure investment etc.) and changes affecting specific locations (e.g. the coast, or the Fens) which again, require a regional level spatial response. Stage 2 will consider changes affecting the whole region where decisions will need to be made at the local level (for example, changes to building structures to cope with subsidence, intense rainfall and hotter temperatures).

NOTES ON INFORMATION SOURCES ON CLIMATE CHANGE IMPACTS

3.2. A key source of information used to identify impacts facing the region is the REGIS study. Some background to this study is presented below.

Background information on REGIS – Regional climate change impact and response studies in East Anglia and North West England

The REGIS study is the first attempt to produce an integrated snapshot of possible futures for specific regions of the UK. It takes into account both climate change and socio-economic trends. The study presents some of the most regionally specific information available on the potential impacts of climate change, focussing on two regions of the UK: the North West and East Anglia. The latter, which covers Norfolk, Suffolk and Cambridgeshire, is very useful for informing this study, although the remainder of the East of England (Bedfordshire, Essex and Hertfordshire) is not covered. Nevertheless the study provides some useful findings in relation to flood risk, water resources, biodiversity and agriculture.

The REGIS scenarios

REGIS looks at how these regions might respond under two contrasting storylines of climate and socio-economic change. These two storylines are based on:

- The UKCIP98 Low and High **climate change scenarios** (whereas this study is based on the UKCIP02 Low and High scenarios) – the key differences between these scenarios is detailed below;
- REGIS **socio-economic scenarios** (using as a starting point the national scenarios commissioned by DETR for UKCIP). This is an important part of the project, because the future world will change even in the absence of climate change. They provide direct numerical model inputs of some parameters, as well as a qualitative and quantitative context within which to interpret the outputs of the integrated modelling and alternative policy visions of the future.

These are combined to provide two storylines, where:

- Climate change is at the upper end of the expected range and socio-economic development follows a 'regional enterprise' scenario, based on laissez-faire planning, individualism and global markets – *A Regional Enterprise future*;
- Climate change is assumed to be at the low end of the expected range, while socio-economic development follows a 'global sustainability' scenario, with heightened concern for the environment, and policies designed to encourage low-impact development and social cohesion – *A Global Sustainability future*.

Overall findings of REGIS

The findings represent a first attempt at an integrated assessment and should be considered indicative of broad trends, rather than concrete forecasts of an inherently uncertain future. Overall the study found that:

- Climate change is likely to have a noticeable impact at a regional level in the UK, but there is still considerable uncertainty about the scale and nature of the impacts;
- Socio-economic developments are likely to have a major influence on the scale of climate change impacts and will be crucial in determining the future of the two regions. Society has an important opportunity to manage the impacts through policy choices and adaptation.

3.3. As noted above, the REGIS study is based on the UKCIP98 scenarios, rather than the recently updated UKCIP02 scenarios, which are detailed in Section 2 of this study. Due to the relatively recent publication of the UKCIP02 scenarios (April 2002), much published research on the impacts of climate change is based on the earlier scenarios. Therefore, it is important to highlight the differences between the two sets of scenarios, to provide an understanding of how the climate change impacts identified in studies may be exacerbated or lessened. The key differences are summarised below, and the scenarios used by different studies are noted in the text.

Key differences between the UKCIP98 and UKCIP02 climate change scenarios

- The UKCIP02 scenarios provide greater regional detail;
- The UKCIP02 scenarios show slightly greater warming rates, especially for the Low Emissions scenario;
- The UKCIP02 scenarios show slightly smaller rates of sea-level rise than the 1998 scenarios, especially for the High Emissions scenario;
- Summers may become drier by a larger amount than under the 1998 scenarios;
- Spring and summer are likely to become slightly drier (the UKCIP98 scenarios suggested they would become wetter);
- The UKCIP02 scenarios suggest different patterns of change in average wind

speed compared to the 1998 scenarios, but there is still little confidence in the simulated changes;

- UKCIP02 includes a more comprehensive analysis in changes in some aspects of extreme weather and extreme sea levels and hence UKCIP has more confidence in the UKCIP02 results.

CLIMATE CHANGE IMPACT TOPICS

3.4. The East of England faces a range of climate change impacts, which will require regional level responses. In order to gain a better understanding of what sort of responses might be required, we have broken down our analysis into four 'impact topics' that capture the significant issues:

- Agriculture and forestry;
- Environmental assets – natural and cultural;
- Housing and the economy;
- Infrastructure – water resources, flood defence, energy and transport.

3.5. The key impacts facing the region are summarised in the box below. The impacts have been identified from a comprehensive literature review (see **Appendix 1**) and through consultation with stakeholders. At the end of each of the four sections on the climate change impact topics the findings from the stakeholder workshop are presented.

Summary of key climate change impacts facing the East of England

Agriculture and forestry

- Agriculture is likely to see an increased growing season; but decreasing soil moisture and availability of water supply for irrigation may constrain opportunities to capitalise on warmer temperatures;
- Access to land in winter may be constrained by increased precipitation, and possible increased storminess, causing waterlogging and flooding;
- Livestock production systems could be affected by higher temperatures, leading to increased requirements for drinking water, water wallowing sites for pigs and water to cool livestock units;
- Inshore and inland fisheries could be affected if low lying land is allowed to permanently flood. Impacts on coastal fisheries are uncertain, but external pressures on declining fish stocks are likely to exert far greater pressures on the industry;
- Favourable forestry species may change e.g. yields of Corsican Pine are predicted to increase, whilst Scots Pine is likely to decrease.

Environmental assets – natural and cultural

- Habitats and species may be affected by both direct loss through physical changes to the environment, e.g. from flooding and indirectly by temperature increases. The coast and wetland habitats will be particularly subject to change and the nature of change will depend greatly on management decisions (both in terms of flood defence and agriculture);
- Flood defence decisions may have implications for habitats e.g. potential 'coastal squeeze';
- Certain woodland species are likely to grow better whilst others will lose ground. Establishment of young trees is likely to be particularly affected;
- Water, soil and air quality may deteriorate to some extent;
- Built cultural assets may be affected by damage from contaminants, mobilised by higher temperatures, attacking foundations, subsidence and structural damage from possible extreme storm events;
- Historic sites in coastal and fluvial floodplains could be at risk of flooding.

Housing and the economy

- Housing and the economy are likely to be primarily affected by flood risk and availability of water supply and increases in occurrence of weather extremes such as storminess;
- Temperature increases may create opportunities for expanding the tourism industry in the East of England;
- Climate change may also create opportunities for other sectors e.g. civil engineering for provision of flood defences and opportunities for developing renewable energy such as solar power.

Infrastructure – water resources, flood defence, energy and transport

- Climate change is likely to cause demand for water to increase;
- Uncertainty over implications for water availability for public water supply systems, but especially under the High Emissions scenario there may be adverse impacts on availability;
- Water infrastructure may not be able to cope with long dry spells in summer, and there may be shortages of water available for direct summer abstractions;
- Combined potential supply pressures and demand increases could lead to supply deficits especially in the south-eastern part of the region;
- Increased climatic variability and increased winter rainfall could put pressure on drainage systems;
- Coastal and fluvial flooding will have impacts on many aspects of the regional economy, society and environment. Existing flood defences will face increased pressure and the costs of flood damage to built property, without increased defences, could be significant;
- Flood risk is likely to be the most important factor affecting existing energy and transport infrastructure and in future locational decisions;
- The nuclear energy plants on the coast will require continued coastal defence at least until fully decommissioned (a period beyond the time frame of this guidance).

Agriculture and forestry

Existing conditions

3.6. Agriculture is an important activity in the East of England in terms of land use and economic activity. Primary agriculture contributes 2.1% to GDP in the East of England compared to England's average of 1.8%. The East of England has 26% of England's cereal hectarage, over a third of its pig population and 21% of the total poultry population[15]. **Figure 3.1** shows the areas of Grade 1 and 2 agricultural land in the region. It can be seen that this is concentrated in the western side of the region, with the largest areas of Grade 1 land in the Fens. There are also pockets of Grade 1 and 2 agricultural land along the north Norfolk coast.

3.7. The East of England has 7.3% woodland cover[16], compared to the highest cover of 14.1% in the South East, and the lowest cover (outside of London) of 5.1% in the East Midlands. Woodland is scattered throughout the region, bar the Fens, which have little or no wooded areas. There are concentrations of woodland in, for example, Thetford on the Norfolk-Suffolk border, and in the southwestern corner of the region in Hertfordshire, as illustrated in **Figure 3.2**.

[15] ACCELERATES East Anglia case study from www.geo.ucl.ac.be/accelerates

[16] National inventory of woodland and trees. Forestry Commission. 2001.

Climate change impacts

3.8. Agriculture and forestry in the East of England may be affected by climate change in a number of ways. Temperature changes and water availability are likely to have implications for arable, livestock and poultry farming and for forestry. Fisheries may be affected by increased flood risks and sea level rise. The possible impacts are elaborated on below.

3.9. The potential impact of climate change on arable farming is a key topic covered by the REGIS study. Temperature increases will lead to an enhanced growing season, as detailed in Section 2. This could benefit arable crop yields. However, reduced summer soil moisture is likely to prove to be a key constraint limiting the potential created by an increased growing season. REGIS found that under the REGIS High Emissions climate change scenario (i.e. UKCIP98 scenario), yields would eventually decline due to drier soils and lack of water available for irrigation, for example, yields of winter wheat would suffer from drier soils and early maturity[17].

3.10. The water resource strategies produced by the Environment Agency indicate that agriculture is putting pressure on water supplies, particularly in the southern part of the region, where water resources are already subject to over abstraction (in terms of summer surface water and year round groundwater). Much of the remainder of the region has no additional summer surface water or year round groundwater available (more detail is provided on this in the section below on Infrastructure – existing conditions). Environment Agency research[18], undertaken prior to the UKCIP02 scenarios, shows that irrigation demand for certain crops could increase by between 12% and 27% over the next 25 years. This would put pressure on water supplies in those times when water is likely to be scarce (namely in long summer dry spells). The Environment Agency has indicated that further research on irrigation needs is ongoing. The REGIS study[19] similarly found that water supply could be a limiting factor, depending on winter storage and demand management measures. The study concluded that water availability issues are likely to be particularly acute in the southern half of the region, in south Suffolk and Essex, and more so under the REGIS High Emissions climate change scenario (ie. UKCIP98 scenario), although the main pressure in the south will be from housing and population growth[20]. It is also

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17 REGIS – Regional climate change impact and response studies in East Anglia and North West England. UKCIP and DEFRA. 2002.

18 Research by Cranfield University at Silsoe reported in the Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

19 REGIS as above.

20 Pers comm. Paul Hart, Environment Agency

of note that whilst some of the greatest demand for irrigation has been in the Fens, these are areas where winter storage is most cost effective[21].

3.11. The REGIS study found that some crops will probably become more popular, such as sugar beet, and the area of irrigated potatoes could double (although socio-economic changes, such as increases in water pricing due to scarcity could limit this). The potential for new crops is likely to be limited. For example, new crops such as sunflowers that have been widely tipped to spread from France as far north as East Anglia under global warming will make little progress. Unless new varieties are bred, yields would remain too low under all scenarios at least until the 2050s. Beyond this date there could be opportunities, but no studies have investigated this. The Assessing Climate Change Effects on Land use and Ecosystems; from Regional Analysis to The European Scale (ACCELERATES) programme should further inform the opportunities for agriculture.

3.12. The increased temperatures and enhanced growing season will be likely to affect planting and harvesting dates.

3.13. The REGIS study also found that flood risk could have significant implications for agriculture, and that the Fens could be particularly affected. The REGIS study modelled the likely extent of coastal and fluvial flooding under the REGIS High and Low climate change scenarios (UKCIP98 scenarios) and interpreted the results in relation to the agricultural sector. The Fens are particularly at risk, due to the fact that they will be subjected to the combined effect of higher sea levels and increased river flow, as well as consideration of the drainage implications for this low-lying area, including ongoing subsidence. Higher mean sea levels will raise the base level and hence exacerbate the impacts of river flooding across the Fens.

3.14. The study found that under the REGIS High Emissions climate change scenario (i.e. UKCIP98 scenario) the degree of flood risk, without substantial augmentation of flood defences and land drainage, would be significant. It found that arable farming would be impossible on 86% of the Fens and 10% of the remainder of East Anglia. The study concludes that: 'any flood event could be catastrophic, potentially drawing seawater into the inland Fens and flooding large areas to significant depths'. It notes that even with 1 in 500 year defences the impacts would only be delayed for up to 30 years (from the 2050s to the 2080s). Nevertheless the study came to the conclusion that larger scale socio-economic trends, such as changes in the Common Agricultural Policy (CAP), would exert greater forces for change on agriculture in the region.

3.15. The REGIS study concluded that arable fields subject to increased flooding, may revert to wet grazing marsh under the REGIS High Emissions climate change scenario (i.e. UKCIP98 scenario) and in the case of the Fens, to

[21] Pers comm. Paul Hart, Environment Agency

natural Fenland habitat, as these areas become unsuitable for arable agriculture.

3.16. Under the REGIS Low Emissions climate change scenario (i.e. UKCIP98 scenario) the study found that, on the other hand, the Fens would remain largely unaffected, since the present standard of service for the 100-year event would remain adequate. Although it notes that if widespread managed realignment was adopted, this would lead to some relatively small losses of arable agricultural land.

3.17. Higher temperatures could also affect livestock production systems, with increased requirements for animal drinking water and water wallowing sites for pigs. Indoor livestock units may require cooling, adding an additional demand for water[22].

3.18. Temperature and rainfall, which determine water availability, are likely to have the greatest impact on woodland[23]. Certain species will fare poorly whilst others will do well. For example, in terms of productive woodland, yields of Corsican Pine are predicted to increase, whilst Scots Pine is likely to decrease. Pests and diseases may become more prevalent, although complex interactions between trees, pests/pathogens and their predators or natural controls make predictions hard (the likely implications of pests and diseases are discussed further in the section below on Environmental Assets).

3.19. Scope for commercial forestry could be limited by water availability, as woodlands typically have higher water demands than other land uses. However, trees could play a role in adapting to climate change and mitigating potential impacts. For example, through providing shelter belt functions and as a means of stabilising river banks and reducing erosion in riparian habitats.

3.20. Short rotation coppice (Poplar and Willow) also has a higher water demand than other species, which may limit the opportunity for bioenergy. However, varieties are being developed to withstand drier conditions. There are also likely to be opportunities for new bioenergy crops e.g. Switch Grass as cultivated in the USA, Prairie Grass and Giant Reed. Miscanthus will continue to be suitable, as it is reasonably drought tolerant[24]. It will also be important to strategically consider which areas are most suitable. For example, due to water demand bioenergy crops may not be suitable in main tributaries and key aquifers, but could be located outside of these areas. Clay soils may also be better suited due to their ability to hold water.

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[22] Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

[23] Broadmeadow (2002) A review of climate change implications for trees and woodland in the East of England.. Forest Research.

[24] Pers comm. Peter Nixon, ADAS.

3.21. The East of England has several inshore fisheries of note, such as Oyster beds in the Blackwater Estuary. These may be affected by sea level rise and flood defence decisions. For example, the fishery in the Blackwater Estuary may be affected by the largest coastal realignment project in Europe at Abbots Hall Farm in Essex. Here Essex Wildlife Trust has converted 84 hectares of arable farmland into saltmarsh and grassland as part of a nation wide initiative to restore the UK's rapidly declining coastal wetlands. Also inland freshwater fisheries may be affected if low lying land is allowed to permanently flood. Marine fisheries could be affected by increases in sea surface temperatures or possibly by sea level rise and extreme events. However the Environment Agency consider these risks to be minor compared to the major threats posed, for example, by over fishing[25].

3.22. Impacts facing agriculture and forestry are summarised in **Table 3.1** below.

Table 3.1: Main climate change impacts facing agriculture and forestry

Main impacts facing agriculture and forestry	Spatial extent of impact
• Agriculture is likely to see an increased growing season; but decreasing soil moisture and availability of water supply for irrigation may constrain opportunities to capitalise on warmer temperatures;	Region wide
• Reduced summer soil moisture will be a key constraint, especially in the south of the region;	Region wide, south of region in particular
• The pressures which agriculture puts on water supplies is already felt in the Anglian region, which is the driest in the UK. Similarly the Thames region is facing great pressures;	Region wide, south of region in particular, where water supply pressures are already more pronounced
• Irrigation demand for key irrigated crops could increase by between 12 and 27% in the next 25 years according to Environment Agency research (the scenarios used to make these predictions is not evident);	Region wide, south of region in particular
• Arable crop yields could initially benefit from temperature changes but would potentially eventually decline under the REGIS High Emissions scenario according to the findings of the REGIS study;	Region wide
• Some crops will become increasingly commercially attractive e.g. sugar beet and potato;	Region wide
• The REGIS study found that potential for new crops would be very limited as yields would remain too low under all scenarios (UKCIP98 scenarios) at least until the 2050s;	Region wide
• Livestock production systems could be affected by higher temperatures, leading to increased requirements for drinking water, water wallowing	Region wide

25 Pers comm. Paul Hart, Environment Agency.

Main impacts facing agriculture and forestry	Spatial extent of impact
sites for pigs and water to cool livestock units;	
• Access to land in winter may be constrained by increased precipitation, and possible increased storminess, causing waterlogging and flooding;	Region wide
• Some agricultural land is likely to be lost due to fluvial and coastal flooding; the extent of which would depend on the climate change scenario and extent of flood risk. Increased flood risk may lead to changes in land use as farmers abandon arable cropping on such land;	The Fens will be particularly affected; will also affect coastal areas and other areas subject to fluvial flooding
• Woodland planting may be limited due to its higher water usage;	Region wide
• Favourable woodland species may change (e.g. yields of Corsican Pine are predicted to increase, whilst Scots Pine is likely to decrease);	Region wide
• Increased risk of forest fires;	Region wide
• Certain short rotation coppice tree species (Poplar and Willow) have higher water demand than other tree species which may limit opportunities; however, varieties are being developed to withstand drier conditions. There are also likely to be opportunities for new bioenergy crops e.g. Switch Grass as cultivated in the USA, Prairie Grass and Giant Reed. Miscanthus will continue to be suitable as it is reasonably drought tolerant;	Region wide
• Inshore fisheries and inland fresh water fisheries could be affected if low lying land is allowed to permanently flood as in the Fens;	Coastal and low lying land e.g. Fens
• Impacts on coastal fisheries are uncertain, but external pressures of declining fish stocks are likely to exert far greater pressures on the industry.	Coastal

Stakeholder workshop discussion

Key climate change impacts facing agriculture and forestry

Using the above information, regional stakeholders were asked at the workshop to prioritise what they saw as being the key impacts facing agriculture and forestry. The biggest concern was impacts on the agricultural and woodland economy arising from:

- Changes in species ranges (impacts on biodiversity, changes in species distribution due to change in habitat, pests/diseases, possible benefits of trees and woods for conservation and biodiversity);
- Changes to crops;
- Water demands/inputs (implications for storage, supply, demand and quality, possible benefits of trees for water quality);
- How managed retreat might affect agricultural practices.

Environmental assets – natural and cultural

Existing conditions

3.23. The East of England has a rich natural heritage, with a large number of internationally and nationally designated wildlife sites, and nationally designated landscapes. Some of the largest designated areas are located on the coast, including The Wash and Norfolk Coast Special Area of Conservation (SAC). Other important areas include the Brecks Special Protection Area (SPA). The Broads are also designated as a National Park, which is the only wetland based National Park in the UK. The North Norfolk coast and Suffolk coast are both designated as Areas of Outstanding Natural Beauty (AONBs) on account of their landscape value. These designations are shown in **Figure 3.3.** English Nature and the Countryside Agency have split the whole of England down into joint character areas, which represent areas with similar landscape and habitat types, shown for the East of England in **Figure 3.4.** English Nature delineated natural areas, which are less detailed and just look at areas in terms of similar habitats, shown in **Figure 3.5**.

3.24. The East of England also has a rich historic legacy, reflected in the many Scheduled Ancient Monuments (SAMs), English Heritage sites, historic towns, National Trust sites, cathedrals and Heritage Economic Regeneration areas, as shown on **Figure 3.6**. These are scattered throughout the region, with numerous sites found on the coast.

Climate change impacts

Natural assets

3.25. Habitats and species may be affected in a number of ways. Some will be affected by direct loss, for example, due to flooding, whilst others will be affected indirectly by temperature increases and changes in water availability. The MONARCH study[26], which like REGIS, is based on the UKCIP98 scenarios, provides a good source of information on potential climate change impacts on habitats and species throughout Britain and Ireland. The REGIS study, undertaken after the MONARCH study, provides a regionally specific investigation of climate change impacts on biodiversity in East Anglia.

3.26. The MONARCH study found that climate change impacts on habitats and species can be explained by several principal factors: related to rainfall variables, temperature variables, wind speed variables and sunshine and evapotranspiration variables. Key findings include:

- Terrestrial environments:
    - The response of plant, insect and amphibian species is likely to be highly variable;
    - The range of some plant species could decline whilst others could expand;
    - Generally plants and insects with a southern distribution are likely to gain climate space;
    - The response of bird species is also likely to be highly variable. For example, Nightingale and Nuthatch may show a positive response to moderate climate change, but with severe climate change their distributions may either contract significantly or become fragmented in southern and eastern England;
    - The degree to which species are able to realise these changes varies. If their climate space is contracting then this is more likely to happen than if they are expanding, as the latter is dependent on migration and the availability of suitable habitat.
- Freshwater environments:
    - Water availability is likely to increase in winter which could benefit raised bogs, wet heaths and coastal dune slacks;
    - In summer there is likely to be a decrease in water availability in the south of Britain, which could lead to drying of wetland habitats with changes in their species composition;

[26] Harrison et al (eds) (2001) Climate change and nature conservation in Britain and Ireland: Modelling natural resource responses to climate change (the MONARCH project). UKCIP Technical Report, Oxford.

    - Raised bogs, wet heaths, coastal dune slacks, drought-prone acid grassland and Beech woodland could be adversely affected by the lower water availability in southeast England. Some chalk grassland species which will lose suitable climate space in the south-east could be further affected by decreased water availability;
    - Overall it is important to combine the effects of predicted changes in climate on species with those for hydrology in order to understand the potential impacts of climate change on wetland habitats.
- Coastal environments:
    - Rising sea levels may affect the shape of estuaries, particularly where isostatic subsidence is occurring (as in the East of England). This will determine intertidal sediments and hence the numbers of waterbirds an estuary can support;
    - Managed realignment of sea defences may result in more extensive intertidal flats at the expense of marshes. This is likely to lead to detrimental changes in habitat quality for most species. Loss of salt and freshwater marshes due to coastal squeeze is likely to be a serious problem for waterbirds, in particular those species that do not feed on the intertidal flats;
    - Warmer weather expected with climate change is likely to drive further changes in wader distributions. As winters in Britain become milder a greater proportion of the East Atlantic Flyway populations of some species may over-winter further north and east on the continent of Europe;
    - Increases in sea level will encourage erosion of many salt marsh, sand dune and vegetated shingle areas, especially if coupled with increases in storm activity. Climate change is likely to introduce additional stress on coastal habitats, especially within the southern part of Britain where the highest rises in sea level are predicted to occur.

3.27. The REGIS study found that, in East Anglia, salt marshes will be under particular threat from both temperature increases (in parts of East Anglia, there is a loss of suitable climate space for all of the modelled species - *Atriplex Portulacoides, Puccinellia Maritima* and *SuaedaMaritime*), with certain species facing extinction and also from coastal flood risk. 'Holding the line' against sea level rise would put all the salt marshes at risk from 'coastal squeeze', as habitat space is reduced as sea level rises and marshes are unable to migrate inland due to hard defences. The study found that the greatest loss of salt marshes is likely to be seen under the REGIS High Emissions climate change scenario (i.e. UKCIP98 High Emissions scenario), as sea level rises will be greater. But it is the response in terms of coastal defence that will ultimately affect the habitat. The REGIS High Emissions climate change scenario combined with hard sea defences could see huge losses, for example over 50% in Suffolk by the 2050s. However, as noted above, predicted sea level rises under the UKCIP02 scenarios are slightly less than under the UKCIP98 scenarios, which would temper this impact to some extent. Managed retreat and utilising salt marshes as natural flood defences would potentially allow salt marshes to expand.

3.28. The REGIS study indicates that the Fens also face radical change. They are likely to be lost to wetlands and salt marshes as sea level rises and could also see a loss of species due to loss of climate space. The study predicted that much would be lost if sea level were to rise by 1.5m. Again, the UKCIP02 scenarios do not predict such a high level of sea level rise (82cm under the High Emissions scenario and 22cm under the Low Emissions scenario), so the losses would be tempered to some degree.

3.29. The REGIS study found that lowland heath is likely to be threatened by land use changes more than direct effects of climate change. Grazing marshes may increase as farmers abandon land vulnerable to flooding.

3.30. As noted above in relation to commercial forestry, the combined effects of rising temperature, falling summer rainfall, lower relative humidity and longer growing season is likely to make water an increasingly scarce resource. A study by Forest Research[27] in relation to woodland planting, indicates that species choice will become increasingly limited as a result of rising summer soil moisture deficits. Some species are likely to lose ground, such as Beech and Upland Oak. Others may gain ground, such as Lime, White Poplar and Holly. Establishment of young trees, and survival of hedgerow and urban trees are likely to be most affected by climate change.

3.31. Pests and diseases may also pose a threat to woodlands as the climate changes. However, predictions as to future trends in damage to woodland caused by pests and diseases are difficult to make. Particularly because of the complex interactions between the trees, pests/pathogens and their predators or natural controls and how climate change affects these relationships. It is likely that trees will become more drought stressed during the summer months and hence susceptible to attack and that development of pests and pathogens will accelerate due to warmer temperatures possibly leading to higher population growth. Certain pathogens may cause root infections across a range of species. Pests are likely to gain ground from climate change making damage more prevalent, while exotic pests could establish devastating populations in the region. The population density of mammalian pests is also likely to increase as a result of milder winters and increased forage availability during Spring.

3.32. As noted in the findings of the MONARCH study, outlined above, water availability combined with temperature increases will have major

[27] Broadmeadow (2002) A review of climate change implications for trees and woodland in the East of England. Forest Research.

implications for habitats. The water resource strategies produced by the Environment Agency[28] provide an indication of water resource availability, which is based on an assessment of needs for environmental assets. These indicate that water resources are already subject to over abstraction (in terms of summer surface water and year round groundwater[29]) in the southern part of the region. Much of the remainder of the region has no additional summer surface water or year round groundwater available (more detail is provided on this in the section below on Infrastructure). Climate change may well worsen this situation, due to a shortened period for recharge of groundwater supplies and lower precipitation in summer. This could particularly affect wetland and riverine habitats.

3.33. There are also likely to be opportunities to create habitats. For example, there might be opportunities to re-create coastal grazing marshes as more intensive agricultural production is abandoned due to increased flood risk.

3.34. Soil quality may be adversely affected. Reduced soil moisture in summer could lead to increased erosion caused by wind, whilst higher winter precipitation could lead to increased runoff and hence erosion into watercourses.

3.35. Water quality may also be adversely affected due to saline intrusion, algal blooms and less dilution of effluent.

<u>Cultural assets</u>

3.36. Cultural assets could be affected in a number of ways. Built assets could be affected by damage from contaminants attacking foundations as higher ground temperatures lead to ground contaminants becoming more active[30]. There might also be disturbance to the chemical equilibrium leading to changes in preservation conditions[31]. Cultural assets (e.g. historic buildings and monuments) could be affected by subsidence and structural damage from possible extreme storm events. Below surface sites, such as buried SAMs, could be damaged by changes in soil moisture levels, water table height and chemical/biological processes. Changes in wind speeds/gustiness could lead to erosion of dry sites, such as barrows[32]. However, as noted in

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[28] Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

[29] It is not appropriate to separate an assessment of groundwater availability between summer and winter, because the characteristics of most aquifers mean that rainfall stored in the winter is released to rivers and wetlands gradually throughout the year.

[30] UKCIP Briefing note: Climate change impact on buildings

[31] English Heritage (2002) unpublished research on the impacts of climate change on the historic environment.

[32] As above.

Section 2, wind speeds may increase slightly, but there is a high level of uncertainty associated with this result. These impacts would occur region wide. Coastal and floodplain areas, which contain a wealth of historic sites, would be at additional risk of coastal and fluvial flooding.

3.37. The main impacts facing environmental assets are summarised in **Table 3.2.**

Table 3.2: Main climate change impacts facing environmental assets

Main impacts facing environmental assets – natural and cultural	Spatial extent of impact
Natural assets	
• Habitats and species may be affected by direct habitat loss (e.g. due to flooding) and also by the effects of temperature increases and changes in precipitation. Some species will experience a loss or reduction of suitable climate space, whilst others will see an increase in climate space;	Habitat losses due to flood risk likely to affect coastal areas and the Fens and Broads in particular; temperature change will exert a regional pressure
• Salt marshes will be under pressure, with certain drought sensitive species facing extinction;	Coastal, Suffolk in particular (according to findings of REGIS) and also in Essex, which was not covered by the REGIS study
• The response to coastal flood risk will also have a major bearing on salt marshes: 'holding the line' against sea level rise would place all the region's salt marshes at risk;	Coastal
• The Fens face major changes due to sea level rise leading to reversion to wetlands and salt marsh, depending on the management response to flood risk;	The Fens
• Lowland heath may be threatened by land use changes more than direct effects of climate change;	Region wide (?)
• Opportunities for re-creation of grazing marshes as farmers abandon land vulnerable to flooding;	Region wide (?)
• Opportunities for creation of other habitats;	Region wide
• Species found in cereal field margins will continue to find suitable climate space in the region;	Arable areas
• Some woodland species e.g. Beech and Upland Oak woodland are expected to lose ground in the East of England, whilst others may gain ground e.g. Lime, White Poplar and Holly;	Region wide
• Reduced summer rainfall and increased temperatures, in conjunction with increased demand for water resources, could have a detrimental effect on river and wetland ecology;	Rivers and wetlands
• The increase in frequency of extreme events, such as storms and droughts, may increase the likelihood of local extinction's;	Region wide
• Pests and diseases are likely to become more prevalent due to warmer summers and milder winters, which could affect some plant species, particularly trees	Region wide

Main impacts facing environmental assets - natural and cultural	Spatial extent of impact
which are likely to become more drought stressed in summer and susceptible to attack;	
• Establishment of young trees and survival of urban trees likely to be particularly affected;	Region wide, urban areas in particular
• A shortened period for recharge of groundwater supplies, and lower precipitation in summer could affect habitats, particularly wetland and riverine habitats by limiting water availability;	Southern part of region in particular, spreading to whole region depending on scenario
• Soil quality may be affected due to drier soils and increased erosion;	Region wide
• Air quality likely to deteriorate, particularly in terms of ozone, which could have health implications;	Region wide
• Water quality may suffer due to saline intrusion, algal blooms and less dilution of effluent. This could also affect water dependent habitats. For example, salt tolerant species found in the Fens and Broads towards the coast are likely to fare better than less tolerant species.	Region wide and Broads particularly vulnerable to saline intrusion
Cultural assets	
• Potential damage from mobilised contaminants attacking foundations;	Region wide
• Increased risk of subsidence;	On clay soils (across the southern and central part of the region)
• Historic sites subject to fluvial and coastal flood risk;	Coastal
• Changes in soil moisture levels and water table height and chemical/biological processes may damage buried sites; wet-dry cycles most damaging;	Region wide
• Changes in wind speeds/gustiness could lead to erosion of dry sites e.g. barrows. However the UKCIP02 scenarios only predict a small increase in wind speeds and do not have a high level of certainty in the predictions;	Region wide
• Structural damage from extreme storm events, including erosion damage.	Region wide

Stakeholder workshop discussion

Key climate change impacts facing environmental assets – natural and cultural

The regional stakeholders at the workshop identified the following as being of most concern:

- Biodiversity (loss/change, particularly coastal habitats, loss of woodland, impacts on designated sites, possible changes in Biodiversity Action Plan (BAP) priorities);
- Agriculture (changes to agricultural practices, changes in the Fens due to uncertainty in the future of agriculture, possibilities for habitat creation);
- Water resources (availability, quality, implications for habitats e.g. wetland sites, management of storms);
- Landscape (changes in landscape character and distinctiveness, changes likely to affect region as a whole and AONBs and Broads and coast, changes in vegetation, tree cover e.g. possible loss of Beech and changes in crop types, impact on amenity and economic value of the countryside and coast).

Housing and the economy

Existing conditions

3.38. The region lacks major conurbations and much of the region is characterised by a strong network of historic cathedral cities, county and market towns and surrounding villages. Major towns in the East of England are found mainly to the south, with the other major towns being Peterborough, in the northwest, Norwich in the northeast and Cambridge towards the centre and a string of towns on the coast, including Great Yarmouth, Lowestoft, Clacton, Southend-on-Sea and Ipswich and Colchester towards the coast (**Figure 3.7**). Southend-on-Sea is the largest urban area with a population of 250,000. The more rural and coastal areas are more sparsely populated. The East of England has a quarter of England's market towns, which illustrates the rural character of much of the region.

3.39. The East of England has a £76 billion per annum economy employing 2.7 million people in 350,000 businesses. In overall terms, its economic performance measured by Gross Domestic Product (GDP) per head is strong by UK standards (3rd in the UK). Food production remains the dominant land use (over 70% of the region is in agricultural use), but the region has developed a wide range of other industrial and commercial activities. The region benefits from its proximity to London and continental Europe. However, in parts of the region the economy has performed less well, which has led to relatively high levels of unemployment, long distance commuting, unsustainable patterns of development and movement and social deprivation.

3.40. The north and east of the region is typically more deprived, with several areas eligible for EU regeneration funding (**Figure 3.8**). In the south, Thames Gateway South Essex is part of the wider Thames Gateway which is a national priority for regeneration. Part of this area (Southend) is also a designated Objective 2 area.

3.41. Three national growth areas[33] (Thames Gateway, London-Stansted-Cambridge and Milton Keynes-South Midlands) lie largely or partly in the East of England. These are also marked on Figure 3.8.

Climate change impacts

3.42. The main climate changes affecting housing and the economy are water related; flood risk and water supply. All sectors of the economy could potentially be affected by fluvial and coastal flooding, as could the location of housing. Existing urban areas that are already subject to flood risk will face a particular challenge for coping with climate change. For new development there will be more scope to minimise the risks. These themes are developed further in Section 4 setting out spatial guidance. The construction industry could be affected by changes in the pattern of development arising as a result of climate change.

3.43. The insurance industry will also be affected by climate change, in particular from increased flood risk and concomitant damage to property and hence increased claims and also from increased risk of building subsidence. The industry is already taking action to address the pressures posed by climate change.

3.44. Industries with a high water demand, such as paper processing and energy generation, could be affected by water shortages. Water shortages are likely to be particularly acute to the south of the region, and more so under the High Emissions scenario.

3.45. The tourism industry could be an industry that benefits from warmer summers. This will be dependent on the relative appeal of the region compared to other areas and also on the maintenance of the quality of the environment. This is likely to benefit areas already popular for tourism, such as the coast and Norfolk Broads. However, 'coastal squeeze' due to rising sea levels and occasional winter closures, as a result of flooding, could limit the opportunities to some extent. Other sectors may also benefit from climate change, for example, civil engineers and others involved in construction of flood defences and water supply infrastructure, and those involved in developing renewable energy technologies e.g. design and construction of solar power infrastructure and offshore windfarms.

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33 ODPM (2003) Sustainable communities for the East of England: Building for the future.

3.46. The main impacts facing housing and the economy are summarised in **Table 3.3.**

Table 3.3: Main climate change impacts facing housing and the economy

Main impacts facing housing and the economy	Spatial extent of impact
• The location of housing could potentially be affected by fluvial and coastal flood risks;	Coastal areas, areas subject to fluvial flooding
• Tourism industry likely to be boosted by warmer summers, but this is also dependent on maintaining the quality of the environment in the face of visitor pressure (or climate change);	Region wide, but likely to benefit existing tourist destinations in particular
• Also other positive opportunities for the economy. For example, civil engineers and others involved in construction of flood defences and water supply infrastructure are likely to see an increase in activity;	Region wide
• There may be increased opportunities associated with renewable energy, such as design and construction of solar power infrastructure and construction of offshore windfarms;	Region wide, and particularly coastal areas for windfarm construction
• All sectors of the economy could potentially be affected by fluvial and coastal flooding;	Coastal areas, areas subject to fluvial flooding
• Industries with a high water demand could be affected by water shortages, although increasing costs are likely to promote increased efficiency in water use;	Region wide, and particularly industry to the south of the region
• The construction industry may be affected by changes in the pattern of development arising as a result of climate change.	Coastal areas, areas subject to fluvial flooding

Stakeholder workshop discussion

Key climate change impacts facing housing and the economy

The regional stakeholders prioritised what they saw as being the key impacts facing housing and the economy:

- Flooding pressure (which will require investment, will create pressures to change spatial policy, and will place buildings in the flood plain at risk);
- Insurance will become significantly more expensive in flood risk areas;
- Water supply constraints:
  - Water shortages will affect current and future housing and employment, particularly in the south of the region;
  - Housing development will place increasing pressures on the lack of existing and future water supply;
  - A big issue to consider is whether it makes sense to crowd more people into

- the parts of the region where water supply is likely to become critical;
  - There is a need to ensure that new development has adequate water supply (may need to plan for new reservoirs);
- Determining development locations may be difficult as there is very little suitable land available and flood plains are no longer on option;
- Potential for disruption to infrastructure.

Infrastructure – water resources, flood defence, energy and transport

Existing conditions

3.47. The East of England has, like the UK generally, invested significantly in infrastructure development. In this section, we examine water resource infrastructure, flood defences and energy and transport infrastructure.

Water resource infrastructure

3.48. In terms of water resource infrastructure, the East of England is served by an extensive public water supply system. The natural resources of the rivers and groundwater are supplemented by artificial storage in major reservoirs and transfers of various kinds, including transfers from outside the region. In addition to the large public supply reservoirs, there are also many smaller farm storage reservoirs throughout the region. This network of storage and transfers has evolved in line with rising water demand over the last century[34].

3.49. A key consideration in determining the need for measures to deal with water availability and potentially the need for new infrastructure or demand management measures is Environment Agency data at the regional strategic level on summer surface water availability and groundwater availability[35]. This shows that the southeastern part of the region is already suffering from a lack of summer surface water resource availability, and licensed abstraction levels are considered to be unsustainable (i.e. the combination of licensed surface and groundwater abstractions exceed the assessed limit,

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[34] Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

[35] The Environment Agency has prepared a series of maps which provide an indication of present water resource availability, in terms of summer surface water and groundwater, which is based on an assessment of needs for environmental assets. This information is presented in the Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

action to resolve the problems and may involve changes to both surface and groundwater licences in the longer term) (**Figure 3.9**). The remainder of the region has no additional water available (i.e. summer surface water is already fully committed to existing abstractions and the environment, and no significant further resource is available. However, in most catchments existing abstractions do not cause widespread environmental problems). In terms of groundwater availability, the southeastern quarter again has an unsustainable abstraction regime (**Figure 3.10**). Much of the remainder of the region has no additional water available (i.e. groundwater resources are broadly in balance, but there is no significant further resource available. However existing abstractions do not cause widespread environmental problems) but there are pockets where there is water available (however, any new or additional abstraction will be subject to local appraisal of need and impacts). This information will be reviewed in detail at the local level by the CAMS process over the next five years.

<u>Flood defences</u>

3.50. Parts of the region are already subject to flood risk, although, it should be noted that the indicative flood plain map produced by the Environment Agency does not take into account existing flood defences (**Figure 3.11**). The Fens are the largest contiguous area of fluvial floodplain and many of the rivers flowing into the Fens have sizeable floodplains. The Internal Drainage Boards (IDBs) have a key role in managing the extensive low-lying areas of farmland in the area. There are also smaller areas of fluvial floodplain throughout the region, much of which is defended by fluvial flood defences. Parts of the coast and a large area inland from The Wash are subject to coastal flooding. Department of Environment Farming and Rural Affairs (Defra) estimates that there are around 283,000 residential properties and 14,000 commercial properties at risk from fluvial or coastal flooding in the Anglian region, 305,000 hectares of Grade 1 and 2 agricultural land at risk of fluvial flooding, and 54,000 ha at risk from coastal flooding[36].

3.51. Information on current coastal flood defences and future plans are set out in Shoreline Management Plans (SMPs). SMPs are produced via a partnership of interests, and set out strategic coastal defence measures. The coastline of the East of England is split into five sections, each with its own SMP. The current approaches taken with regard to coastal flood defences are set out in the box below. Defence decisions are broadly split into 'hold the line', 'managed retreat' and 'do-nothing', which are defined below. However, these plans will be reviewed shortly and will take account of new information on coastal processes, climate change/sea level rise and associated planning considerations. Therefore the decisions set out in the

[36] National appraisal of assets at risk from flooding and coastal erosion, including the potential impact of climate change. DEFRA, July 2001

current plans may well change and could be influenced by decisions made in relation to climate change.

Summary of Shoreline Management Plans in the East of England

The following paragraphs summarise the approach taken to flood defence in the East of England at present and possible future approaches. Defence decisions are broadly split into:

- 'Hold the line' - maintain or improve the existing defence
- 'Managed retreat' - move the existing defence line landward, in a controlled manner
- 'Do-nothing' - this entails no coastal defence activity apart from undertaking safety measures.

The Wash (Gibraltar Point to Snettisham)

The Wash area has a predominantly rural hinterland and is widely accepted as an important region for nature conservation. The shoreline here is relatively stable.

Sea defences consist almost exclusively of earth embankments. The main policy to be adopted in this area is 'hold the line'; however it is recognised that in the future there may be isolated areas of defence that would benefit from 'managed retreat'.

North Norfolk (Snettisham to Sheringham)

North Norfolk is predominantly recognised for its conservation importance, with almost the entire coast designated as an Area of Outstanding Natural Beauty. Towns and smaller communities provide residential and holiday facilities in the area.

Coastal defences take on a varied form including cliffs, shingle ridges, artificially nourished beaches and stretches of salt marsh with dynamic silt, sand and shingle ridges towards the central section of the area. The area has adopted a mix of the three coastal management options: 'hold the line' in certain areas, 'managed retreat' in others, namely by intervention by moving the existing defence line landwards, and some areas where the approach is 'do nothing'.

Norfolk (Sheringham to Lowestoft)

The northern coastal stretch contains two major towns, Great Yarmouth and Lowestoft, where there is a mix of industry, including tourism, although much of this is under pressure. Extensive sections in the southern region are built-up, comprising permanent residential buildings and holiday facilities. Tourism is the principal industry.

A mix of geological features including cliffs, sand dunes and low lying land are present in the area with the majority of the coast covered by designations that recognise its national and international environmental importance. The coastline is historically retreating with the exception of the land between Winterton and Great Yarmouth. This trend has resulted in 40% of the coastline being fronted by hard seawall structures, 25% subject to cliff revetment works, and 43km of the shoreline incorporating permanent groyne fields. The recent construction of offshore reef breakwaters at Sea Palling is designed to protect the shoreline and ensure healthy beaches are maintained.

The primary approach here is to 'hold the line' with some smaller areas favoured for 'do nothing' and 'managed retreat'.

Suffolk (Lowestoft to Harwich)

The main towns in the area are important for reasons of their commercial, residential, recreational and tourism contributions and will continue to need protecting from coastal erosion and flooding. Similarly, the continued protection of Sizewell Nuclear Power Station situated towards the centre of the area, will need to be ensured. The major Haven Ports complex, which includes Felixstowe, is also found on this stretch of coastline. Many stretches of the coastline have substantial conservation and landscape value including a number of sites of international importance.

The strategic defence recommendations for the region comprise a balance of selective protection where positive economic justification criteria are present, combined with allowing ongoing erosional process in other areas to continue, thus ensuring adequate longshore nourishment of adjacent natural beach defences. The policies adopted are again a mix of the three approaches.

Essex (Harwich to Mardyke: R. Thames)

The Essex area includes tidal regimes within six estuaries and open coast. With few exceptions, the coastal frontage is predominantly rural, incorporating nationally and internationally recognised wildlife and conservation sites including coastal marshes. Interspersed with such sites, important tourism and recreational interests, along the coastline and estuaries, complement the more traditional seaside resorts.

The coastline is characterised by an eroding or 'drowned' foreshore and a shoreline that is artificial in nature due to extensive reclamation of saltmarshes during the period 1650 to 1850. Much of the coastline is low-lying and protected by earth flood embankments with sea facing revetment works. A combination of sea level rise, increased storminess and land tilt is exerting unique and unrelenting pressures on this stretch of coastline.

Two approaches have been adopted in the area, they are 'hold the line' and 'do nothing', although in some areas where a medium term (10 years) 'hold the line' policy has been adopted, a longer term plan of 'hold the line' and 'managed retreat' (in selective locations) is recommended. Future decisions in these areas will be based on additional monitoring, modelling and economic evaluation to ensure sustainable defence policies.

Energy and transport infrastructure

3.52. In terms of energy infrastructure, the East of England has several coastal facilities, including a combined cycle gas turbine, a wind farm and two nuclear power stations (**Figure 3.12**). There are also two power stations in the Thames Gateway (one oil/coal fired and one CCGT). Other Combined Cycle Gas Turbine (CCGT) power stations are located throughout the west of the region. Transmission lines and substations are located throughout the region.

3.53. The region has several airports, including Stansted and Luton, and several major coastal ports, including the Haven Ports complex, which comprises Felixstowe, Great Yarmouth and Lowestoft further up the coast (**Figure 3.13**). Rail infrastructure is typically north-south and includes rail links between Lowestoft, Ipswich and London along the coast. Road infrastructure is also found along the coast, including the A12 from Great Yarmouth down through Colchester to London.

Climate change impacts

Water resource infrastructure

3.54. Climate change will have implications for water availability throughout the region and therefore resource infrastructure requirements. In particular temperature increases, changes in precipitation and increased climatic variability will have implications for water resources. The Environment Agency has carried out research based on the UKCIP98 scenarios[37] and is now interpreting analysis carried out on the implications of the UKCIP02 scenarios. It will provide an 'official position' on climate change and water resources shortly. A key difference between the scenarios, with water resource implications, is that under the UKCIP02 scenarios drought conditions are expected to be worse (due to larger summer warming rates expected and summers predicted to become drier by a larger amount). The Agency has indicated[38] that the question of whether recharge in the region will increase or decrease under climate change is still uncertain.

3.55. The following paragraphs present possible implications of climate change for water resources, as discussed in the Environment Agency 25 year strategies. As already noted these are based on the UKCIP98 scenarios and it is recognised that there is a great deal of uncertainty attached to the findings, but until findings based on the new UKCIP02 scenarios are available, they represent the best source of information currently available.

3.56. The research based on the UKCIP98 scenarios, found that wetter winters and drier summers, would mean that most reservoir systems and aquifers would

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[37] Research carried out for the Environment Agency by Arnell (1999) *Effects of global warming on water resources: Implications of multi-decadal variability and changes in year-to-year variability – Report to the Environment Agency*. Department of Geography, University of Southampton. The findings of this research are presented in the Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

[38] Pers comm. Paul Hart, Environment Agency.

gain a little yield and that over a 25-year time period, estimated yields would change by less than 1%. This led to an assumption that most public water supply systems would at least retain their existing yields over the next 25 years. However, this finding may well change in light of the UKCIP02 scenarios.

3.57. The research based on the UKCIP98 scenarios also indicates that direct abstractions will become less reliable in summer, as groundwater levels are reduced. This means that abstractors, particularly farmers and industries that rely on these sources, will have to consider adapting in some way if they wish to maintain current levels of reliability. The water industry may also face challenges to meet peak water demands when resources are depleted, for example in long dry summers, which will become more frequent. One would expect this conclusion to hold true under the UKCIP02 scenarios.

3.58. The Environment Agency 25-year strategies also look at how climate change will affect demand for water. They predict that household water use is likely to increase in times of peak demand (i.e. in hot, dry summers), and agricultural demand for irrigation will increase as summers get hotter and the growing season increases. Industrial use may increase, for example for air conditioning, but it is expected that industry will continue to develop water efficient technologies. This will be equally true under the UKCIP02 scenarios, under which the demand could well be even higher given the more pronounced increases in summer temperatures and decreases in summer rainfall.

3.59. Based on currently available resources and considering societal and environmental demands for water, it is likely that deficits will occur in the south-eastern part of the region, and Environment Agency research suggests this could occur by 2025. However, for the reasons set out above the extent and timing of deficits is far from certain.

3.60. Availability of water supply will therefore be a key issue for the water industry to address, which could have implications for the location of industry and housing. The region will also face external pressures on water resources, particularly in the southeastern part of the region, from London.

3.61. Increased climatic variability with increased rainfall in winter, particularly heavy rainfall, could also put pressure on drainage systems. Saline intrusion could pose a threat to coastal aquifers, as sea level rises and groundwater levels become depleted[39]. Although the study (based on UKCIP98 scenarios) concluded that this would be of minor significance.

Flood defence

[39] *Water resources for the future: A strategy for the Anglian region March 2001*.

3.62. From the above discussion it is apparent that coastal and fluvial flooding as a result of climate change could have significant consequences for all the climate change impact topics (agriculture and forestry, natural and cultural environmental assets, economy and housing and infrastructure). Many existing flood defences will be unable to cope with the increased flood risks posed by climate change, from increased winter precipitation and extreme precipitation events leading to fluvial flooding and sea level rise and extreme storm surges causing coastal flooding. The Environment Agency does not have a clear handle on exactly what implications climate change will have for flood defences, but it knows there will be 'increased pressure'[40].

3.63. In terms of coastal defences several studies provide an indication of how defences will become less effective. For example, where crest levels are sufficient to defend against a 1 in 50-year event now, that same crest height may in 2075 only represent adequate defence against a 1 in 25-year event[41]. The more recent UKCIP02 scenarios suggest that these figures may even understate the issue. For example, a 1 in 150-year event at Immingham (just north of the study region) could become a 1 in 7-year event by the 2080s under the Medium-High scenario (an intermediate scenario not presented in this study).

3.64. However, the Environment Agency has also stressed that existing flood defences will not be rendered useless by climate change, but the standard of protection that they provide will diminish as sea level rises and winters get wetter. Sea and tidal defences constructed since 1989 have a 6mm/year allowance for sea level rise/NW-SE land tilt (agreed by DEFRA) built into their design. For example, a defence with a 50-year asset life is constructed 300 mm higher than the level for the design standard, so that as sea level rises the standard of protection diminishes to the design standard that will apply at the end of the 50-year asset life[42].

3.65. Our understanding of the geographical extent and magnitude of climate change related to flood risk is far from complete. So far flood risk maps for climate change related flooding, have not been produced (the indicative floodplain maps currently produced by the Environment Agency, which are widely used, are based on current flood risks, but do not take into account the increased risk which climate change will pose as sea level rises). The Environment Agency are working on the Extreme Flood Outline Project which

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40 Pers comm. Paul Hart, Environment Agency.

41 National appraisal of assets at risk from flooding and coastal erosion, including the potential impact of climate change. DEFRA, July 2001. The future climate assumptions used in this study are based on results from the UKMet Office Hadley Centre for Climate Predictions and Research (HADC2) and the Max Planck Institute for Meteorology (Hamburg) (ECHAM4) models.

42 Pers comm. Environment Agency

will show the 1:1000 return period including an allowance for climate change to guidelines suggested by DEFRA[43]. Also the Department of Treasury (DT) Foresight Programme on Flood and Coastal Defence is engaging leading scientists and engineers to produce independent, evidence-based advice to inform development of future policy and action for flood management. The first stage of this work will involve developing scenarios and examining potential responses.

3.66. The REGIS study attempts to estimate the potential spatial extent and magnitude of climate change related flooding in East Anglia. In East Anglia effective sea level rise will be greatest in the Fens and Norfolk Broads because of localised land subsidence, as the remaining peat wastes away. Most of the Fens already lie below high tide. Possible increases in storminess as a result of climate change may exacerbate flood risks. Most flood risks and breaks of sea defences occur during storms, but climate models are not yet reliable at making predictions of trends in storminess.

3.67. A final cause of flooding is likely to be higher winter river flows. The REGIS study uses earlier work to form the assumption that extreme fluvial flood flows will be 5% greater than today under the REGIS low climate change scenario (i.e. UKCIP98 Low Emissions scenario) and 20% greater under the REGIS high emissions scenario (i.e. UKCIP98 High Emissions scenario). In East Anglia, many of the catchments where peak flows in winter are likely to increase, are in coastal areas, where the rise in sea level will also raise the height of the river flows. This combined pressure will greatly reduce the effectiveness of flood defences in these areas.

3.68. The REGIS flooding studies assume no adaptation to the increased flood risks, even though such policies are already adopted for new or improved flood defence works. The consequences of climate change under the REGIS Low Emissions scenario are relatively small. However, under the REGIS High Emissions scenario, high water levels currently experienced only once a century, on average, could occur every two to eight years. In the absence of enhanced adaptation this will have an impact on defence standards. In the Fens, where the effect is likely to be compounded by greater river floods and land subsidence, there will probably be severe and routine flooding over a wide area, without further adaptation through investments in defence. Without further investment in flood defences, floods will sometimes invade urban areas and infrastructure such as roads.

3.69. Several studies have estimated the possible costs of flood damage. A study by DEFRA[44] provides the best available data at the country scale on flood and coastal erosion risk for policy development purposes. This study found that

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43 Personal communication with Peter Gilkes, Environment Agency, Project manager for the Extreme Flood Outline Project

44 National appraisal of assets at risk from flooding and coastal erosion, including the potential impact of climate change. DEFRA, July 2001

under existing defence conditions annual average damages from tidal flood damage to built property, in the Anglian Region,[45] would be £71 million by 2075; this is 332% of current annual average flood damage. Tidal flood damage in the Lower Thames region is estimated to be in the order of £163 million, although this does not include any increase in damage from flooding in the Tidal Thames upstream of the Barrier due to the assessed 0.1% defence standard in this reach. Increases in fluvial flood damage to built property in the Anglian Region could amount to between £78 and £111 million, under 10% and 20% flood flow increases, respectively. The REGIS study has separately assessed that if there is a higher degree of climate change than assumed in the DEFRA study and more urban development, damages could be in the order of £950 million per year in East Anglia.

3.70. Both studies conclude that it will be well worthwhile for society to continue to provide high standards of protection for the most significant risk areas. The DEFRA study notes that advance investments to accommodate climate change would also be worthwhile. But given the possibility that sufficient investment to maintain or improve current defence standards throughout may not be forthcoming, there is a very real need for a strategic framework to guide the difficult decisions necessary[46]. Furthermore, the cost estimates outlined above are based on the costs of damage to built property. A sustainable strategy should take into account the environmental costs of providing such defence. Also including fundamental decisions about whether we should continue to increase vulnerability, by increasing the value of assets in vulnerable areas, for example, through increasing investment in housing and in economic development in areas which rely on increasing defence capabilities. These difficult but important issues are discussed further in Section 4.

Energy and transport infrastructure

3.71. The main climate changes affecting energy and transport infrastructure are those leading to increased flood risks. Existing energy and transport infrastructure will be susceptible to coastal and fluvial flooding, and the location of new infrastructure will be affected by flood risk. Flood risk is likely to affect coastal areas in particular, as well as inland areas at risk from fluvial flooding.

3.72. A major consideration in terms of energy generation is the long-term liabilities of the two coastal nuclear sites at Sizewell and Bradwell. The latter closed last year and Sizewell A will close in 2006, whilst Sizewell B will continue to operate for some time to come. The length of time required for decommissioning (in excess of 100 years), the presence of radioactive waste

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45 The Environment Agency Anglian region corresponds most closely with the East of England, although it does include parts of Lincolnshire which are in the East Midlands, and omits the southern part of the East of England, which is in the Thames region.

46 Flood and Coastal Defence Research News. Issue 1 4 June 2001. DEFRA/EA.

on the sites, and the fact that Sizewell B is located next to Sizewell A will mean both sites will still need defending from rising sea levels and coastal erosion until fully decommissioned (well beyond the period covered by this study).

3.73. Parts of the transport infrastructure in the East of England is located close to areas at risk of coastal or fluvial flooding. For example transport links from Ipswich to Peterborough, the A12 from Great Yarmouth to Ipswich and the East Coast rail link from Lowestoft to London, via Ipswich and Colchester. However, the Environment Agency has indicated[47] that major links are not at risk. They have stated that if the Fens were intentionally flooded (i.e. returned to their pre-agricultural state), major work would be needed to maintain the rail links in these areas. Otherwise it is envisaged that Ipswich to Peterborough rail links would require only limited improvement. Norwich to Peterborough road links are also constantly being improved. The main transport issues would be local access, which is not well defended and would be overwhelmed in emergencies. New schemes are already being designed to new standards and most are unlikely to be at risk, except in storms. The Environment Agency believes that upgrading standards of design will be adequate to cope with the potential impacts of climate change[48].

3.74. Climate change will also affect infrastructure outside the region, which could have a knock-on effect in the East of England. In particular impacts on London's infrastructure would have a serious knock on effect for businesses throughout the East of England and workers who commute from the region into London.

3.75. Existing infrastructure may also be susceptible to subsidence, which is likely to be a particular issue in the central and southern parts of the region underlain by clay soils. Possible higher wind speeds and storms could threaten electricity transmission lines.

3.76. On a positive note, there is likely to be increased potential for renewable energy generation, particularly solar power generation as temperatures and sunlight increase. There may also be increased opportunities for offshore wind generation, although the extent of changes to wind speeds are uncertain, as discussed earlier.

Table 3.4: Main climate change impacts facing infrastructure

Main impacts facing infrastructure -water resources, flood defence, energy and transport	Spatial extent of impact
• Climate change is likely to cause demand for water to increase;	Region wide

[47] Pers comm. Paul Hart, Environment Agency

[48] As above.

Main impacts facing infrastructure -water resources, flood defence, energy and transport	Spatial extent of impact
• Uncertainty over implications for water availability for public water supply systems, but especially under the High Emissions scenario there may be adverse impacts on availability;	Region wide, and particularly to south of region
• Vulnerability of water supply systems to long dry periods; water infrastructure may not be able to cope with long dry spells in summer, and there may be shortages of water available for direct summer abstractions;	Region wide, and particularly to south of region
• Combined potential supply pressures and demand increases could lead to supply deficits especially in the southeastern part of the region;	Region wide, and particularly to south of region
• Saline intrusion into coastal aquifers is a further risk to groundwater resources, although currently assessed as a relatively minor issue;	Coastal
• Increased climatic variability and increased winter rainfall could put pressure on drainage systems;	Region wide
• Coastal and fluvial flooding will have impacts on many aspects of the regional economy, society and environment. Existing flood defences will face increased pressure and the costs of flood damage to built property, without increased defences, could be significant;	Coastal and areas at risk of fluvial flooding
• Flood risk is likely to be the most important factor affecting existing energy and transport infrastructure, and in future locational decisions;	Coastal and areas at risk of fluvial flooding
• Increased frequency of storms damaging electricity transmission and distribution systems;	Region wide but greatest in coastal areas
• The nuclear energy plants on the coast will require continued coastal defence at least until fully decommissioned (a period beyond the timeframe of this guidance);	Coastal
• Infrastructure also susceptible to flood risk and subsidence;	Particularly south of region
• Summer surges in electricity demand for cooling on extremely hot days.	Region wide

Stakeholder workshop discussion

Key climate change impacts facing infrastructure – water resources, flood defence, energy and transport

The regional stakeholders identified the following as being of particular concern:

- Water will drive the key impacts; there is too much in some places and not enough in others;

- Coastal and fluvial flood defence, including where to concentrate flood defences;
- Issues surrounding water transfers;
- The likely high cost of infrastructure for both water transfers and flood defences e.g. in the Thames Gateway;
- Insurance and risk;
- Water resources and supply, including for habitats such as wetlands, particularly in the southeast;
- Land use and water quality;
- Impact on transport infrastructure, especially in coastal areas and whether such infrastructure should receive further significant investment.

4. SPATIAL GUIDANCE

KEY DECISIONS TO BE MADE

4.1. It is clear from the previous section that the impacts faced by the East of England as a result of climate change are significant, and will require long-term planning. This section presents a discussion of some of the decisions that will need to be made as the region attempts to adapt to climate change, such as:

- In terms of water supply, there is a need to acknowledge that emerging deficits will be exacerbated by the expected demographic trends, unless patterns of water use are encouraged to change. Management decisions need to be made in terms of infrastructure needs. Demand management measures could also become increasingly important in order to encourage self-sufficiency;
- In terms of flooding, a key issue is to decide whether the region should protect against flooding and what it should be aiming to protect;
- Continuing decisions need to be made regarding managed realignment;
- An important question regarding environmental assets centres around what should be allowed to change and what the region should aim to retain. This may also have bearings in terms of environmental law;
- The cost of 'technical fixes' is also an important issue. Technical fixes are often possible, but whether they are desirable from a sustainability perspective is questionable. The issue of the value of community and other intangible values is relevant in this context;
- Decisions also need to be made in terms of suitability of agricultural systems and agricultural land use patterns;
- Risk, insurance, societal response and political factors could have a significant bearing on the range of options available for addressing climate change.

4.2. In response to these issues and on the basis of our research and the views expressed by stakeholders at the workshop, this section sets out:

- The existing regional policy context;
- Potential adaptation measures for each of the climate change impact topics described in Section 3;
- A set of suggested spatial guiding principles for dealing with the impacts of climate change;

- Discussion of the implications of applying these principles to the East of England.

EXISTING SPATIAL POLICY CONTEXT

4.3. It is very important to remember, that the region is not starting with a 'blank canvas' - it has invested a huge amount in built development and infrastructure. Not forgetting to mention the very significant, but intangible value of communities – and indeed this is why it is so important to plan for and respond to climate change, as there are important assets that are potentially at risk.

4.4. Thinking purely in terms of climate change may lead one to recommend a particular course of action in terms of location of development and principles governing development and other activities. However, existing patterns of development and infrastructure and policy objectives that are already in place may conflict with principles for climate change adaptation.

4.5. Regional Planning Guidance is currently set out in RPG 6 (RPG for East Anglia to 2016, November 2000) and RPG 9 (RPG for the South East, March 2001). The regional boundaries have since been revised, and the East of England incorporates the whole of East Anglia and the counties of Bedfordshire, Essex and Hertfordshire which were formerly in the South East region).

4.6. RPG 6 sets out a strategy that is designed to:

- Provide for continued population growth and meet the housing needs of all sections of the community;
- Provide for sustained economic growth across the region above the national rate;
- Concentrate development in the main cities and larger towns in preference to the smaller towns and villages and within built-up areas in preference to previously undeveloped land. In rural areas development should be focused on market towns which have access to good quality public transport where this would contribute to greater self containment;
- Protect and enhance the distinctive environmental qualities of the region, enhance biodiversity and diversity in local landscape and urban character;
- Resolve environmental, economic and social problems and in particular address the remaining disparities in opportunities and quality of life across the region, through a focus on the priority areas of regeneration.

4.7. RPG 6 makes only limited reference to climate change. The main issue addressed is in relation to the water environment, such as coastal and fluvial flooding. However, other aspects of RPG 6, such as the general distribution of development, are likely to be affected by the impacts of climate change in the future. For example, RPG 6 sets out policies in relation to regeneration and identifies the coastal towns of Great Yarmouth and Lowestoft as Priority Areas for Regeneration and priority locations for employment. In climate change terms, however, such areas are potentially quite vulnerable, and are likely to require significant investment in flood defences, which may be very costly with a high degree of risk attached.

4.8. RPG 9, which includes London and a number of counties outside the East of England region, sets out a series of key development principles. This is followed by a core strategy that recognises the importance of the region for its links with Europe and the rest of the UK, in particular from London. It identifies the regeneration of Thames Gateway as a regional and national priority, as a vital and major contributor to the growth of the regional economy and enhancement of its environment. In the Rest of the South East (ROSE), priority areas for regeneration (PAERs) are identified in a number of locations, including Harlow, Luton, Dunstable and Houghton Regis and the Tendring Coast, which now fall within the East of England region. East London and the Lea Valley are also identified as a PAER on the edge of the East of England. The Western Policy Area in RPG 9 falls outside the East of England region. The need for a strategy for a London-Stansted-Cambridge sub-region is also identified.

4.9. The significance of climate change is recognised in RPG 9, which states that greater attention needs to be given to planning new developments so as to avoid areas with a tendency to flood and to take account of the availability of water resources. It also recognises other implications of climate change, such as the need to anticipate deterioration of built structures, to avoid disruption to transport and power supplies or changes in cropping patterns, and the associated development required for processing and storage. However, it is not clear how (or whether) these have influenced the overall spatial distribution of development in the region, beyond more local adaptation measures and planning considerations.

4.10. Regional policy is also influenced by national decisions. Three national growth areas have recently been identified by the ODPM[49], which lie largely or partly in the East of England: Thames Gateway, London-Stansted-Cambridge and Milton Keynes-South Midlands. A fourth growth area, Ashford, lies outside the region.

CLIMATE IMPACT STUDIES IN NEIGHBOURING REGIONS

4.11. London and the South East have both completed studies looking at the impacts and approaches to dealing with climate change. The issues for London are examined in the study: *London's warming: The impacts of climate change on London*. This study provides a detailed overview of a

[49] ODPM (2003) Sustainable communities for the East of England: Building for the future.

wide range of impacts facing London at differing spatial scales. Key messages include:

- Flood risks facing London. Unless investment in flood management measures is continued, the increased risk of flooding could lead to damage of buildings and property, and disruption of London's transport network;
- New developments to address the growing demand for housing will need adequate flood protection from all flood sources;
- London is already one of the driest capital cities, and climate change could reduce the amount of water available and increase demand in summer;
- London may also be particularly sensitive to increases in temperature in the future because of the urban heat island effect;
- The study also highlights possible opportunities, including benefits to tourism and recreational industries.

4.12. The study provides general adaptation options and comments on the implications for spatial planning. For example, in relation to the Draft London Plan it notes that some of the areas of significant housing development planned for East London are at increasing risk from flooding, and general adaptation possibilities are suggested. Similarly the potentially very significant water shortages, which London may face, are flagged up, and again general adaptation measures are suggested.

4.13. *Rising to the Challenge: Impacts of climate change in the South East in the 21st century* similarly provides a synthesis of the range of impacts facing the South East. It looks at impacts facing the coast, the countryside, heritage, water supply, the floodplain and the economy. Again, the significant challenges posed by rising water demand and supply issues and flood risks are highlighted.

4.14. The study sets out the importance of developing a sustainable approach to managing the threats and making the most of the opportunities presented by climate change. The study notes the importance of a 'new planning agenda' to ensure integrated regional decision-making, which manages the uncertainties posed by climate change.

CLIMATE CHANGE IMPACT TOPICS – POTENTIAL ADAPTATION MEASURES

4.15. Whilst our understanding of the forecast impacts of climate changes is improving all of the time, we are still in the early stages of preparing a response. A study undertaken by Environment Resources Management (ERM) on behalf of the Office of the Deputy Prime Minister, then DETR[50], provides a good overview of potential adaptation responses available to a range of sectors. In order to further explore the implications, attendees at the workshop were asked to put forward their ideas about how we should be aiming to adapt to the impact of climate change for each of the climate change impact topics described in Section 3. The findings are set out below.

Agriculture and forestry

4.16. In terms of agriculture and forestry a range of specific adaptation measures are suggested in the ERM report, although some are more applicable at the local response level than at a strategic level. Adaptation measures include:

- Adoption of better adapted crop varieties and animal breeds;
- Adoption of techniques to control soil erosion;
- Close crop monitoring;
- Development of weed, pest and disease control strategies;
- Adoption and development of appropriate low-cost water conservation and water-efficient irrigation methods;
- Protect existing trees and forests and enforce/enhance protection;
- Avoid sites for forestry that are likely to be affected by increased wind and storm risks or reduced soil moisture/drought, possible use of new species should be taken into account;
- Use appropriate species mix.

4.17. The views expressed by stakeholders at the workshop, in relation to adaptation measures for agriculture and forestry, are presented in the box below.

50 ERM (2000) Potential UK adaptation strategies for climate change: Technical report

Stakeholder workshop discussion

The workshop attendees agreed that the approach for agriculture and forestry should be to work with the impacts of climate change, rather than defend against them. Consistent with this approach should be a general aim to look for opportunities to secure positive benefits. For example, increasing woodland planting (it was noted that multi-use woodland is now more important to the region than commercial forestry) can help to maintain clean water and alleviate run-off and flood risk. Another example suggested was looking to achieve import substitution, such as tomato canning.

In order to adapt to climate change, it was recognised that significant challenges lay ahead, such as:

- The type of crops that might be best placed to benefit from longer growing seasons are in many cases likely to be water thirsty (e.g. some bio-energy crops may be good as alternative sources of energy, but bad in terms of water use), at a time when water resources are likely to become more scarce;
- The region may need to re-think how it deals with water resource issues at both the strategic and local levels, with an increased emphasis on demand management;
- If irrigation is not possible because of lack of water resources, then the land use implications are likely to be significant in terms of the types of crop that can be grown;
- Farmers working land on the coast are likely to be particularly affected, and as a result there needs to be a policy response to compensate for loss of productive farmland, if a policy of managed retreat is pursued – parts of Suffolk and Essex are likely to be particularly vulnerable;
- It may be necessary at some stage to decide where the thresholds to different approaches to agriculture and forestry lie (in line with the above issues);
- More stringent controls on agricultural inputs will be required in order to maintain environmental quality at a time of increased stress;
- Rural communities and the rural economy will need to be more flexible than in the past to adapt to the challenges and opportunities that will result from climate change.

While it is clear that there is still some uncertainty, as to what approach should be adopted, because of the likely significance of issues, such as availability of water resources for irrigation. There was a general feeling that climate change could bring opportunities for agriculture and woodland so long as a flexible stance is taken by the industry and by local people.

Environmental assets

4.18. The possible changes facing natural assets, in particular habitats and biodiversity, leave environmental managers with difficult decisions to make.

Habitats and populations currently protected or valued may become impossible to maintain and habitats, which are currently unprotected may become scarce and/or vulnerable and thus merit active management for the first time. Moreover entirely new biodiversity benefits may become possible.

4.19. In terms of nature conservation, the ERM adaptation study notes the importance, under the law, of seeking to ensure that designated areas continue to meet their nature conservation objectives. Under the EU Habitats and Birds Directives, member states are obliged to maintain the ecological integrity of the network of SACs and SPAs. Decisions, for example, in relation to managed retreat and flood defence works must adhere to this, which could potentially limit the possibility of allowing habitats to change and evolve with climate change. However, where it is not possible to protect a site from the impacts of climate change, evolution may necessarily have to take precedence.

4.20. The study notes that adaptation responses should, where possible:

- Rely on natural migration processes;
- Facilitate colonisation whereby barriers to the continuation of natural ecological processes are removed;
- Undertake wholesale re-creation or restoration of habitats that have been lost or are under serious threat.

4.21. Several 'no regrets' actions are suggested:

- Improve protection and management of existing designated areas;
- Ensure policy builds on the natural dynamics of ecosystems and incorporates buffer zones in designated areas;
- Incorporate opportunities to facilitate colonisation in agri-environment schemes, flood defence schemes and coastal planning.

4.22. The study suggests possible changes to nature conservation policy, including changing the site designation system in light of the more dynamic context created by climate change. For example, creating buffer zones, considering de-designations and addressing the issue of losing sites that may potentially become important in the future. Strengthening conservation systems, outside designated areas, could support this, which is the way policy is already starting to move, through, for example, English Nature's Natural Area approach.

4.23. In terms of cultural assets, measures will need to take place at the local level, which will be covered in Stage 2 of the study.

4.24. The views expressed by stakeholders at the workshop, in relation to adaptation measures for environmental assets, are presented in the box below.

> ***Stakeholder workshop discussion***
>
> Again, the workshop attendees generally agreed that the approach for environmental assets should be to work with climate change. For example, in terms of landscape the focus should be on the wider countryside, accepting that designated areas will change and that we probably cannot and should not attempt to stand in the way of such change. Similarly, the general view was expressed that we should plan positively to create new habitats and landscapes, and provide corridors and stepping stones to allow species to adapt and migrate, in order to embrace the opportunities created by climate change.
>
> However, several important issues were raised which must be resolved in order to determine an appropriate response to climate change, including:
>
> - The need to consider what assets are tradable and which are irreplaceable;
> - Linked to this is the requirement of European law and whether this provides a decision making framework that allows such decisions to be made; at present there is a strong focus on protecting and preserving designated nature conservation sites.
>
> The general feeling amongst workshop attendees appeared to be that we would have to accept that there would be some losses of habitats and landscapes.

Housing and the economy

4.25. There is a wide body of literature on local level adaptation measures for housing and building design; however at the strategic spatial level, adaptation responses very much depend on responses to the other impact topics, such as how water demand and flood risk are to be addressed. These issues are addressed in the next section on infrastructure adaptation measures.

4.26. The views expressed by stakeholders at the workshop in relation to housing and the economy are presented in the box below. Again, most of these were infrastructure oriented.

Stakeholder workshop discussion

Several priority issues were highlighted which need to be addressed in order to determine an appropriate approach for housing and the economy in relation to climate change. In the most part these were identified as being water related: i.e. water supply and flood risk. In terms of water supply several issues were identified:

- Water supply issues are already apparent;
- Certain types and location of development will make the problem worse;
- A variety of solutions will be required to address water supply issues.

Adaptation measures suggested for dealing with water supply issues were wide ranging. Some suggested RPG should promote reservoir construction and look at water transfer opportunities; although the cost implications of these measures was recognised. Others felt that water supply constraints should be taken into account more fundamentally in determining spatial development patterns and that the aim should be for the region to be more self sufficient in meeting its water demands. This would have implications for the nature and scale of future development.

A need for other measures to address water supply constraints was also raised, including promotion of water efficiency and re-use, such as through building regulations, local authority mechanisms and targets.

In terms of flood risk the following issues were raised:

- Some parts of the region are already susceptible to flood risk, including existing developed land, and this needs to be taken into account when looking ahead;
- There is a need to address current problems and avoid creating further problems in the future;
- There is a need for better information on risk;
- Flood risk will challenge the urban structure.

The workshop attendees agreed that there is a need to identify areas to protect and areas where managed retreat strategies should be employed. The issue of cost was raised, which could influence this decision (e.g. cost of urban restructuring to avoid flood risk, cost of new settlements to avoid flood risks and the possibility of some form of climate change tax, was raised as a mechanism to meet such costs).

The workshop attendees also noted that climate change could create economic opportunities such as changes in agriculture, possibilities for tourism development, and linked to this, economic regeneration of coastal settlements, although this would also depend on the approach taken to managing coastal flood risks. There could also be opportunities for alternative energy. The overall feeling was, again, that we should be seeking to work with climate change, rather than against it, recognising that this will affect our approach to economic and other development in terms of its geography, scale and character.

Infrastructure

4.27. Some critical decisions will have to be made with respect to infrastructure, particularly in relation to flood defence and water supply infrastructure. Water issues have been identified as key to the region's response to climate change – in terms of both flood defence and water supply. Should the aim be to defend the coast from flooding at all costs, or should there be some managed retreat? And should the aim be to provide technical fixes to overcome water shortages or should a more sustainable and self-sufficient approach be adopted?

Water resources

4.28. The ERM adaptation study suggests a number of adaptation responses for water resources including:

- More flexible forward resource management planning;
- Developing a range of possible supply-side options to deal with the expected shortfall of supply. These could include reservoirs, conjunctive use schemes (where winter river flows are stored in uplands as groundwater for release during the summer months), bulk transfer schemes, desalination plants and leakage reduction;
- Improving domestic water demand management measures so that the shortfall in supply can be minimised as much as possible;
- A number of measures for adapting to changes in water quality such as controlling discharges and better catchment management.

4.29. A number of 'no regrets' actions:

- Awareness raising of water scarcity issues;
- Demand side management measures;
- Addressing leakage reduction in priority areas.

Flood risk

4.30. The ERM adaptation study suggests the following possible adaptation responses to flood risk:

- Accelerating investment in existing programmes of coastal and river flood defences to protect flood prone areas against increased risks from climate change;

- Avoiding, or ensuring adequate protection for, new development in areas likely to be at increased risk of flooding.

4.31. The approach advocated by the Environment Agency seeks to provide adequate, economically, technically and environmentally sound and sustainable flood and coastal defences and to discourage inappropriate development in areas at risk from flooding[51]. In responding to climate change, the Environment Agency is advocating 'holistic' approaches to defence, which rely on 'joined-up' understanding of complex river and tidal systems and on realism about where homes and infrastructure can be sited in the future[52]. The Environment Agency supports sustainable defences being 'designed in' to developments at the outset and also supports managed realignment in appropriate circumstances, particularly in agricultural areas. For example, it has publicised several examples where saltmarshes have been created on agricultural land in order to provide nature conservation benefits as well as flood protection to homes and agricultural land.

4.32. Linked to the idea of a holistic, joined-up approach, is a further possible adaptation measure. This is to avoid development in areas that might worsen flood risk elsewhere, and to avoid development in locations, which might in future provide vital flood management services, for example, space for balancing ponds for temporary water storage.

4.33. The ERM adaptation study provides a useful overview of adaptation measures open to the insurance industry, which will evidently have major implications for housing and the economy in the face of increasing flood risks. It notes that the sector needs to respond to flood and coastal damage in a way that will not cause illogical or unconsidered responses in the market. Responses might include:

- Publishing risk maps for the UK or discussing them with a wider audience;
- Withdrawing insurance cover for new build in flood risk areas;
- Introducing Building Research Consultancy (BRE) recommended building codes for new buildings.

4.34. The study identifies several 'no regrets' actions:

- Improve flood risk identification;
- Raise awareness of practical steps to minimise exposure to flood damage risks;

[51] DEFRA (2002) The Environment Agency's objectives and contributions to sustainable development: Statutory guidance by the Secretary of State for Environment, Food and Rural Affairs.

[52] Environment Agency journal: Environment Action (January 2003) Flood supplement: *A hard rain* pp.18–19.

- Use planning and insurance to help discourage future development in high risk areas.

Transport and energy infrastructure

4.35. As is the case for housing and the economy, there is much that can be done at the local level. For example, in terms of design to adapt to climate change; however at the strategic spatial level, adaptation responses very much depend on broad locational decisions, which will depend on responses to other impact topics, such as how flood risk is to be addressed.

4.36. Design issues that are carefully considered spatial decisions could help to adapt to the impacts of climate change on infrastructure. However, in terms of access to vital services, which traditionally depends on transport infrastructure, there may be benefits of making access less dependent on mobility, for example, by delivering public services nearer to users and increasing the diversity of local economies.

Stakeholder workshop discussion

The workshop attendees discussed the issues surrounding infrastructure, in particular in relation to water resources and flood defence and came up with the following responses:

- Water supply is already an issue and in areas where the problem is acute (e.g. parts of Essex), the nature and scale of any future development will need to be carefully considered;
- There will be a need to plan for more winter water storage;
- A policy stance should be taken to locate certain types of new development outside areas at risk of climate change related flooding. Decisions in relation to location of all new development, energy and transport infrastructure should be based on the need to minimise risk of flooding;
- New transport infrastructure should be located away from groundwater sensitive areas, since areas prone to soil cracking and leaching could be highly susceptible to pollution.

The attendees also discussed how decisions should be made in relation to flood defences. The issue of cost was raised; there was a feeling that some form of cost-benefit analysis should be used to determine those areas that should be defended, taking into account monetary costs as well as environmental and other values. Similarly it was felt that cost should be taken into account when considering water supply infrastructure decisions, since a technical fix will usually be possible, but may not be desirable, when less tangible costs are taken into account as well as monetary costs and values.

However, the attendees raised the challenging question of what value should be placed on communities. For example, it is very difficult to weigh up the value of existing communities (in social, economic and environmental terms) against the monetary costs of providing or not providing flood defence.

Linked to the difficult issues surrounding defending against flooding versus managed retreat, are concerns relating to equitable compensation for loss of property affected by policies for dealing with climate change and local concerns over the difficulties and cost of insuring property that may be at risk from sea-level rise.

The attendees also suggested other measures, which will be important at the local level for dealing with pressures on infrastructure, such as Spatial Planning Guidance (SPG) on design for buildings to minimise flood risk and subsidence, and SPG to promote water efficiency and sustainable urban drainage systems (SUDS).

PRINCIPLES FOR LIVING WITH CLIMATE CHANGE

4.37. The analysis of the impacts of climate change, the review of relevant scientific and policy literature, and the discussions held by attendees at the workshop, provide a good basis for considering how the East of England should begin to go about planning to live with climate change.

4.38. We have developed a set of 'spatial guiding principles' based on this context, which will help decision makers to plan for climate change. The principles reflect guidance on climate change responses set out in PPG 11: Regional Planning, which states that:

"RPBs should consider their regions' vulnerability to climate change using the most recent climate change scenarios available from the draft UK climate impacts programme….. The spatial strategy for the region should take account of the need to avoid new development in areas that increase vulnerability and consider possible adaptation options for vulnerable areas" (p.19)

4.39. The principles seek to influence the pattern of spatial development from a climate change perspective. However, there will of course be many other policy objectives, some of which may require a different spatial response. Indeed, a response that focuses purely on living with climate change may not necessarily be the most appropriate response under other sustainability objectives. The aim of this report, though, is to draw out the climate change dimension to inform the debate on regional priorities and spatial planning, and should be read in this light.

4.40. It should be remembered that the study is focussed on climate change **response** rather than **mitigation of impacts** and the principles developed reflect this.

4.41. The overarching aim sets out a position that acknowledges the reality of climate change and a willingness to respond positively to it:

Overarching Aim for Living with Climate Change in the East of England:

To work with climate change, rather than against it and manage the impacts for the benefit of future generations

4.42. Whilst many of the adaptation measures that will need to take place will be at the local level (e.g. the form and design of development), there will be a number of major decisions that will have to be made at the regional scale, particularly with respect to planning for the spatial distribution of development.

4.43. In order to guide spatial development, a key spatial guiding principle is suggested:

Key Spatial Guiding Principle for Living with Climate Change in the East of England:

To reduce risk by guiding new development to those locations least vulnerable to the potentially adverse impacts of climate change

4.44. In order to inform the key spatial guiding principle, a number of supporting guiding principles have been developed. These aim to address all of the main spatial climate change impacts that are likely to affect the East of England. Reflecting the views of the stakeholders attending the workshop and our understanding of the sort of response that will be required in the longer term (i.e. over the period to 2100 covered by the UKCIP02 research, rather than the shorter term time horizons of RPG and other related strategies).

Supporting Spatial Guiding Principles for Living with Climate Change in the East of England:

- ***Protect existing land uses from the impacts of sea level rise and fluvial flooding only where the benefits of doing so in environmental, economic and social terms clearly outweigh the capital and revenue costs***
- ***Avoid allowing development in locations that could constrain or reduce effectiveness of future options for adaptation (e.g. allowing development in areas that might prevent effective coastal and fluvial flood management in the future)***
- ***Where possible, allow for sea level rise to take its natural course***
- ***Avoid new development being located in areas at risk from sea level rise and storm surges***
- ***Guide new development to areas not at risk from fluvial flooding***
- ***Minimise the requirement for 'technical fixes' to solve flooding and water supply issues***
- ***Encourage local access to goods, services and facilities in order to reduce the need for movement and reliance on transport infrastructure that could be vulnerable to climate change impacts***
- ***Guide new development to locations that are least likely to experience water supply shortages***
- ***Guide development to locations that will not be at risk from subsidence arising from climate change (e.g. clay soils)***
- ***Exploit the environmental, social and economic opportunities afforded by climate change***
- ***Where possible compensate for loss of habitats by creation of similar habitats in less vulnerable areas***

- ***Identify opportunities to create new habitats and landscapes as a result of climate change and create corridors and stepping stones to allow species to adapt and migrate***
- ***Promote agricultural production systems in areas that are compatible with and adaptable to the impacts of climate change***

4.45. The principles outlined above provide a framework for planning the future of the East of England, if the impacts of climate change are to be taken fully into account.

4.46. In order to explore the implications of these principles if they were to be pursued, we have applied them to four further aspects:

- To break down the East of England region into 'climate change sub-regions', in order to define those parts of the region facing similar challenges from the impacts of climate change, which may therefore require a co-ordinated response;
- To consider what these principles mean, in spatial terms, for the four climate impact topics (agriculture and forestry, natural assets, housing and the economy and infrastructure);
- To appraise the RPG14 Options Consultation Document Spatial Scenarios to determine where their strengths and weaknesses lie in climate change terms;
- To consider what spatial issues with respect to climate change impacts are relevant to other regional strategies.

CLIMATE CHANGE SUB-REGIONS

4.47. The impacts of climate change are likely to vary across the region, depending upon the natural characteristics of the area affected (e.g. whether it is low-lying, or has scarce water resources) and the vulnerability of human assets affected (e.g. patterns of development). We have sought to map this variation with reference to 'climate change sub-regions'.

4.48. The sub-regions reflect both intrinsic natural character (informed by English Nature's 'Natural Areas') and human issues, such as the pattern of development, future development policies and economic conditions and also the climate change pressures facing the areas, such as coastal flood risk. The sub-regions help to distinguish between issues that affect specific areas and identify overlaps of others, will help to guide the scale and distribution of development in climate change terms.

4.49. Five climate change sub-regions have been identified: The Coast, the Fens, the Thames Gateway and fringes, the Southern Heartland and the Northern Heartland. These are shown on **Figure 4.1**. The key characteristics and climate change vulnerabilities of each sub-region are summarised below, together with an indication as to which of the guiding principles are most likely to be relevant to each sub-region (summarised in **Table 4.1**).

The Coast

4.50. The Coast broadly comprises the Natural Areas of North Norfolk, The Broads, Suffolk Coast and Heaths and the northernmost part of the Greater Thames Estuary. The natural character of The Coast is quite varied, containing for example the extensive dune systems to the north and the lowland heath to the south. It is a very dynamic part of the East of England region, with strong coastal processes at work. The Coast is home to some of the region's most important wildlife habitats (e.g. intertidal mudflats especially important for waders).

4.51. In terms of human activity, The Coast is characterised by relatively remote and rural and coastal communities, interspersed by larger towns such as Great Yarmouth and Lowestoft. Pockets of the sub-region are relatively wealthy (e.g. North Norfolk), but much of the sub-region is in significant need of regeneration, particularly the larger urban communities. Tourism is an important industry (although declining in some parts), as is agriculture, offshore oil and gas, transport and some manufacturing.

4.52. In climate change terms, The Coast is most vulnerable to sea level changes, storm surges and saline intrusion. It is likely that there will be considerable pressure for managed retreat and decisions will need to be made as to where and how much investment, in coastal flood defence, should take place with respect to communities and key infrastructure.

4.53. This area is also likely to be subject to a loss of habitats, either through 'coastal squeeze' as habitats are squeezed against hard sea defences, or through flooding of coastal habitats. Therefore the principles relating to habitats are likely to be influential.

4.54. Agricultural systems may also be subject to change, as certain systems of farming may be lost while others become more suitable, such as coastal grazing marshes rather than arable agriculture; therefore the principle relating to agricultural systems is important.

The Fens

4.55. The Fens are neatly defined by a single Natural Area of the same name. It is very low-lying, with large slow-flowing rivers and drains and many flooded gravel pits. Small, scattered areas of relict fen and marsh can be found, but it is dominated by intensive agriculture.

4.56. The population density of The Fens is very low, with a few small communities and towns such as Wisbech, and on its edge King's Lynn and Peterborough. These communities are in need of economic regeneration.

4.57. The Fens are perhaps the part of the region most vulnerable to climate change, because so much is already below sea-level and depends upon pumping out of water to remain dry. The impacts likely to be of most significance are coastal and fluvial flooding, saline intrusion and impacts facing agriculture, including soil moisture availability and effects of increased temperatures.

4.58. In this region, therefore, the principles applying to coastal flooding, fluvial flooding and agriculture are the most important, since the area is predominantly agricultural land in a low lying area already subject to significant flood risk.

4.59. The significant changes, which may occur in terms of flooding and agricultural systems, may well have impacts for the Fenland habitat, so the principles relating to habitats would also apply.

East of England Northern 'Heartland'

4.60. The East of England Heartland is a broad region that we have divided into two. They are distinguished by the issue of water resource availability. The Northern Heartland comprises the Natural Areas of Breckland, West Anglian Plain and East Anglian Chalk, Bedfordshire Greensand Ridge and the northern part of the East Anglian Plain. This part of the Heartland does not have the potential water resource supply issues of the Southern Heartland. The character of this sub-region is very varied ranging from the extensive areas of dry lowland heath of Breckland to the lowland oaks and mixed deciduous woodlands of the West Anglian Plain.

4.61. The three main settlements in the sub-region are Bedford, Cambridge and Norwich. Cambridge in particular, but also Norwich, are experiencing significant development pressure. Other areas, such as Breckland, on the other hand, are in need of regeneration. The sub-region is quite rural in character, with the exception of the main settlements.

4.62. In terms of climate change impacts, this sub-region is less vulnerable than many of the others, with fluvial flooding and impacts facing agriculture including soil moisture availability and effects of temperature perhaps being the most significant. This area is also likely to be less prone to subsidence due to the lesser presence of clay soils.

4.63. The key principles that are likely to apply therefore relate to fluvial flood risk, changing conditions for agriculture and providing an adaptive approach to changes facing habitats and landscapes.

East of England Southern 'Heartland'

4.64. The East of England Southern Heartland is distinguished from its northern counterpart by its potential lack of water resources. It comprises the western part of the Northern Thames Basin, the Chilterns, and the southernmost part of the East Anglian Plain. It is characterised by the chalk hills of the Chilterns, and related chalk streams, which become tributaries of the Thames and the lowland areas to the north of London.

4.65. This part of the East of England is perhaps the most under pressure for development, as it includes the commuter belt of London and many of the towns of Hertfordshire, which are performing well in economic terms. It also includes Stansted airport, which is potentially the subject of considerable growth in the future. There are pockets in need of regeneration, such as Luton and Harlow.

4.66. The sub-region is relatively less vulnerable to the impacts of climate change than the Coast, Fens and Thames Gateway. However, it does face impacts on agriculture including soil moisture availability and the effects of temperature on agricultural production and most importantly deficiencies in water resources, indicating that several principles should apply relating to water supply and 'technical fixes'. Due to the water supply issues facing the sub-region, agricultural systems are likely to need to adapt, so the principle relating to agricultural systems also strongly applies. Similarly landscapes and habitats are also likely to be affected by water availability and also by temperature rises, so the principles relating to habitats and landscapes are very important. The risk of subsidence on clay soils is also an important issue in this region. To some extent the sub-region is also subject to risks from fluvial flooding which means that the several principles relating to fluvial flooding also apply.

Thames Gateway and fringes

4.67. The Thames Gateway falls into the Natural Areas defined by the Greater Thames Estuary and the easternmost part of the Northern Thames Basin. It is therefore highly influenced by coastal processes. It is home to important wetland habitats.

4.68. The Thames Gateway climate change sub-region stretches beyond the policy sub-region to be found in RPG. Nonetheless, the regeneration policies that apply to Thames Gateway are the most significant influence on this area, as there is likely to be major housing and economic growth, with associated transport and servicing infrastructure, over coming decades. London (into which the Thames Gateway policy area extends) heavily influences the sub-region.

4.69. In climate change terms, the sub-region is particularly vulnerable to water resource deficiencies, sea level changes, and fluvial flooding. In this region, therefore, the principles relating to coastal and fluvial flooding again apply, as do the principles relating to water supply issues, since the sub-region is already subject to unsustainable levels of water use. This sub-region is also likely to be at risk from subsidence.

Where do the other principles apply?

4.70. Several principles could be applied to parts of or all of the sub-regions, and do not specifically relate to any one sub-region.

4.71. The principle to 'encourage local access to goods, services and facilities in order to reduce the need for movement and reliance on transport infrastructure that could be vulnerable to climate change impacts' should be applied throughout the region.

4.72. The principle to 'exploit the environmental, social and economic opportunities afforded by climate change' should again be applied throughout the region, and would apply in different ways to different areas. For example, coastal areas could respond positively in terms of capitalising on potential increases in tourism and possibly offshore wind renewable energy generation.

Table 4.1: Key climate change principles applying to each climate change sub-region

Climate change principles	Climate change sub-regions ● - Key principle ○ - Secondary principle				
	The coast	**The Fens**	**The Thames Gateway and Fringes**	**East of England southern 'Heartland'**	**East of England northern 'Heartland'**
Protect existing land uses from the impacts of sea level rise and fluvial flooding only where the benefits of doing so in environmental, economic and social terms clearly outweigh the capital and revenue costs	●	●	●	○	○
Avoid allowing development in locations that could constrain or reduce effectiveness of future options for adaptation (e.g. allowing development in areas that might prevent effective coastal and fluvial flood management in the future)	●	○	●	○	○
Where possible, allow for sea level rise to take its natural course	●	●	●		
Avoid new development being located in areas at risk from sea level rise and storm surges	●	●	●		
Guide new development to areas not at risk from fluvial flooding	○	●	●	○	○
Minimise the requirement for 'technical fixes' to solve flooding and water supply issues	●	●	●	●	○
Encourage local access to goods, services and facilities in order to reduce the need for movement and reliance on transport infrastructure that could be vulnerable to climate change impacts	Should be applied throughout				
Guide new development to locations that are least likely to experience water supply shortages			●	●	

Guide development to locations that will not be at risk from subsidence arising from climate change (e.g. clay soils)			●	●	
Exploit the environmental, social and economic opportunities afforded by climate change	Should be applied throughout				
Where possible compensate for loss of habitats by creation of similar habitats in less vulnerable areas	●	●	○	●	●
Identify opportunities to create new habitats and landscapes as a result of climate change and create corridors and stepping stones to allow species to adapt and migrate	●	●	○	●	●
Promote agricultural production systems in areas that are compatible with and adaptable to the impacts of climate change	●	●		●	●

THE FUTURE OF THE EAST OF ENGLAND IN CLIMATE CHANGE TERMS

4.73. Having looked at the impacts of eliminate change on the East of England in terms of a series of sub-regions, we have attempted to provide an interpretation of what this means for the region as a whole. This is presented in terms of the four climate change impact topics:

- Agriculture and forestry;
- Environmental assets – natural and cultural;
- Housing and the economy;
- Infrastructure – water resources, flood defence, energy and transport.

4.74. For each impact topic an 'ideal' approach to responding to climate change in spatial terms is presented.

Agriculture and forestry

4.75. The climate change principles suggest that agricultural production should be concentrated primarily in the northern 'Heartland' where water supply is not subject to such acute constraints. Agriculture, in the southern 'Heartland', should be limited to production which does not require large supplies of irrigation water, which may require significant adjustments, possibly to less intensive agricultural systems. However, there are ways to adapt to climate change at the local level, for example through more careful irrigation e.g. using water efficient systems, careful timing, etc. It is also important to note that agriculture will need to be able to continually adapt as temperature rises and water availability lessens. New crops may need to be grown that can adapt to a wider and changing range of climatic conditions, unless it is decided to grow crops under glass to allow greater control of micro-climate. Elsewhere, in the Fens and Coast, the primary cause for change is the increased flood risk. In these areas more extensive pastoral agriculture may be more appropriate, for example using grazing marsh.

4.76. Large scale commercial forestry is no longer a major consideration in the East of England, although if it were to take place it may be better suited to the northern 'Heartland' where water supply is less constrained. However, multi-purpose forestry could take on a more significant role throughout the region, perhaps on a local scale, due to the important functions played by trees, including mitigating against flooding and soil erosion and the screening of development from wind. The Forestry Commission states that trees can also perform a useful water storage function. This suggests that woodland planting could be important in the south as well as the north of the region.

Environmental assets - natural and cultural

4.77. Environmental assets in the Coast sub-region and the Fens are prone to flood risk and possibly 'coastal squeeze' in the former, depending on flood defence decisions. The main aim in these sub-regions should be to allow habitats to migrate where possible. Where habitats are lost due to flooding the aim should be to replace them or facilitate the creation of similar habitats elsewhere. A similar principle should apply to landscapes. Habitats and landscapes in the northern and southern 'Heartlands' are likely to be subject to temperature related pressures and some fluvial flood risks; in these areas it is important that opportunities to create new habitats and landscapes are recognised.

4.78. Cultural assets are fixed in nature and their survival will depend primarily on localised protection measures and on flood defence decisions.

Housing and the economy

4.79. Housing and economic growth should, from a climate change perspective, be located away from those areas subject to flood risk, of which The Coast sub-region is at greatest risk. Housing and economic growth should also be steered away from those areas facing severe water supply pressures, which are primarily found in the southern 'Heartland' and the Thames Gateway and fringes. These areas should also be avoided due to the risks of subsidence due to clay soils.

4.80. Ideally development should be focussed in the northern 'Heartland' since this sub-region is least vulnerable to water supply shortages, and also faces a lesser risk of coastal flood risk. Within the northern Heartland there are a number of major settlements that fall just outside those sub-regions most vulnerable to the impacts of climate change, most notably, Peterborough, Cambridge and Norwich, which, in the future could act as the 'gateways' to the region if significant retreat as a result of sea level rises were to be contemplated. In many respects Cambridge seems particularly well placed to deal with the impacts of climate change, given the availability of water supply. Careful consideration of fluvial flood risks will apply to all settlements.

4.81. Other settlements, such as those in the Fens, on the coast (e.g. Great Yarmouth, Lowestoft, Clacton, and Southend-on-Sea) are particularly vulnerable to climate change. All are currently in need of regeneration. However, these established settlements are probably best placed to take advantage of tourism benefits that could arise as a result of a warmer climate and in the case of Great Yarmouth and Lowestoft, are also very well placed to take advantage of the emerging offshore wind energy industry.

Climate change could therefore bring new opportunities against which to balance any judgement over the risk of adverse impacts.

4.82. The southern towns, particularly those in Hertfordshire and around Stansted, are not so well placed in climate change terms, especially with respect to water resources and to a lesser extent fluvial flood risk. However, here the importance of these towns to the economy of the sub-region suggests that technical fixes (e.g. provision of new water supply sources, and flood defence measures) may be required to overcome such climate change impacts.

Infrastructure – water resources, flood defence, energy and transport

4.83. Decisions relating to infrastructure stem from decisions made primarily in relation to the location of housing and the economy, as infrastructure is required to support these land uses. Ideally the need for technical fixes to remedy flood risk and water supply shortages should be avoided and this will be possible if development is located away from those areas most at risk of flooding and most subject to water supply shortages. However, this in practical terms may not be possible. For example, there is already considerable investment proposed for Thames Gateway, where it is likely that considerable investment will be required to mitigate for the impacts of climate change (e.g. to provide flood defence, flood relief, and water supply). There will also be a need to co-ordinate decision-making with neighbouring regions and particularly with London over issues such as water supply and the vulnerability of key transport and other service infrastructure to extreme events and flooding.

4.84. Energy infrastructure, such as power stations should be located away from areas at risk of flooding and of subsidence. So again this suggests that major energy generation infrastructure should, where possible, be located away from the most vulnerable locations (e.g. the Coast). However, new opportunities will arise as a result of climate change, for example energy generation from solar power and possible increased opportunities for offshore wind turbines, which may help to offset any adverse economic consequences arising from reduced emphasis on more traditional forms of energy production. Regional strategies should promote renewable energy, and this will also contribute towards mitigating against climate change. In the future energy distribution and transmission infrastructure will need to be designed to withstand risks of subsidence and damage by high winds and storm surges. There are also the long-term liabilities of the coastal nuclear sites at Sizewell A and B and Bradwell which will need to be defended from rising sea levels and coastal erosion until fully decommissioned. As noted in Section 3, Bradwell closed last year and due to the presence of radioactive waste on the sites, the length of time required for decommissioning (in excess of 100 years), it will need defending from rising sea levels and coastal erosion until fully decommissioned (well beyond the period covered by this study). Sizewell A will close in 2006, whilst Sizewell B will continue to operate for some time to come. As the two sites are located adjacent to each other both sites will need defending well beyond the period covered by this study.

4.85. Again, the principles imply that major transport infrastructure should not be built in areas at risk from flooding. In particular this would suggest that additional investment in coastal transport infrastructure should be avoided. Further investment in rail improvements and where necessary, road improvements should include east-west links, rather than the historic north-south links, in order to promote an alternative axis of development, which would help to relieve pressures on water supplies in the southern 'Heartland' and competition on this resource from London. Transport infrastructure required in areas at risk of subsidence should be designed in such a way to withstand the risks as far as possible.

IMPLICATIONS FOR RPG SCENARIOS

4.86. RPG14 will drive the pattern of spatial development in the East of England until 2021. In order to generate debate, the East of England Local Government Conference issued an Options Consultation Document (Sept 2002). This presented four spatial scenarios to inform the choice of spatial development pattern (the four scenarios are summarised below).

Summary of Spatial Scenarios from RPG 14 Options Consultation Document (September 2002)

(1) **Continuation of existing regional policies**, as set out in RPG6 East Anglia (November 2000) and RPG9 South East England (March 2001), being balanced growth across the East of England and building on the existing settlement pattern. This scenario identifies Priority Areas of Regeneration (PAERs) in Harlow, Lower Lee Valley, Luton/Dunstable/Houghton Regis, Tendring, Great Yarmouth/Lowestoft, Wisbech, the remote rural areas of Norfolk, Suffolk and Cambridgeshire and inner Ipswich, Norwich and Peterborough. It also envisages a west-east shift to divert development from overheating west of London to regenerate Thames Gateway.

(2) **Building on the strengths of key regional centres**, focusing and promoting growth around major towns at the intersections of radial and orbital multi-modal transport routes, primarily Bedford, Colchester, Ipswich, Norwich, and Peterborough, and restricting growth in the Metropolitan Green Belt and around Cambridge. This scenario envisages growth of the market towns to support rural diversification. Thames Gateway would be the subject of both housing and economic growth.

(3) **Building on regional strengths**, with growth in the dynamic economies of the Hertfordshire towns, Cambridge and the A12 corridor to Chelmsford, extended to Luton/Dunstable and the Lee Valley/Harlow, with other larger towns building on their own respective strengths but not to such a scale. This scenario would maximise the agricultural potential of the region, and strengthen the leisure/tourist industry in the north and east. Major investment would be provided in Thames Gateway.

(4) **A new settlement as a prime location of growth**, which would be located in a central position in the region subject to environmental constraints, and would aim to have a population of 200,000 over a 40 year period.

4.87. In order to contribute to an understanding of the impact of climate change and to feed into the preparation of RPG14, we have carried out a strategic appraisal against each of the 14 supporting climate change spatial guiding principles. The appraisal matrix is included as **Appendix 3**.

Common issues

4.88. All the scenarios, except scenario 4, propose some degree of development in most of the key settlements. Therefore there are some common issues between the scenarios, although the scale and type of development often influences the significance of the issue.

4.89. Development in the Thames Gateway is common to scenarios 1,2 and 3. Scenarios 1 and 3 propose employment led growth, whilst scenario 2 proposes housing and employment led growth. This falls within one of our 'climate change sub-regions' and as outlined above, this sub-region will be subject to coastal and fluvial flood risk, water supply issues and risks of subsidence.

4.90. From a solely climate change point of view, the Thames Gateway is not well suited to major development, although in terms of employment growth, warehouses and distribution sectors are possibly less vulnerable than manufacturing. Housing is likely to be particularly vulnerable, which suggests there will be a need to ensure that housing is resilient to occasional flooding – a point that will be developed in the next stage of this research. The decision for Thames Gateway to act as a major focus of regeneration for East London and beyond has already been taken at the national level. Concentrating development here is contrary to a number of key climate change spatial guiding principles, which means that considerable investment is likely to be required in future years to counter the increasing risk of the area becoming vulnerable to the adverse impacts of climate change.

4.91. Coastal flooding, in combination with fluvial flood risk, could also be an issue for some other settlements. Norwich, Ipswich and Colchester all appear in scenarios 1, 2 and 3 to some degree (in scenarios 1 and 3 this growth is moderate, but in scenario 2 these areas are proposed for major growth). These towns all lie at or just beyond the inland reach of (current) coastal flood risk, and have areas of fluvial floodplain. There may be an increased risk of flooding in these settlements as coastal and fluvial flood risks increase. However, careful location of growth within these settlements could avoid placing new development at risk of fluvial or coastal flooding. Further information on climate induced flood risk is needed in these areas to ensure any risk is minimised.

4.92. Scenarios 1, 2 and 3 also all include an element of development, which could be affected by flooding in the Fens. On the edge of the Fens, Cambridge is proposed as an area for major growth in all three scenarios. Peterborough is identified for major growth in scenario 2 and less so in scenarios 1 and 3. Kings Lynn is identified as an area for some growth in all three scenarios and Wisbech, is identified for some growth in scenario 1.

Issues in terms of climate change principles which do not clearly vary across the RPG scenarios

4.93. Some issues do not clearly vary across the RPG scenarios and the outcome in terms of each climate change principle will depend on other policy responses and initiatives, rather than broad spatial development decisions. These include the following:

- Encourage local access to goods, services and facilities in order to reduce the need for movement and reliance on transport infrastructure, that could be vulnerable to climate change impacts. Scenarios 1, 2 and 3 could all perform very similarly in terms of this principle; the outcome will depend on other decisions on how facilities, such as schools and hospitals, are located. Scenario 4, discussed below has significant scope for working with the principle;

- Compensate for loss of habitats by creation of similar habitats in less vulnerable areas – whether this principle is met will depend on other policy responses, such as the Regional Environment Strategy (discussed below);

- Identify opportunities to create new habitats and landscapes as a result of climate change - again, whether this principle is met will depend on other policy responses, such as the Regional Environment Strategy (discussed below);

- Promote agricultural production systems in areas that are compatible with the impacts of climate change – a dispersed settlement pattern which supports market towns could perhaps help to support agriculture and hence support transition in farming, although this is highly uncertain. Whether or not a change in agricultural production systems can occur will also depend on support mechanisms provided by Defra, such as adequate funding to facilitate conversion to less intensive agriculture, and changes to CAP.

Key issues facing each RPG scenario

4.94. The following paragraphs outline the key issues facing each spatial scenario, in climate change terms, based on the appraisal against the climate change principles (Appendix 3).

Spatial scenario 1: continuing existing policy

4.95. The issue of coastal flooding, outside of the Thames Gateway, is the most significant in scenario 1, due to the focus on regeneration in several coastal PAERs (Great Yarmouth, Lowestoft and Tendring). This has implications for the region's ability to adapt to climate change in a sustainable manner. Locating significant investment in these areas will inevitably require, and possibly be used to justify, significant investment in coastal defences. The key climate change issues are summarised below:

- Development is located in areas at risk of coastal flooding (in the Thames Gateway and coastal PAERs);
- There is likely to be a heavy reliance on 'technical fixes' to address coastal flood risk (on the open coast and in the Thames Gateway);
- The scenario would require the region to 'fight' sea level rise with concomitant impacts for coastal habitats (for example, loss of salt marshes due to coastal squeeze);
- By investing in areas at risk of coastal flooding, this scenario would be likely to tip the balance in favour of continuing/increasing flood defences in these areas, but this should be subject to careful consideration balancing the full range of costs and benefits to reach the most sustainable decision;
- Significant growth in the south (along the M11 corridor, and around Milton Keynes and Luton/Dunstable) would potentially require significant investment in water supply infrastructure;
- Major growth in the south would place development at risk of subsidence on clay soils.

Spatial scenario 2: regional centres

4.96. This scenario is likely to place more development at risk of fluvial flooding than scenarios 1or 3. This being due to proposed major development in Norwich, Ipswich and Colchester, which could be subject to fluvial flooding, and major development in Cambridge and Peterborough, which could be affected by increased fluvial flooding in the Fens. All these locations could also possibly be at risk from coastal flooding. However, overall this scenario does not place development at very high risk of coastal flooding, unlike scenario 1.

4.97. Potential fluvial flood risk could be mitigated by careful decisions on development within settlements at the local level.

4.98. This scenario may require an increase in water supply infrastructure in Essex, but the dispersed nature of development throughout the region should generally facilitate greater access to sustainable water supplies, outside of Essex. This dispersed pattern also means that there is less risk of subsidence, compared to scenarios that concentrate more development on the clay soils of the south of the region.

Spatial scenario 3: building on regional strengths

4.99. This scenario places new development at least risk of fluvial or coastal flooding, but it may still require some extra investment in terms of fluvial flood defences, although probably less so than scenario 2.

4.100. The scenario is also likely to require an increase in water supply infrastructure due to concentration of development in the south of the region and risk of competition with London for water resources. Major growth in the south will also place more development at risk of subsidence.

Spatial scenario 4: a new settlement as a prime location of growth

4.101. This scenario offers a great deal of scope to adapt to climate change, since criteria based on the climate change principles could be incorporated into the location decision. It should be noted that some development would still be required throughout the region in line with scenario 1, but the majority of development could be located according to 'climate change criteria'. This would enable development to occur in area(s):

- Subject to lesser risk of coastal flooding;
- Subject to lesser risk of fluvial flooding;
- That would not increase the value of assets at risk from flooding and hence encourage further flood defences;

- That are least likely to experience water supply shortages;
- That would minimise the need for technical fixes to respond to flooding and water supply issues;
- Not subject to risks of subsidence.

4.102. Based on these criteria, if a new settlement were to be provided in the region, it should be located somewhere within the northern 'Heartland'. However, the suitability of areas within this sub-region are likely to be strongly driven by other sustainability criteria as well as those relating to climate change.

4.103. A new settlement would probably also help to encourage local access to goods, services and facilities and reduce the need to travel to reach such facilities and services. This will reduce vulnerability to climate change, largely through not needing to rely on infrastructure which might be subject to flood risks, subsidence etc. and would also facilitate mitigation of climate change through reduced emissions of carbon dioxide.

Discussion

4.104. Any decision about the location of future development in the region will be taken in the light of a number of factors. Adaptation to climate change will be increasingly important. In climate change terms, the Thames Gateway, and some of the coastal settlements of the region, are either vulnerable to the impacts of climate change, or will require significant investment in order to reduce the risk of the impacts of climate change. This may be justified in order to achieve other policy objectives (e.g. regeneration) but could be costly. In addition, the considerable existing financial and social investment in some of these communities will need to be taken into account.

4.105. In many respects, the Southern Heartland offers many advantages in climate change terms, although flood risk and lack of water resources will be influential. The least vulnerable area to develop in climate change terms is the Northern Heartland.

4.106. The relationship of the region with London will be critical to any decision. London is planning for significant growth and this will put considerable strain on the infrastructure of not only the capital, but also surrounding counties. Water supply is likely to be a particular issue, as will be the vulnerability of transport infrastructure to storm events. How these tensions are managed and resolved are likely to be critical in determining the regions success in living with the impacts of climate change.

4.107. One of the spatial guiding principles relates to encouraging access to local goods services and facilities. If this guiding principle were to be adopted by all settlements and all regions, then many of the adverse impacts of climate change would begin to be reduced, albeit that there will be some locations that will remain vulnerable to the impacts of climate change. This is one of the reasons why Scenario 4 (new settlement) performs relatively well. However, as a society we are reliant on increasingly complex geographical inter-relationships. We are highly dependent on movement – of goods, of water, of energy, of waste, of people accessing work, for holidays and leisure visits. This requires an increasing amount of servicing infrastructure, not least transport. The more dependent we become on such infrastructure, the more vulnerable we will be to the impacts of climate change. Encouraging local access to everyday needs, close to home, has for a long-time underpinned our notion of sustainable development and this is entirely compatible with the way we should be thinking about responding to climate change.

4.108. The above analysis has been presented very much in climate change terms. In reality, there will be many other sustainability considerations that may be just as important in the region, if not more so. The role of decision-makers is to take all these considerations into account in determining the most sustainable pattern, scale and form of development.

4.109. In many instances, this may mean development being located in parts of the region that are not ideal from a climate change point of view. In such locations, the specified guiding principles should continue to apply so that the vulnerability of development to the impacts of change is reduced.

4.110. In this way, the specified guiding principles provide a useful framework for locational decisions at all levels – regional, sub-regions and local.

OTHER REGIONAL STRATEGIES & GUIDANCE

4.111. Whilst the main focus of this report has been spatial guidance for RPG14, the brief requires the implications for other regional strategies to be considered. The Regional Sustainable Development Framework, produced by the East of England Regional Assembly, provides the overarching context for an Integrated Regional Strategy for the East of England. In addition to RPG14, the key elements of this Integrated Regional Strategy comprises:

- Regional Economic Strategy (produced by East of England Development Agency);
- Environment Strategy (produced by East of England Environment Forum);
- Health & Social Inclusion Strategy (produced by the Regional Assembly Health & Social Inclusion Panel);
- Regional Cultural Strategy (produced by Regional Cultural Forum);

- Regional Housing Strategy (produced jointly by the Housing Corporation and the Regional Housing Group).

4.112. The spatial expression of these strategies will largely be reflected in RPG14, which will aim to achieve consistency between different objectives. Inevitably there will be some instances where there are competing or conflicting objectives and RPG14 will provide guidance on where the priority should lie where there is a spatial dimension.

4.113. Nonetheless, the guidelines presented in this report will have implications for each of the strategies listed above, which we have summarised below and in **Table 4.2**. Whilst it is difficult to be prescriptive in most instances, we have sought to identify which of the issues relating to the impacts of climate change are most relevant. This should help to promote consistency in approach to climate change between the various strategies.

4.114. We have already noted that accordance with the climate change guidelines presented in this report may not always be the most sustainable solution, if other sustainability objectives are more pressing. It is extremely important that a co-ordinated approach is adapted to planning for climate change to ensure that the most sustainable approach is adopted. This means identifying solutions that maximise the benefits across the full range of sustainability considerations.

Regional economic strategy

4.115. There is much in the RES that is consistent or will not be affected by the impacts of climate change. The main message for the RES is to be cautious in promoting economic activity and/or economic development in areas most vulnerable to the impacts of climate change and instead focus efforts on increasing the resilience of the region's economy in general to climate change.

4.116. There may well need to be some changes to where and how economic activity takes place. Of particular concern is the approach that will need to be taken to the more disadvantaged communities that are also vulnerable to climate change, particularly along the coast. Careful consideration will need to be given as to whether, in the long term, the amount of investment to achieve both regeneration and acceptable risk in the face of increasing climate change impacts is acceptable compared with other alternatives. In social, political and economic terms, this is perhaps the most difficult and fundamental of all decisions to have to make, but at some stage, the decision may well have to be made.

4.117. The second major implication is with respect to types of economic activity. The RES currently places great emphasis upon investment in transport infrastructure, inward investment and promotion of the region internationally. Whilst these may well be ingredients of economic growth and success, the principles developed with respect to responding to climate change argue for greater emphasis upon local access to goods, services and facilities and reduced dependence upon vulnerable transport and movement networks. Whilst it is acknowledged that continuing investment and changing design standards as aimed at reducing such vulnerability, we recommend that this apparent conflict is examined further in order to determine the most sustainable approach in the long-term.

4.118. Climate change also offers opportunities. Tourism is perhaps the most obvious beneficiary, particularly as the East of England becomes a more attractive location compared to southerly latitudes that could lose their appeal. Other economic openings are also likely to emerge. The use of ICT, environmental technologies to deal with the impacts of climate change and reduce the region's contribution to it and changing agricultural activity could all be of benefit to the region. Economic activity could also help to deliver improvements and investment required in the natural environment to accommodate changes to species distributions and habitats. This could help to make the region more attractive to live and work in.

Environment strategy

4.119. The environment strategy will play a key role in providing the guidance to allow the region to adapt to the changes that climate change will bring about. It should provide support for the guiding principles embodied in this report, which aim to let climate change take its natural course wherever possible. It should plan ahead to provide for new distributions of species and types of habitat, whilst identifying those environmental assets, both natural and man-made (e.g. historic assets), which are of such value to the region that they should be protected from the adverse impacts of climate change.

Health and social inclusion strategy

4.120. Climate change will impact upon health and social inclusion in a number of ways. There may well be changes to the way that people work, and certain communities are likely to be more vulnerable than others. The costs and benefits of investing in such communities in the face of significant change will need to be carefully considered against the alternatives. The stress to local people of major upheaval may justify such investment, but this needs to be weighed against the risks involved (e.g. from water shortages, storm surges, etc.), and the diversion of resources from other priorities.

4.121. On the other hand, climate change is likely to bring about considerable benefits to both health and social inclusion by increased emphasis upon local service provision, further efforts to reduce commuting, the creation of new accessible environmental assets and the opening up of a healthier 'outdoor' lifestyle. The most extreme impacts of fuel poverty, such as excess winter deaths, are likely to decline with fewer extremely cold days each year.

4.122. Some commentators point to the potential for large-scale migration in the longer term from those countries worst affected by climate change (possibly including the Mediterranean states within the EU) to those least affected. The implication is that there could be a higher level of migrants wanting to come to the UK. The East of England, as one of the gateways to the country, is likely to be affected. The implications in terms of social cohesion will therefore need to be planned for and addressed.

Regional cultural strategy

4.123. This is likely to be the least affected strategy, although there will still be implications with respect to tourism and cultural heritage as outlined above. Again the increased emphasis upon local services, attractions, and leisure will need to be reflected in the strategy.

Regional housing strategy

4.124. The implications for the regional housing strategy are similar to those for the RES. In spatial terms, the aim should be to deliver new housing in better balance with jobs in locations that are not vulnerable to climate change. Housing development could also be used as a lever for delivering other benefits that are likely to be needed as a result of climate change, such as local service provision, environmental improvements, etc.

4.125. One of the biggest issues will be how to address the housing stock and communities that already exist in the most vulnerable locations. In this respect, it is essential that a co-ordinated approach is adopted that ensures that all the strategies make best and efficient use of available resources. This could mean that not all communities can be supported indefinitely, in which case it will be important to face up to the reality that a decision needs to be made and full and proper alternatives put in place in good time.

Table 4.2: Implications for other regional strategies

Climate change principles	Strategy				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Protect existing land uses from the impacts of sea level rise and fluvial flooding only where the benefits of doing so in environmental, economic and social terms clearly outweigh the capital and revenue costs	*Include a requirement for evaluating the economic costs and benefits of protecting vulnerable locations*	*Include a requirement for evaluating the environmental costs and benefits of protecting vulnerable locations*	*Include a requirement for evaluating the health and social costs and benefits of protecting vulnerable communities*	*Include a requirement for evaluating the cultural costs and benefits of protecting vulnerable locations*	*Consider the extent of investment in existing housing stock in vulnerable locations, and the implications in social, environmental and economic terms of loss*

Climate change principles	Strategy				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Avoid allowing development in locations that could constrain or reduce effectiveness of future options for adaptation (e.g. allowing development in areas that might prevent effective coastal and fluvial flood management in the future)	*Acknowledge that such locations should not be identified for economic development, taking into account alternative means and/or locations for achieving economic objectives in accordance with wider sustainability objectives*	*Outline the environmental role and functions of such locations in helping to achieve adaptation to climate change, and seek to twin with the delivery of wider environmental objectives (e.g. biodiversity, landscape)*	*No action required*	*No action required*	*Acknowledge that such locations should not be identified for housing development, taking into account alternative means and/or locations for achieving housing objectives in accordance with wider sustainability objectives*

Climate change principles	Strategy				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Where possible, allow for sea level rise to take its natural course	*Acknowledge that such locations should not be identified for economic development, taking into account alternative means and/or locations for achieving economic objectives in accordance with wider sustainability objectives*	*Include provision for managed retreat*	*Ensure that there is no risk arising to health and safety, and review the need for a policy (backed by funding) for compensation for loss of productive land*	*Consider effects on cultural assets (e.g. historic environment) that may be vulnerable to sea level rise*	*Acknowledge that such locations should not be identified for housing development, taking into account alternative means and/or locations for achieving housing objectives in accordance with wider sustainability objectives*

Climate change principles	Strategy				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Avoid new development being located in areas at risk from sea level rise and storm surges	*Acknowledge that such locations should not be identified for economic development, taking into account alternative means and/or locations for achieving economic objectives in accordance with wider sustainability objectives*	*No action required*	*Include as a core objective due to risk to health and safety*	*No action required*	*Acknowledge that such locations should not be identified for housing development, taking into account alternative means and/or locations for achieving housing objectives in accordance with wider sustainability objectives*

Climate change principles	Strategy				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Guide new development to areas not at risk from fluvial flooding	*Acknowledge that such locations should not be identified for economic development, taking into account alternative means and/or locations for achieving economic objectives in accordance with wider sustainability objectives*	*No action required*	*Include as a core objective due to risk to health and safety*	*No action required*	*Acknowledge that such locations should not be identified for housing development, taking into account alternative means and/or locations for achieving housing objectives in accordance with wider sustainability objectives*
Minimise the requirement for 'technical fixes' to solve flooding and water supply issues	*No action required*	*Include as an objective due to potentially damaging effects on the environment of flood defence and water supply infrastructure*	*Include as an objective, but ensure that there is no risk to health and safety as a result of implementation*	*No action required, except possible with respect to cultural assets that may be vulnerable to flood risk, and therefore require protection*	*No action required*

Climate change principles	**Strategy**				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Encourage local access to goods, services and facilities in order to reduce the need for movement and reliance on transport infrastructure that could be vulnerable to climate change impacts	*Include as a core theme of RES to reduce vulnerability of settlements - aim to increase support for provision of local goods, services and facilities and reduce reliance on commuting and movement generally*	*Include as a core theme, as this will also help to reduce emissions of greenhouse gases*	*Ensure that essential services are provided within locally*	*Consider improvements to local amenities and attractions, support for sustainable tourism initiatives that support local economies and reduce reliance on travel*	*Aim to provide for a better balance of housing and jobs within local communities*

Climate change principles	Strategy				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Guide new development to locations that are least likely to experience water supply shortages	*Acknowledge that locations likely to experience water supply shortages should not be identified for economic development, taking into account alternative means and/or locations for achieving economic objectives in accordance with wider sustainability objectives*	*Include as a theme in order to reflect concerns of water abstraction on habitats and landscapes*	*A safe and secure supply of water is increasingly likely to become relevant to health and social inclusion*	*No action required*	*Acknowledge that locations likely to experience water supply shortages should not be identified for housing development, taking into account alternative means and/or locations for achieving housing objectives in accordance with wider sustainability objectives*

Climate change principles	Strategy				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Guide development to locations that will not be at risk from subsidence arising from climate change (e.g. clay soils)	*Acknowledge that such locations should not be identified for economic development, taking into account alternative means and/or locations for achieving economic objectives in accordance with wider sustainability objectives*	*No action required*	*No action required*	*No action required*	*Acknowledge that such locations should not be identified for housing development, taking into account alternative means and/or locations for achieving housing objectives in accordance with wider sustainability objectives*
Exploit the environmental, social and economic opportunities afforded by climate change	*Acknowledge in RES as a core theme, focusing on sustainable tourism opportunities, ICT, technologies and crops supporting adaptation to (and reducing contributions to) climate change*	*Identify opportunities to create new habitats suited to a warmer and more extreme climate*	*Promote healthier 'outdoor' lifestyles, which could become more attractive as a result of climate change, ensuring access for all*	*Explore opportunities for tourism and leisure industries*	*No action required*

Climate change principles	**Strategy**				
	Regional economic strategy	**Environment strategy**	**Health and social inclusion strategy**	**Regional cultural strategy**	**Regional housing strategy**
Compensate for loss of habitats by creation of similar habitats in less vulnerable areas	*Consider role of economic development in helping to secure compensation*	*Include as a core theme of strategy*	*Ensure experience of wildlife by local communities is at least as good as, and preferably enhanced*	*No action required*	*Consider role of economic development in helping to secure compensation*
Identify opportunities to create new habitats and landscapes as a result of climate change and create corridors and stepping stones to allow species to adapt and migrate	*Consider economic benefits of supporting habitat creation associated with economic development*	*Include as a core theme of strategy*	*Ensure experience of wildlife by local communities is at least as good as, and preferably enhanced*	*No action required*	*Consider social benefits of supporting habitat creation associated with housing development*
Promote agricultural production systems in areas that are compatible with and adaptable to the impacts of climate change	*Include as a core theme in RES*	*Ensure reflected in strategy*	*No action required*	*No action required*	*No action required*

CONCLUSIONS

4.126. It is clear from the above discussion that the impacts of climate change are likely to be significant and are not straightforward. They are further complicated by the fact that other economic, environmental and social objectives are likely to be of equal if not greater importance to regional stakeholders. The key will be in determining where these objectives converge and how to resolve any issues of conflict.

4.127. This study has deliberately taken a climate change focused view in order to provide a clear additional dimension to the future development of the region. It deals primarily with spatial issues and will be followed by a report on local service delivery, which will complement many of the findings in this report. For example, in climate change terms, the way that development is delivered on the ground will often be as important as its precise location.

4.128. However, this report strongly suggests that there are some considerable challenges ahead if we are to 'live with' climate change. There appears to be a broad consensus that we should be working with the impacts of climate change, rather than fighting against them and we should seek advantage from this wherever we can.

4.129. However, there are areas of considerable importance in the region, particularly on the coast, that are especially vulnerable and where some difficult decisions will need to be made. If the spatial guiding principles we have put forward were to be followed to the letter, then such locations would either not be defended, or would not be the focus for new investment. We are not suggesting this should be the case. Neither are we suggesting that all development should be guided to the areas that are least vulnerable, as this would mean that important social and regeneration goals would not be pursued. However, this report does help to highlight the implications of taking decisions that will go against the climate change spatial principles. In other words, where possible, the climate change principles should be followed at all levels – the regional, sub-regional and the local - but where for other reasons it is not possible to do so, the region should be prepared to invest heavily in order to minimise the risks.

Land Use Consultants
CAG Consultants
SQW Limited
February 2003

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APPENDIX 1

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APPENDIX 2

Summary table of climate change impacts

Summary matrix of literature review

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Economic activity							
Tourism	Temperature	*Temperature rises will make the area more desirable as a tourism destination – may revitalise coastal resorts.*	Mean summer temperature will increase by over 4.5C (1)	2.5-3C increase in summer (1)	Gradual increase, data shows effect will be marked by 2080s. (1)	Temperature increases will occur across the region. This will be most likely to benefit tourism in those areas already popular with visitors: coast, broads, other attractive areas (towns, countryside)	The UK Tourist Board, local tourist boards and Local Authorities to determine strategy to capitalise on enhanced potential. May require a linked response with neighbouring regions/nationally.
	Number of extremely warm days	*Increased number of extremely warm days is likely to enhance tourism potential.*	The number of extremely warm days annually will rise by 60+ (1).	Increase of 30-60 extremely warm days (1)	By the 2080s (1)	Change will be greatest away from coasts (1) but effects of increased temperatures will be likely to benefit whole region.	As above.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Sea level rise, Increase in extreme events - storm surges and large waves (1)	*Could conversely limit tourism in areas where tourism resources are threatened.*	Areas affected by coastal and fluvial flooding will be more extensive under high scenario (See coastal flooding below).	Areas affected by coastal and fluvial flooding will be less extensive under high scenario	See coastal flooding below.	Coastal areas.	As above.
Agriculture	Temperature	Enhanced growing season, but other constraints e.g. water availability may limit. (1)	Increase of up to 100 days under the high scenario (1).	Lengthening by between 45 and 55 days per year under the low scenario (1)	Well before the 2080s parts of s England will have a year round growing season in some years.(1)	Regional	Defra to provide advice on national basis.
	Rainfall, evaporation due to temperature increase	Reduced summer soil moisture will be a constraint (1) which will lead to increased demand for irrigation (2).	High scenario – may constrain agriculture (and other developments) by 2050s (2).	Under the low scenario, water will also be a constraint, especially in south Suffolk, but with a lesser level of economic development, etc. demand management may mitigate (2)	May be a constraint by the 2050s under a high scenario.	Regional, particular problem in south Suffolk	As above.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Inland flooding	Loss of agricultural land due to inland flooding. (2)	Fens particularly likely to be affected by fluvial/inland flooding. Coastal flooding will have a greater impact under the high scenario (See fluvial/inland flooding section below).	Lesser impact of flooding (see fluvial/inland flooding section below)	See fluvial/inland flooding section below.	Fens particularly likely to be affected. (2)	Environment Agency and DEFRA to respond/ provide appropriate advice.
	Sea level rise, Increase in extreme events - storm surges and large waves (1)	*Loss of agricultural land along the coast and saline intrusion (?) will have a negative impact on agriculture. Vulnerable land may be taken out of agricultural use.*	Impacts will be greater under the high scenario (See coastal flooding below).	Impacts will be lesser under the low scenario (See coastal flooding below).	See coastal flooding below.	Coastal areas.	As above.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Combined effect of variables	Change in crop yields and crops grown. (2) Yields of arable crops that form basis of agriculture in region will initially benefit. But by 2050s under high scenario yields would begin to decline (2). Root crops such as sugar beet and potato increasingly attractive, but dependent on irrigation in summer. Potential for new crops would be very limited. N.B. socio-economic factors will have greatest effect on agriculture – subsidies, etc. (2)	Water shortages will become the key constraint under both scenarios, but particularly under the high scenario in study (2).	A constraint to a lesser extent.	Increasing yields up to 2050s, after that would decline under high scenario (2). Water shortages becoming an increasing problem, especially under the high scenario (2).	Regional	As above - relevant agencies to respond and provide advice to agricultural industry.
The EU funded Accelerate project (8) is aiming to assess the vulnerability of European agroecosystems to environmental change, and it includes East Anglia (Norfolk, Suffolk and Cambridgeshire) as a case study. So far there is some case study data available on the agricultural baseline of the area, but modelling won't begin until around February 2003.							
Productive woodland	Combined effect of variables (changes in temperature, rainfall, soil moisture, longer growing season)	Woodland planting may be limited by its increased water usage compared to other land uses (3). Likely to require changes in the species planted (3).	*More likely to be limited under the high scenario due to lack of water availability and other pressures for irrigation.*	*Less likely to be limited under a low scenario.*		Regional	Forestry Commission to provide national response to climate change and advise appropriately.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Offshore oil and gas industry and fishing	Sea level rise, Increase in extreme events - storm surges and large waves Mean sea surface temperature (1)	*Will all have an impact on the operation of the offshore industry and fishing industry. Increased sea levels may require changes in equipment and working practices, and increased extreme events may have safety and operational implications.*	Likely to be a greater impact under the high scenario. (See section below on flood risk - extreme coastal events).	Likely to be a lesser impact under the low scenario. (See section below on flood risk - extreme coastal events).		Offshore	
Construction industry	Temperature, rainfall, flooding, extreme events	The construction industry will need to adapt to the pressures/issues created by climate change (see the section on the built environment below). This will involve a locational response to development (avoiding areas at risk of flooding/inundation) and a design response (better ventilation, ability to withstand storm damage, structural issues, etc.).	Subsidence and flood risk are considered to be particularly significant risks which the construction industry will need to respond to (see references to CRISP research (9) below). Likely to be more significant under the high scenario.	Impacts likely to be of a lesser magnitude.		Regional, and those areas at risk of flooding/ inundation.	
Manufacturing and service sectors (excluding tourism)	Sea level rise, water supply issues	Manufacturing and service sectors could be affected in terms of location, if they are located in areas at risk of	Likely to be a greater impact under the high scenario. (See flood risk and	Likely to be a lesser impact under the low scenario. (See flood risk and	See flood risk and water supply sections below.	See flood risk and water supply sections below.	Economic strategies, RPG to plan for.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
		flooding/permanent inundation. Manufacturing processes that require water may also be affected.	water supply sections below).	water supply sections below).			
Biodiversity							

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Findings of REGIS study (2)	Temperature, Rainfall	Regis study found that salt marshes will be under pressure, with certain species becoming extinct due to summer drought. (2) Lowland heath is anticipated to survive direct effects better. Main threat will come from land use changes.	Suffolk likely to see the largest losses: over half the existing salt marsh could be lost by the 2050s. The high scenario would see a decline in heath, except where conservation bodies were able to purchase the land directly. (2)	Magnitude of loss is likely to be lesser. The low impacts scenario would see heathlands restored as agriculture becomes less intensive (2)		Specific locations of habitats. Would be possible to look at location of natural areas/designa ted habitats to determine areas likely to be most affected. Fens, Coastal grazing marshes and Salt marshes likely to be most affected.	In terms of response, need to consider issue of obligation to protect designated sites e.g. Ramsar[53] sites.

53 **Ramsar Convention:** An international **convention** originally agreed in Ramsar in 1975. It aims to stem the progressive encroachment loss of **wetlands** and promoting the wise use of wetland wildlife. It requires the designation of Wetlands of International Importance (also known as Ramsar sites).

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Sea level rise	Sea level change also likely to cause major decline in salt marshes. Greatest threat is from coastal management policies. 'Holding the line' against sea level rise would place all of the regions salt marshes at risk. (2) Greatest changes are anticipated for the Fen lands. Decline in coastal drainage marshes, which cover some 25,000 ha in region. Grazing marshes likely to increase as farmers abandon land vulnerable to flooding.	Particularly significant under high scenario (2) Sea level rise of 1.5 m would mean that much of the fen land would revert to wetlands and salt marsh. Would take decades to recreate elsewhere. (2) *N.B. a 1.5 m sea level rise was anticipated in UKCIP98, but under UKCIP02, a maximum of 82 cm is predicted which would temper the impacts.* .	Lesser impact under the low scenario. *Under the UKCIP02 low scenario sea level rise is anticipated to be 22cm. Therefore loss of Fenland would be less extensive.*		As above	

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Change in mean sea surface temperature (1)	This will affect marine species sensitive to temperature (1) The UKCIP study MarClim is a new study aiming to investigate how climate change will affect future distribution of marine biodiversity (no output yet available).	Will be greatest under high scenario (1)	Will be lesser under the low scenario.		Offshore – specific locations not known.	
Threats and opportunities for species – findings of the MONARCH study (5)		The MONARCH study identifies the potential implications for species and habitats in four environments: terrestrial, freshwater, coastal and marine. It notes that winners and losers emerge, including some species threatened with national extinction. From this it is possible to draw general conclusions with regard to biodiversity in the East of England – however, more detailed conclusions for the East of England emerged from the REGIS study. For example, for salt marshes the study finds					

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
		that variable species' response is likely to result in altered species' composition. Salt marshes may migrate inland as sea levels rise, depending on coastal protection policies. It identifies winners, such as Sea Purslane and losers, such as Flat Sedge and common salt marsh grass. A further UKCIP study, Climate change and nature conservation (2000) (6) similarly identifies impacts on species and habitats and outlines policy responses to climate change.					

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Woodlands – findings of Forest Research study (3)	Temperature and rainfall which determine overall water availability, which will have the greatest impact on woodlands (3)	Certain species will fare poorly e.g. *Alnus Incana*, some will fare better e.g. *Fagus Sylvatica* and other species may need to be introduced e.g. *Acer* spp. – with a redefinition of what is classed as a 'native species' (3). Pests and diseases may become more prevalent, although complex interactions between trees, pests/pathogens and their predators or natural controls make predictions hard (3) Establishment of young trees, and survival of hedgerow and urban trees are most likely to be affected by climate change. (3). Urban trees in particular are likely to suffer due to 'heat island' effects and lesser availability of water.	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Regional	

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Sea level rise	Woodland is unlikely to be affected by salinisation, except in coastal areas, or areas of the fens subject to saline ingress.	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		May be some impact from salinisation in fens and coastal areas.	
	Inland flooding	Could increase scope for riparian woodland, as an alternative land use, which would act to stabilise river banks and reduce erosion.	Likely to be greater under the high scenario.	Likely to be lesser under the low scenario.			
Environmental resources							

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Water supply	Rainfall – annual rainfall likely to decline by around 10% (low and high scenarios), Seasonality of rainfall – variations more pronounced under High scenario - winters up to 30% wetter and summers up to 50% drier. Winter rainfall increasingly in short, intense episodes. (1)	East Anglia depends on groundwater. Increased recharge due to heavier winter rainfall offset by increased evaporation in other seasons – shortened period for recharge. (2)	Significant decline in groundwater reserves. (2) Under high scenario, effects will be felt throughout the region (2)	Under the low scenario there will be a lesser effect, but will still particularly affect south Suffolk (2).		Under low scenario confined to certain areas such as south Suffolk. Under high scenario stores will decline over much of the region. (2)	Utilities to plan for; RPG to plan for implications in terms of development location and capacity.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Increased demand for irrigation and rising household water demand (2)	Increased pressure on groundwater reserves, leading to general water supply problems requiring restrictions on demand or import of additional supplies. (2)	Regis study used 2 scenarios. Under 'high climate change and regional enterprise' there will be constraints across the region. (2)	There will also be an issue under the 'low climate change and global sustainability scenario' especially in south Suffolk, however, there will also be more opportunities to mitigate the effects under this scenario (2).	By 2050s (2)	Regional pressures, with effects felt throughout region, but particularly acute to the south, e.g. south Suffolk.	
Soil quality	Increase in frequency and severity of droughts	Drier soils and increased erosion, which will particularly affect the East of England due to large areas of land used for arable agriculture. Trees could be used to provide shelter belts (3).	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Agricultural land throughout the region.	
Wind energy	Daily mean wind speeds	Increased 'windiness' may benefit windfarms, for example, offshore. However, this will depend on the gustiness and maximum speeds as turbines have specific requirements.	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Offshore and exposed/ elevated areas	Utility companies to respond to threats/ opportunities, RPG to plan for ?

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Solar energy	Sunlight, cloudiness	More intense sunlight might make solar energy more effective.	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Regional, particularly urban areas	As above, and construction industry to take on board opportunities.
Bioenergy	Groundwater availability	The Forest Research study (3) notes that certain short rotation coppice species (Poplar and Willow) have higher water demands than other tree species, which might have implications for their implementation.	Water shortages are likely to be more extreme under the high scenario in the Regis study (2). *Therefore SRC may be less suitable under this scenario.*	The low scenario will have a lesser effect, as water shortages will be less extreme and more manageable.		Regional	
Air quality		Ozone is the main pollutant likely to increase with climate change. It is formed by sunlight in the presence of nitrogen oxides and VOCs (3). See health implications below.	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Regional	
Water quality	Reductions in groundwater reserves (see above)	Saline intrusion. (2) Need for alternative sources of drinking water (4) Need to ensure careful monitoring of water used for recreational purposes	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Coastal regions (2) *Could, for example, require more monitoring of*	

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
		(as algal growths and algal blooms may increase) (4)				*the Broads.*	
The built environment and archaeological heritage							
Damage from pollutants	Temperature increases	Higher ground temperatures would lead to ground contaminants becoming more active, and consequently attacking foundations (7).	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Region	Local Authorities (planning, building control), English Heritage advice
	Increased UV	Degradation of materials. Research by the CRISP Climate Change Task Group concludes that this is of low to moderate risk (9).	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Region	Local Authorities (planning, building control), English Heritage advice
Changes to soil structures and subsidence	Temperature increases, Reduced rainfall	Climate change may exacerbate cracking and shrinkage of clay soils leading to subsidence (3). Subsidence is expected to increase in buildings on clay soils, new buildings should include improved foundation design. Felling of nearby trees would	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Region	Local Authorities (planning, building control), insurance companies

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
		reduce effects (7). CRISP research (9) rates subsidence as a high risk effect.					
Flood risk to built environment and archaeological heritage	Sea level rise Fluvial flooding	Flooding of buildings will be more common. Can cause contamination, damage and structural collapse. Some buildings could become uninsurable (7). Coastal erosion due to sea level rise and storm surges could lead to loss of vulnerable buildings (7). Coastal and riverine flooding is rated as a very high risk by CRISP research (9).	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Areas subject to flood risk	RPG to plan for; construction industry to respond
Damage	Extreme events, rainfall	More frequent storms could result in increased structural damage, and driving rain might affect facades and internal structures and lead to more penetration around openings (7). CRISP research (9) rates wind and storm damage to be a high risk.	Impacts likely to be greater under the high scenario.	Impacts likely to be lesser under the low scenario.		Regional	Local Authorities (planning, building control), insurance companies

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Design issues	Temperature increases, decreased water availability	New buildings will need to take greater consideration of pressures on water resources and ensure water is used efficiently. Designs will also need to take into account increased need for ventilation and air conditioning (7). The impact of warmer summers on thermal comfort is considered to be a moderate to high risk of climate change (9).	Impacts likely to be greater under the high scenario, and more need to consider design issues.	Impacts likely to be lesser under the low scenario, and the need to alter building designs will be lesser.		Regional	Local Authorities (planning, building control), construction industry to take on board
N.B. the UKCIP is currently commissioning further research on climate change impacts on buildings.							
Flood risk							
Coastal flooding	Sea level rise	*Coastal flooding - this will affect all land uses in the affected coastal areas and will have implications for the efficacy/need for coastal defences.*	Eastern England under a high scenario would see an 82cm rise. This is one of highest rates in the UK (1)	Under a low scenario the region will see a 22cm rise (1)	By 2080s	Coastal zone, but actual extent has not been mapped - Tyndall research might augment (?)	RPG to plan for; Environment Agency to plan appropriate defences as agreed through extensive consultation.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Extreme events - storm surges/large waves	*This will affect flood vulnerability, settlement patterns, agriculture, etc.*	UKCIP02 shows the change in 50 year return period surge height (incorporating increased sea level, possible increased storminess and isostatic subsidence). Shows that Eastern region will see greatest increases, by between approx. 0.9-1.3m under the high scenario (but high level of uncertainty) (1)	The change in 50 year return period surge height will be between 0.2-1m under the low scenario (1)	By 2080s (but high level of uncertainty) (1)	Primarily coastal zone - appears more intense to south of region, but extent of effect inland has not been mapped. (1)	As above.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Fluvial/inland flooding	Rainfall, Seasonality of rainfall	*Intermittent increases in river flows and risk of flooding*	Under the REGIS 'high' scenario without substantial augmentation of flood defences and land drainage, arable farming would become virtually impossible on 86% of fens and 10% of remainder of East Anglia. Under 'high' scenario there would be need for investment in defences to protect urban areas and infrastructure. (2). Study provides cost implications: flood damage could top £120 m, or up to £950 m under high scenario (2)	Regis study found that flood risk impacts of the 'low' model used could be adequately coped with.	By 2050	Broads and Fenland particularly vulnerable to inland flooding (2)	As above

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	N.B. Several research projects by the Tyndall centre and the UK Foresight flood and coastal defence project will in future provide further information on fluvial and coastal flood risk. We will contact the Tyndall Centre to find out if any research output is available yet (particularly for East Anglia, which many of their studies focus on).						
Settlement pattern							
	Coastal flooding, Fluvial flooding, Other variables affecting settlement pattern??	*Flood risk and flooded areas will particularly affect settlement patterns – need for managed retreat, defences, location of new housing.*	See other relevant variables.			Coastal, other areas at risk of flooding	RPG to plan for.
Transport infrastructure							
	Coastal flooding, Fluvial flooding, Other variables affecting infrastructure??	*Flood risk and flooded areas will particularly affect existing infrastructure and locations for new infrastructure – need for managed retreat, defences, etc..*	See sections on flood risk and subsidence above.			Coastal, other areas at risk of flooding and subsidence throughout region. Based on maps of current flood risk, and assuming	RPG to plan for.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
						these will worsen, the A12 coastal road from Ipswich to Lowestoft and Great Yarmouth and the Ipswich-Lowestoft rail link could be particularly affected. The Cambridge – King's Lynn rail link and A10 road could also be at increased risk due to flooding of the Fens.	
Utilities							
Energy requirements	Temperature	Building heating requirements will decline, but cooling requirements will increase.	Heating degree days will decline by 20%-45% in region. Parts of the area could have up to 300 cooling Degree days by	The heating degree days will decline to a lesser extent under the low scenario. Cooling degree days will increase to a	By end of century By 2080s.	Region	RPG to plan for; utility companies to respond to threats and pressures.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
			2080s.	lesser extent.			
Drainage systems	Increased rainfall in winter and an increase in extreme events could lead to drainage systems being unable to cope.		*Increased winter precipitation and increased occurrence of extreme precipitation events will exert greatest pressure under the high scenario (1).* By the 2080s winter precipitation could increase by 30%+ and there could be an increase of around 1.25 intense rainfall days in winter.	*Pressure on drainage systems will be lesser, although still significant* (1). By the 2080s winter precipitation could increase by 20%+ and there could be an increase of around 0.75 intense rainfall days in winter.		Region	As above.
Social issues							

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Health	Temperature	Decline in cold weather deaths (4). Increase in heat-related deaths (although total numbers in the UK still very low) (4). Food poisoning likely to accelerate (although should be preventable) (4). Vector borne diseases are not predicted to become serious causes of illness (4).	The study (4) does not provide high/low scenario predictions. It makes overall predictions: Reduction of 20,000 cases pa (UK wide) Increase of 2000 cases pa (UK wide) Could be up to 10,000 cases pa			Regional *Unlikely to have a spatially differentiated impact or require a spatial response*.	Health Authorities to plan for.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Increased UV penetration	Potential increase in skin cancer and eye damage.	The study (4) does not provide high/low scenario predictions. It makes overall predictions: Up to 30,000 additional cases of skin cancer and 2000 cataract cases, but this will depend on emissions levels of ozone depleting substances and use of preventative measures, such as sun screens. Could be limited to 5,000 skin cancer cases per year (4).		By 2050 (4).	*Whole region. Could require additional/ specialist health care facilities.*	As above.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
	Extreme events (floods, gales, etc.) (4)	Likely increase in occurrence of severe winter gales is a cause for concern. Deaths during severe gales are commonplace. Loss of electrical power supplies adds to problems. Therefore need careful building inspections and better forecasting of gales and preparation of disaster plans (4). Similarly flooding could increase deaths and injuries (4)				Regional	As above.
	Air pollutants	In general, the effects of air pollutants on health are likely to decline, but the effects of ozone during the summer are likely to increase. (4)	The study (4) does not provide high/low scenario predictions. It makes overall predictions: Several thousand extra deaths and a similar number of hospital admissions may occur each year (4).			Regional	As above.

Key issues/spatial aspects	Variables influencing the issue	Description of effect	Magnitude of the effect: High scenario	Magnitude of the effect: Low scenario	When the effect is likely to take place	Geographical extent of the effect	Links with neighbouring regions, either in terms of effect or response
Social exclusion		It is not easy to predict what impacts climate change might have on social exclusion. Possible implications might arise from: • Differing resources available amongst different social groups to deal with housing design issues, such as ventilation and cooling. • Access to specialist healthcare may also widen social disparities. • Ability to respond to the threats of flood risk might also differ between social groups??	Not able to predict.	Not able to predict.		In areas with higher deprivation throughout the region.	Local authorities to consider implications and respond to.

(1) Climate change scenarios for the United Kingdom: the UKCIP02 Scientific Report April 2002
(2) UKCIP study: RegIS-Regional climate change impact and response studies in East Anglia and North West England
(3) Forest Research: A review of climate change implications for trees and woodland in the East of England
(4) Health effects of climate change in the UK
(5) UKCIP study: MONARCH
(6) Review of Climate Change Implications for UK Habitat and Species Conservation Policy April 2000.
(7) UKCIP briefing note: Climate change impact on buildings

(8) EU funded Accelerate project (includes an East Anglia case study)
(9) A review of recent and current initiatives on climate change and its impact on the built environment: impact, effectiveness and recommendations

APPENDIX 3

Appraisal of RPG scenarios against the climate change principles

Appraisal of RPG scenarios against the climate change principles

<table>
<tr><th>Spatial Option 1</th><th>Spatial Option 2</th><th>Spatial Option 3</th><th>Spatial Option 4</th></tr>
<tr><td colspan="4">Protect existing land uses from the impacts of sea level rise and fluvial flooding only where the benefits of doing so in environmental, economic and social terms clearly outweigh the capital and revenue costs</td></tr>
<tr>
<td>The scenario indicates which existing areas are going to be expanded further, therefore implying that, if necessary, flood defences would be provided.
However, requires more consideration to determine if the scenario is in line with this principle.
Would require protection of coastal areas such as Great Yarmouth, Lowestoft and Tendring – which may or may not be in line with this principle. Would require further consideration.
Some development in Norwich, Ipswich and Colchester could be at risk of coastal flooding.
Regeneration in the Thames Gateway would also potentially require increased expenditure on flood defences. Again, further consideration is needed to determine whether this is a robust and defensible pattern of growth in terms</td>
<td>The scenario indicates which existing areas are going to be expanded further, therefore implying that if necessary, flood defences would be provided.
However, requires more consideration to determine if the scenario is in line with this principle.
This scenario is more likely to be compatible with this principle than scenario 1, as there is no major growth in coastal areas, so this would not place additional assets at very high risk of coastal flooding.
However, Norwich, Ipswich and Colchester are all identified as areas of major growth. These settlements all lie on rivers which are subject to fluvial flooding and are also located at the furthest inland reaches of coastal flooding. However, with climate change the reach of coastal flooding may well extend further</td>
<td>The scenario indicates which existing areas are going to be expanded further, therefore implying that if necessary, flood defences would be provided.
However, requires more consideration to determine if the scenario is in line with this principle.
No major development on coast or in areas close to coast (i.e. Norwich, Ipswich or Colchester).
These areas (Norwich, Ipswich and Colchester) are identified for some growth. Could be at heightened risk of coastal and fluvial flooding.
Generally major development concentrated in south where less risk of fluvial flooding.
Major development in Cambridge and also Peterborough and Kings Lynn identified for some development, which could be at risk of increased</td>
<td>In addition to a new settlement this scenario would continue the settlement pattern as per scenario 1 with some growth going to existing settlements and PAERs.
So would still require decisions to be made re protection of existing land uses.
But this scenario would not lead to significant changes, in the value of built/developed assets, in areas at risk of flooding.</td>
</tr>
</table>

of cost benefit analysis, including environmental costs. • Growth in several areas (Peterborough, Cambridge and Wisbech and possibly other areas, such as Norwich which has a flood plain associated with the Wensum) could be vulnerable to fluvial flooding which would require flood defences. Again, further consideration would need to be given to such a strategy.	inland along river channels, which will also be subject to heightened risk of fluvial flooding. • As with scenario 1, the Thames gateway is identified as an area for regeneration and growth. This would potentially require increased expenditure on flood defences. • As with scenario 1, Cambridge is identified as an area of major growth and Peterborough is also identified for major growth. Both these areas could potentially be at risk of flooding in the Fens.	flooding in the Fens.	
Avoid allowing development in locations that could constrain or reduce effectiveness of future options for adaptation (e.g. allowing development in areas that might prevent effective coastal and fluvial flood management in the future)			
• Development in the coastal regions could jeopardise the ability to provide for future coastal flood defences. • Development in fluvial flood plains could similarly hamper future flood defence works; this will need to be addressed in terms of where development should be located within/around settlements.	• Development in fluvial flood plains could hamper future flood defence works; this will need to be addressed in terms of where development should be located within/around settlements.	• Development in fluvial flood plains could hamper future flood defence works; this will need to be addressed in terms of where development should be located within/around settlements.	• This scenario allows flexibility to build in climate change adaptation criteria. Therefore would be possible to avoid areas, which, if developed, could hamper future adaptation to climate change.

Where possible, allow for sea level rise to take its natural course			
• As noted above, this scenario would require continued investment in coastal defences, particularly in Great Yarmouth, Lowestoft and Tendring • Therefore goes against this principle.	• This scenario is more likely to allow such a course of action. • However, as noted above, sea level rise could affect Norwich, Ipswich and Colchester (identified for major growth) which are located at the (current) inland reaches of coastal flood risk. • However, to determine actual risk from coastal flooding and degree to which this scenario is compatible with this principle requires further information.	• This scenario is more likely to allow such a course of action. • However sea level rise could affect Norwich, Ipswich and Colchester (identified for some growth), which are located at the (current) inland reaches of coastal flood risk. • However, to determine actual risk from coastal flooding and degree to which this scenario is compatible with this principle requires further information.	• This scenario allows flexibility to build in climate change adaptation criteria. Therefore would be possible to avoid areas at risk of coastal flooding and to allow sea level rise to take its course. • Rest of development similar to scenario 1 – so would still require some development in areas at risk of coastal flooding and therefore hamper attempts to allow natural course of sea level rise. • But the scenario would not place so much additional development in areas at risk of sea level rise.
Avoid new development being located in areas at risk from sea level rise and storm surges			
• This option would place new development in areas at risk from sea level rise and storm surges, in particular Great Yarmouth, Lowestoft and Tendring. • The scenario also envisages some growth in Norwich, Ipswich and Colchester, which are currently at the most inland point of coastal flood risk. However, it is	• This scenario, places new development at lesser risk of flooding, as a result of sea level rise and storm surges. However, as noted above, Norwich, Ipswich and Colchester (identified for major growth) could potentially be affected by coastal flood risk, depending on the degree of sea level rise.	• This scenario, places new development at a lesser risk of flooding, as a result of sea level rise and storm surges. However, Norwich, Ipswich and Colchester (identified for some growth) could still potentially be affected by coastal flood risk, depending on the degree of sea level rise. • To determine the extent of	• Again this scenario allows flexibility to build in climate change adaptation criteria into decisions on locations of new development. • Therefore could avoid significant new development in areas at risk of sea level rise and storm surges.

possible that as sea level rises, these areas could be at greater risk, especially in combination with increased risks of fluvial flooding.	• To determine the extent of risk, would require further information.	risk, would require further information.	
Guide new development to areas not at risk from fluvial flooding			
• Meets principle better than scenario 2. • The major growth in the south in the M11 corridor and Milton Keynes is in line with this principle, as fluvial flood risk is typically lesser here than in the north and east of the region. • However, Cambridge which is identified as an area of major growth, and Peterborough (some growth) and Wisbech (a PAER) could all be vulnerable to flooding in the Fens. • Other existing settlements identified for some growth; such as Norwich and Ipswich also have land in the flood plain, which could be at risk. • However, there is scope to ensure that new development in areas centred on rivers at risk of flooding avoids land in the floodplain. But must ensure that new information on	• Possibly more new development at risk of fluvial flooding in this scenario than scenario 1. • This scenario would primarily be affected by fluvial rather than coastal flooding. • Cambridge and Peterborough are identified as areas for major growth, and Kings Lynn is highlighted for some growth. All these areas could be affected by fluvial flooding of the Fens. • Norwich, Ipswich and Colchester (all subject to major growth) all lie on rivers which are subject to some degree of fluvial flood risk. • It may be possible to avoid those areas around these settlements, which are subject to fluvial flood risk. • It is important that such decisions factor in the likely increase in fluvial food plain	• Very similar in terms of fluvial flood risk to scenario 1. • Major growth in the south in Hertfordshire and south Essex is in line with this principle, as fluvial flood risk is typically lesser here than elsewhere in the region. • However, Cambridge (major growth) and Peterborough (some growth) may be subject to flood risk in the Fens. • Other existing settlements identified for some growth; such as Norwich and Ipswich also have land in the flood plain, which could be at risk. • However, there is scope to ensure that new development in areas centred on rivers at risk of flooding, avoids land in the floodplain. But must ensure that new information on	• Again this scenario allows flexibility to build in climate change adaptation criteria into decisions on locations of new development. • Therefore could avoid significant new development in areas at risk of fluvial flooding.

fluvial flood risk, in relation to climate change, is taken on board as it emerges.	as a result of climate change.	fluvial flood risk in relation to climate change is taken on board as it emerges.	
Minimise the requirement for 'technical fixes' to solve flooding and water supply issues			
• Requires significant investment in flood defence infrastructure. • Significant growth in south of the region – M11 corridor, Milton Keynes, Luton/Dunstable – which will probably require increases in water transfer and storage infrastructure. • Diverges from this principle.	• May require increase in fluvial flood defences. • May require an increase in water supply infrastructure, including desalinisation plant or reservoirs in Essex. • But overall likely to put less pressure on water supplies due to growth, in north of region as well as south and therefore not rely too heavily on technical solutions to water supply issues.	• May require an increase in fluvial flood defences, but probably less so than scenario 2. • Likely to require an increase in water supply infrastructure, due to development in the south of the region	• Again this scenario allows flexibility to build in climate change adaptation criteria into decisions on locations of new development. • Therefore could locate a new settlement in such a way that it has access to sustainable water supplies (generally towards the north of the region) and out of areas of flood risk (typically away from the coast and localised areas of fluvial flood risk). This will minimise the need to apply technical fixes to adapt to climate change.
Encourage local access to goods, services and facilities in order to reduce the need for movement and reliance on transport infrastructure that could be vulnerable to climate change impacts			
• Dispersed nature of growth throughout the region and in peripheral coastal locations is likely to increase movement in the region, and therefore go against this principle. However, it could facilitate a dispersed pattern of provision of some	• Difficult to determine, as will depend on how services and facilities are located in relation to settlements.	• Difficult to determine, as will depend on how services and facilities are located in relation to settlements.	• Very likely to facilitate self-sufficiency through locating a significant amount of development in one location. This will help to decrease vulnerability to climate change by allowing services to be located close to people. This will also

services, such as health care, in market towns and hence reduce vulnerability to climate change. • This pattern of development could also facilitate supplies of food from local sources. • Some areas will clearly be able to develop in line with this principle, such as the concentration of growth in Cambridge, and the concentrations of development in the south of the region.			help to mitigate against impacts of climate change by limiting emissions of CO2 from road based transport.
Guide new development to locations that are least likely to experience water supply shortages			
• Significant growth in the south of the region means that much development will take place in areas subject to water shortages. • Goes against this principle.	• Increased pressure on water supply in Essex and Thames Gateway. • However, due to the dispersed nature of development, including development in the north of the region water supply issues are likely to be less apparent in this scenario than scenarios 1 and 3.	• Significant growth in the south of the region means that much development will take place in areas subject to water shortages.	• Again this scenario allows flexibility to build in climate change adaptation criteria into decisions on locations of new development. • Therefore could locate a new settlement in such a way that it has access to sustainable water supplies (generally towards the north of the region)
Guide development to locations that will not be at risk from subsidence arising from climate change (e.g. clay soils)			
• Major growth in the south of the region means that much development will take place on clay soils prone to subsidence.	• Less risk due to dispersed growth, so less concentration on clay soils in south.	• Major growth in the south of the region means that much development will take place on clay soils prone to subsidence.	• Again this scenario allows flexibility to build in climate change adaptation criteria into decisions on locations of new development. • Therefore could locate a

			new settlement on areas less sus
Exploit the environmental, social and economic opportunities afforded by climate change			
• Continued support for rural areas, market towns and coastal locations is likely to enhance the ability of the region to capitalise on potential benefits to tourism • Coastal development and by implication an increased need for defences could have negative implications for coastal habitats ('coastal squeeze') • Overall other policies to promote such opportunities will determine whether this principle is met.	• Regional centres likely to support rural areas and market towns, which could enable opportunities for tourism to be capitalised on • Overall other policies to promote such opportunities will determine whether this principle is met.	• More concentration in south of region may provide less support for those areas which could otherwise benefit from growth in tourism. • However, could relieve pressures in some areas and enable environmental opportunities of climate change to be recognised throughout the region (such as allowing habitats to migrate/adapt), and allowing coastal habitats to migrate inland (if hard coastal defences are avoided where possible) • Overall other policies to promote such opportunities will determine whether this principle is met.	• Depends on location and other policies to promote such opportunities.
Where possible compensate for loss of habitats by creation of similar habitats in less vulnerable areas			
• This will depend on other policy responses and initiatives • Could potentially be compatible with this principle	• This will depend on other policy responses and initiatives • Could potentially be compatible with this principle	• This will depend on other policy responses and initiatives • Could potentially be compatible with this principle	• This will depend on other policy responses and initiatives • Could potentially be compatible with this principle
Identify opportunities to create new habitats and landscapes as a result of climate change and create corridors and stepping stones to allow species to adapt and migrate			

• This will depend on other policy responses and initiatives. • Could potentially be compatible with this principle.	• This will depend on other policy responses and initiatives. • Could potentially be compatible with this principle	• This will depend on other policy responses and initiatives. • Could potentially be compatible with this principle	• This will depend on other policy responses and initiatives. • Could potentially be highly compatible with this principle, since a new settlement has the flexibility to be located so as to avoid areas suitable for creation of new habitats and landscapes
Promote agricultural production systems in areas that are compatible with and adaptable to the impacts of climate change			
• Continued support for rural areas and market towns through dispersed growth in a number of areas could help to support an agricultural economy that is able to respond to the pressures and opportunities of climate change. For example, through providing new types of local produce and adapting to environmental conditions which might facilitate provision of environmental benefits, such as grazing marshes in areas at increased risk of flooding. • However, this is far from certain and will largely depend on the support provided by other strategies, and the actions of DEFRA,	• Hard to determine what implications this scenario has for meeting the principle. • Will largely depend on the support provided by other strategies, and the actions of Defra, such as providing adequate funding to facilitate conversion to more extensive agricultural systems.	• Hard to determine what implications this scenario has for meeting the principle. • Will largely depend on the support provided by other strategies, and the actions of Defra, such as providing adequate funding to facilitate conversion to more extensive agricultural systems.	This scenario may provide less support for the rural economy and mean that adaptation is less easily achieved.

such as providing adequate funding to facilitate conversion to more extensive agricultural systems.			

APPENDIX 4

Wider project steering group

EAST OF ENGLAND SUSTAINABLE DEVELOPMENT ROUND TABLE
CLIMATE CHANGE SUB-GROUP
(Wider project steering group)

JOHN RUMBLE (Chair)	Hertfordshire County Council
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RICHARD POWELL	Regional Director
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JO HEFFORD	Government Office for the East of England
PETER LEE	EEDA
STEVE SCOTT	Forestry Commission
NICK BURFIELD	East of England Local Government Conference
NICOLA GEORGE	English Nature
DAVID VOSE	Countryside Agency
VANESSA TILLING (Secretary)	Government Office for the East of England

APPENDIX 5

Stakeholder workshop of attendees

CLIMATE CHANGE STAKEHOLDER WORKSHOP
FRIDAY 29TH NOVEMBER: DUXFORD

ATTENDEES

Michelle	Colley	UKCIP
Anne	Dansey	Hertfordshire CC
Nicola	George	English Nature
Paul	Hannan	Thurrock Council (unitary)
Paul	Hart	Environment Agency
Jo	Hefford	GO-East Sustainable Development Team
Renny	Henderson	RSPB
Peter	Lee	East of England Development Agency
Corinne	Meakins	Sustainable Development Round Table
Adam	Nicholls	Suffolk CC
Richard	Rigby	Essex CC
John	Rumble	Hertfordshire CC
Philip	*Smith*	*Consultant LUC*
Brian	Stewart	Chairman, EELGC
Alan	Storah	Luton Council (unitary)
Vince	Thurkettle	Forestry Commission
Jonathan	Tiley	Hertfordshire CC
Vanessa	Tilling	GO-East, Secretary to Sustainable Development Round Table & Climate Change Group.
Sean	Travers-Healy	CPRE
Sarah	Tunnicliffe	English Heritage
David	Vose	Countryside Agency
Alan	Wheeler	East of England Local Government Conference (EELGC)
Mark	Wilson	Essex CC
Sue	Young	EELGC

Living with Climate Change in the East of England

Stage 2: Draft Guidance for Local Service Provision

Prepared for
Hertfordshire County Council
on behalf of the
East of England Regional Assembly
and
East of England
Sustainable Development Roundtable
by
Land Use Consultants
in association with
CAG Consultants
and SQW Limited

September 2003

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The study has been overseen by a steering group, who have guided the research and format of the output, made up of the following members:

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PROFESSOR KERRY TURNER*	Director, Zuckerman Institute for Connective Environmental Research, University of East Anglia
ALAN WHEELER*	Regional Planning Board/East of England Regional Assembly (EERA)
NICK BURFIELD	East of England Development Agency
MEGAN GAWITH & MICHELLE COLLEY	UK Climate Impacts Programme (UKCIP)
NICOLA GEORGE	English Nature
PAUL HART	Environment Agency (Anglian Region)
JO HEFFORD	Government Office for the East of England
PETER LEE	East of England Development Agency
ED SMITH	Anglian Water
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VINCE THURKETTLE	Forestry Commission

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1. INTRODUCTION

INTRODUCTION TO THIS GUIDANCE DOCUMENT

Why is guidance needed?

1.1. The issue of climate change has been of increasing concern for many years. It is now widely accepted in both scientific and political circles that climate change is happening, that human activity is contributing to it, and that the impacts are likely to be dramatic, if not for this generation, then certainly for future ones. Accommodating the impacts of climate change is vital and this will require adaptation strategies.

1.2. There are likely to be many decisions and actions that need to be taken at the local level. It is essential that those who have a leading role to play at this level fully understand the implications of climate change and the need to start responding to the challenges it poses.

1.3. It is recognised that many actions are already being undertaken by local authorities and other service providers, which will help them to adapt to climate change, some intentionally and some as a beneficial secondary effect of other actions ('win-win' situations). This guidance provides a checklist for organisations to ensure that they are comprehensively addressing climate change.

1.4. In September 2002, the East of England Regional Assembly and Sustainable Development Roundtable, appointed Land Use Consultants in association with CAG Consultants and SQW Ltd, to undertake a study to provide authoritative guidance, to enable the development of a range of policy initiatives and practical actions for regional adaptation to climate change.

What does the guidance cover?

1.5. The study '*Living with climate change in the East of England*' consists of three stages (the overall objectives and outputs of the study are outlined in **Appendix 1**). This report provides guidance on adaptation measures for responding to climate change at the local level; specifically it provides guidance on adaptation responses for local authorities' and other agencies' service provision and comprises **Stage 2** of the study. This follows on from the **Stage 1** report '*Living with Climate Change in the East of England Stage 1 Interim Report: Guidance on Spatial Issues*', which looked at regional level spatial adaptation responses.

1.6. The background to the guidance and the research undertaken to inform it is included in **Appendix 1**.

Methodology

1.7. Preparation of this guidance document has involved a range of research, consultation and professional judgement. Key sources of information used are referenced throughout the document.

1.8. Two consultation workshops were held (in Great Yarmouth and Letchworth) to which local government and other service providers were invited. The aim of the workshops was to identify the key decisions and measures that may need to be taken to adapt to make the most of opportunities that climate change presents, to minimise its adverse effects and to consider how these might vary across the region. Stakeholders were consulted, via roundtable discussions, on a draft of suggested actions for local authority service providers and were also invited to send in comments on the suggested actions for other service providers.

1.9. The specific objectives were of the consultation workshops were to:

- Determine whether the key services provided by local authorities had been correctly identified.
- Discuss the extent to which local services are likely to be affected by the impacts of climate change and the nature and significance of any effects.
- Consider whether the impact of climate change and effects on local service provision are likely to be similar across the region as a whole, or whether they are likely to vary depending upon location.
- Explore what opportunities might be afforded by the impacts of climate change (e.g. promotion of environmental technologies, tourism, agricultural diversification etc.).
- Identify and prioritise the key decisions that will need to be made with respect to these impacts and opportunities and when these decisions will need to be made.
- Assess the level of uncertainty and risk attached.
- Identify service areas where a co-ordinated response between local authorities and statutory agencies/infrastructure providers will be required.

1.10. Comments and suggestions made by stakeholders at the workshops have been incorporated into the guidance.

Structure of the guidance

1.11. ***Section 2*** of the guidance sets out the changes the East of England is likely to experience under two different scenarios of future climate.

1.12. *Section 3* describes a series of 'climate change sub-regions', which represent areas which are likely to experience similar impacts and require similar adaptation responses. The subsequent sections of this guidance use these broad sub-regions to indicate the types of adaptation responses likely to be appropriate.

Section 4: Adaptation responses for local authorities' service provision

1.13. This section is primarily targeted at local authorities. It is structured into seventeen service areas. These are listed in **Table 1.1**; the table also outlines the roles and responsibilities of local authorities in relation to each of these service areas[1].

Table 1.1 Local authority service areas and responsibilities

Service areas and responsibilities	
Transport infrastructure	**Highways/drainage management and traffic management** Local authorities provide, manage and maintain more than 96 per cent of roads in England and Wales, as well as maintaining major parts of the motorway and trunk road network for the Department of Transport, a service which costs almost a billion pounds a year. This includes a range of activities such as maintaining bridges, lighting and drainage systems, undertaking road surfacing, managing highway flooding, undertaking weed control etc. Local authorities are also responsible for other functions associated with the use of highways, including traffic regulation and management, road safety and on-street parking.
	Traffic management liaison with the Strategic Rail Authority (SRA) Disruption of rail networks could have knock on effects on the road network. Therefore local authorities liase with the Strategic Rail Authority to ensure an appropriate traffic management response is in place.
Buildings and Estates	**Property services and corporate engineering (including education and social service properties)** Local authorities administer a range of properties including schools, nursing homes and children's homes, in addition to housing, which is discussed below.
	Housing Housing services take a strategic role in insuring local authority housing needs are met throughout their area with a mixture of housing association and private sector stock. Housing the homeless is a responsibility of the local authority. Although the housing service has undergone a great deal of change it still has a total expenditure of around £12 billion in England and Wales and provides around 3.5 million homes.
	Parks and estate management Local authorities are responsible for the management and

[1] Based on information from a Local Government Association leaflet: Local Authority Services

	maintenance of parks and estates in their ownership, including public recreation areas, open spaces and play areas. **Social services** Social services co-ordinate work with other agencies to provide integrated care within the community. They administer childrens' homes, and arrange care for the elderly in their own homes, in residential care and nursing homes. They are also responsible for adoption and fostering services, sensory impairment and disability services and other services for vulnerable people. In total, social services account for nearly £12 billion of local government expenditure in England and Wales.
Emergencies	**Emergency planning** Emergency planning plays a vital role in co-ordination to combat disasters. It plans for the continued efforts of the police, fire brigades and other emergency services to respond to a range of disasters including flooding, chemical emissions and even terrorist attacks. This service area may include the management of planning facilities e.g. an emergency planning centre. **Police** Local authorities work with the police authorities (who provide the policing service) for example, through councillors who are involved in the running of the police authorities. **Fire services** The fire service, run by local authorities, has a wide range of responsibilities in addition to safeguarding people from fire. It also deals with road traffic accidents, chemical spills, and fire safety inspections.
The economy	**Economic development and regeneration** Local authority economic development sections work with a range of organisations, such as the Regional Development Agency (RDA), to advise businesses on a range of issues. **Leisure and tourism** Local authorities manage leisure facilities such as sporting grounds and swimming pools, and promote countryside recreation. They may play a role in promoting tourism and may have a tourism officer.
Waste and pollution	**Waste disposal, collection and recycling** County councils are responsible for the disposal of waste with district councils responsible for waste collection from households in their areas. Metropolitan district councils and unitary authorities act as collection and disposal authorities. The Environment Agency controls pollution of air, land and water by issuing environmental permits, enforcement and monitoring. **Pollution control and monitoring** Local authorities work to reduce pollution of land, air and water (through Environmental Health), and monitor and report on environmental quality. The Environment Agency plays an important role in monitoring and measuring the quality of our waterways. **Environmental health**

	The environmental health service has many activities including food safety, housing standards, pollution control, animal health, Agenda 21, noise control and pest control.
The wider environment	**Conserving the natural environment** Local authorities are involved in conserving the natural environment in a number of ways, from preparing biodiversity action plans, to managing land in their ownership, such as local nature reserves.
	Historic environment Local authorities have a key role to play in the care, conservation and enhancement of the historic environment. Activities include providing advice on heritage issues, updating records and promoting heritage.
Wider co-ordination	**Co-ordination of flood prevention and coastal protection** Local authorities on a day to day basis must ensure that they co-ordinate with statutory agencies (eg. Environment Agency) and other stakeholders. This guidance highlights two areas, flood prevention and coastal protection, where a co-ordinated response is particularly important.

1.14. Under each service, the guidance is divided into:

- Region-wide impacts and adaptation responses to climate change.
- Adaptation responses applicable to specific parts of the East of England (climate change sub-regions – the Fens, the Coast, the Thames Gateway and Fringes, the Southern Heartland and the Northern Heartland).

1.15. **Table 1.2** sets out in summary matrix form, the specific guidance provided for local authority service areas by sub-region, including guidance applicable to 'all climate change sub-regions'. Notably there is little specific guidance in relation to the Northern and Southern Heartlands. This reflects the fact that the main impacts in these regions are also likely to be experienced throughout the region as a whole (e.g. impacts likely to occur as a result of temperature changes).

Section 5: Adaptation responses for other agencies' service provision

1.16. This section is targeted at other agencies. It is structured into the following areas:

- Water related services (water resources and supply, water quality, sewerage, flood risk management and coastal defence).
- Energy services (gas, electricity).
- Transport services (road, rail).

- Nature conservation.
- Historic built and archaeological environment.
- Agriculture, fisheries, woodland and forestry.
- Health services.
- Economic sectors.

1.17. Again the guidance is divided into:

- Region-wide impacts and adaptation responses to climate change.
- Adaptation responses applicable to specific parts of the East of England.

1.18. **Table 1.3** sets out in summary matrix form the specific guidance provided for other agencies by sub-region, including guidance applicable to 'all climate change sub-regions'.

1.19. ***Section 6*** discusses implementation issues, namely the importance of, and approaches to, joint working between local authorities and other agencies and the importance of awareness raising and communication in relation to climate change adaptation responses.

Table 1.2: Summary of guidance for local authority service areas, by climate change sub-region

Local Authority service area guidance	**Climate change sub-region**					
	All climate change sub-regions	The Coast	The Fens	The Thames Gateway and Fringes	The Southern Heartland	The Northern Heartland
Highways/drainage management and traffic management	X	X	X	X	X	
Traffic management liaison with the Strategic Rail Authority (SRA)	X	X	X	X		
Property services and corporate engineering (including education and social service properties)	X	X	X	X	X	
Housing	X	X	X	X	X	
Parks and Estate management	X					
Social services	X	X	X	X		

Emergency planning.	X	X	X	X		
Police and Fire services	X					
Economic development and regeneration	X	X	X	X		
Leisure and tourism (including leisure centres and swimming pools)	X	X	X	X		
Waste disposal, collection and recycling	X					
Pollution control and monitoring	X					
Environmental health	X					
Conserving the natural environment	X	X	X	X		
Historic environment	X	X	X	X		

Co-ordination of flood prevention	X					
Co-ordination of coastal protection		X	X	X		

X – specific guidance provided

(N.B. there is little specific guidance in relation to the Northern and Southern Heartlands. This reflects the fact that the main impacts in these regions are also likely to be experienced throughout the region as a whole (e.g. impacts likely to occur as a result of temperature changes))

Table 1.3: Summary of Guidance for other service providers, by climate change sub-region

Other service provider guidance	Climate change sub-regions					
	All climate change sub-regions	The Coast	The Fens	The Thames Gateway and Fringes	The Southern Heartland	The Northern Heartland
Water resources and supply	X	X		X	X	
Water quality	X	X	X	X		
Sewerage	X	X		X		
Flood risk management and flood and coastal defence	X	X	X	X		
Coastal defence		X				
Electricity supply	X	X				
Gas supply	X					
Road network	X	X	X	X	X	

Rail network	X	X	X	X	X	
Nature conservation	X	X	X	X		
Historic built and archaeological environment	X	X		X	X	
Agriculture	X	X	X		X	X
Fisheries		X				
Woodland and forestry	X					
Health impacts and adaptation responses	X	X		X		
Economic services	X	X	X		X	x

X – specific guidance provided

(N.B. there is little specific guidance in relation to the Northern and Southern Heartlands. This reflects the fact that the main impacts in these regions are also likely to be experienced throughout the region as a whole (e.g. impacts likely to occur as a result of temperature changes))

How to use the guidance

1.20. All users should read Sections 1, 2 and 3, to understand the background to the guidance and the climate change issues facing the East of England. Local authorities and other agencies will have to make many important decisions in terms of service provision, which will require actions and possibly a redistribution of resources. Specific sections are targeted at local authorities depending on their location and at a range of other agencies. The paragraphs below direct users to the sections most relevant to them for easy reference, but it is important to remember that climate change requires a co-ordinated response within and between local authorities and other agencies. Therefore it is advisable to read the document as a whole.

1.21. In order to help inform the decisions that need to be made, **local authorities** will find **Section 4** particularly relevant to their needs. The guidance is structured into seven broad service areas, each of which covers:

- **Region wide** impacts and adaptation responses, which will be relevant to all local authorities.
- And impacts and adaptation **responses specific to the five climate change sub-regions**. These sub-regions are outlined in section 3.Each local authority should determine which sub-region they fall into and use these sections of the guidance to help plan adaptation responses applicable to their geographical location. Local authorities in coastal locations are likely to face additional challenges to those in inland areas.

1.22. The guidance is set out in a series of tables to make it clear to use. These are laid out as follows:

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners

1.23. **Other agencies** will find **Section 5** to be most relevant, which is structured into **eight service areas**. Service providers should identify the section, which corresponds to their range of activities. Local authorities will also find much of the guidance contained here relevant to particular services that they provide, and it will provide useful guidance in terms of co-ordination between local authorities and other agencies.

1.24. Again the guidance is set out in tables which are laid out as follows:

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners

SOME KEY ISSUES UNDERPINNING THE GUIDANCE ON LOCAL SERVICE PROVISION

The relationship between climate change perspectives and wider sustainability considerations

1.25. The guidance aims to provide a recommended approach to service provision from one perspective only: that of climate change. Thus in terms of implementation, this approach is clearly – and necessarily – partial. Issues relating to climate change will need to be considered alongside a whole range of other factors pertaining to sustainability in the round. As set out in the region's framework for sustainable development[2] (e.g. use of brownfield sites, imperatives for social and physical regeneration, high and stable levels of employment, etc.).

1.26. In addition, the UK Sustainable Development Strategy[3] contains ten guiding principles which should shape the development of sustainable policy, and are very useful when considering how to respond to the impacts of climate change:

- Putting people at the centre.
- Taking a long-term perspective.
- Taking account of costs and benefits.
- Creating an open and supportive economic system.
- Combating poverty and social exclusion.
- Respecting environmental limits.
- The precautionary principle.
- Using scientific knowledge.
- Transparency, information, participation and access to justice.
- Making the polluter pay.

1.27. Several of these principles are particularly important when considering how to integrate adaptation measures into service provision, for example, taking

[2] East of England Regional Assembly and East of England Sustainable Development Round Table (October 2001) *Sustainable Development Framework for the East of England*.

[3] *A Better Quality of Life: A strategy for sustainable development in the UK*. May 1999.

a long-term perspective, respecting environmental limits, and implementing the precautionary principle.

1.28. Furthermore, many of the adaptation actions suggested in the guidance simply reinforce what would be good practice in wider sustainability terms. For example, reducing the vulnerability of local transport services to disruption from climate change related incidents, is entirely compatible with the wider sustainability aim of reducing the need to travel. Minimising the use of natural resources will encourage less water use and waste, hence the need for investment in water infrastructure and disposal facilities, which themselves could be impacted upon by climate change.

Relationship with stage 1 spatial guiding principles

1.29. This document seeks to provide guidance for local level decisions, which will play a very important role in adapting to climate change, for example through building design and management of flood risks. Such measures will have a major influence in dealing with the impacts of climate change on existing settlements. Such measures will also be critical in the context of future new development which may – in the light of wider sustainability considerations – be planned in areas which are likely to be affected by the impacts of climate change.

1.30. Whilst this document provides guidance for local level decisions, the Stage 1 report provides a broader strategic context, with recommendations, to guide spatial development at the regional level. This set out an overarching aim and spatial guiding principles which it is recommended should be used to take into account the impacts of climate change when planning for the delivery of development and other activity in the region. These were informed by a review of research on the impacts of climate change and the economic, environmental and social character of the region, and the views of stakeholders consulted during Stage 1.

1.31. The overarching aim in Stage 1 sets out a position that acknowledges the reality of climate change and a willingness to respond positively to it:

Overarching Aim for Living with Climate Change in the East of England:

To work with climate change, rather than against it and manage the impacts for the benefit of future generations

1.32. It was acknowledged that, whilst many of the adaptation measures that will need to take place, will be at the local level (e.g. the form and design of development), a number of major decisions will have to be made at the regional scale. Particularly with respect to planning for the spatial distribution of development. In order to guide spatial development, a key spatial guiding principle was therefore suggested:

Key Spatial Guiding Principle for Living with Climate Change in the East of England:

To reduce risk by guiding new development to those locations least vulnerable to the potentially adverse impacts of climate change

1.33. A number of supporting guiding principles was developed to show how the Key Spatial Guiding Principle might be implemented. These aimed to address all of the main spatial climate change impacts that are likely to affect the East of England and our understanding of the sort of response, that will be required in the longer term (i.e. over the period to 2100 covered by the UKCIP02 research, rather than the shorter term time horizons of RPG and other related strategies).

Supporting Spatial Guiding Principles for Living with Climate Change in the East of England:

- *Protect existing land uses from the impacts of sea level rise and fluvial flooding only where the benefits of doing so in environmental, economic and social terms clearly outweigh the capital and revenue costs.*
- *Avoid allowing development in locations that could constrain or reduce effectiveness of future options for adaptation (e.g. allowing development in areas that might prevent effective coastal and fluvial flood management in the future).*
- *Where possible, allow for sea level rise to take its natural course.*
- *Avoid new development being located in areas at risk from sea level rise and storm surges.*
- *Guide new development to areas not at risk from fluvial flooding.*
- *Minimise the requirement for 'technical fixes' to solve flooding and water supply issues.*
- *Encourage local access to goods, services and facilities in order to reduce the need for movement and reliance on transport infrastructure that could be vulnerable to climate change impacts.*
- *Guide new development to locations that are least likely to experience water supply shortages.*
- *Guide development to locations that will not be at risk from subsidence arising from climate change (e.g. clay soils).*
- *Exploit the environmental, social and economic opportunities afforded by climate change.*
- *Where possible compensate for loss of habitats by creation of similar habitats in less vulnerable areas.*
- *Identify opportunities to create new habitats and landscapes as a*

result of climate change and create corridors and stepping stones to allow species to adapt and migrate.

Promote agricultural production systems in areas that are compatible with and adaptable to the impacts of climate change.

1.34. Whilst the above principles were developed for use at the strategic level, they are also relevant to more local decision-making. The adaptation measures for local service provision are therefore consistent with these guiding principles.

Adaptation versus mitigation

1.35. It is important to recognise that much of the change in climate over the next 30 to 40 years has already been determined by historic emissions and because of the inertia in the climate system. We are likely; therefore, to have to adapt to some degree of climate change however much future emissions are reduced. The climate of the second half of the twenty-first century and beyond, will be increasingly influenced, however, by the volume of greenhouse gases emitted by human society over the coming decades.

1.36. Action in key areas is needed now if future solutions are to take account of climate change. Failing to take action today and plan for the future could increase risk and incur higher costs as the climate changes and remedial maintenance and renewal is required. Local authorities and other service providers should seek to find 'no regret' solutions, which will deliver benefits whatever the extent of climate change, such as raising awareness of flood risks or planting trees that will thrive in current and future climate conditions.

Case study: Defra's, approach to 'no-regret' policies for addressing climate change

Across Defra, a variety of potential win-wins (i.e. policies that can contribute to desired outcomes, whilst also improving resilience to potential climate change), have been suggested, including piloting robust land management demonstration projects within the Countryside Agency. Providing buffering zones through agri-environment schemes to increase the resilience of biodiversity within designated sites and strengthening policy on water demand management.

The Impacts of Climate Change: Implications for Defra, 2003. A report by the In House Policy Consultancy.

1.37. This document primarily seeks to provide guidance on adaptation strategies to enable the communities in the East of England to live with climate change. Whilst mitigation measures will play an important role in a long-term strategy to reduce our contributions to climate change, these are not the focus of this guidance.

Case study: A clause from the Nottingham Declaration on Climate Change

"We commit our council to: work with key providers, including health authorities, businesses and development organisations to assess the potential effects of climate change on our communities and to identify ways in which we can adapt"

Timescales – when to act

1.38. Climate change is a gradual process that happens over decades. Work to adapt to climate change needs to start now, but it will be a long-term process that needs to be tackled in a staged, prioritised way. Some of the most immediate adaptation priorities fall on those responsible for planning and developing major infrastructure, such as new buildings or roads. Costs of adapting to climate change can be minimised if adaptation is built in when:

- Infrastructure is upgraded anyway.
- Plans come up for review.
- Assessments are undertaken as part of a wider sustainability review.
- Before service providers are forced to act by a sudden event or mounting maintenance costs.

1.39. The study provides guidance for local authority service providers and other service providers on recommended actions for adapting to climate change. A timeframe is indicated for each recommended action, indicating when the service provider needs to act. Each action falls into one of three timescales:

- Act now.
- Plan for the future.
- Keep a 'watching brief'.

1.40. These timescales are drawn from UKCIP guidance for local authorities[4] and are described in more detail in the box below. It is very important that decision-makers incorporate climate change into their thinking as soon as possible. For example actions that are taken in the relatively near future (e.g. the next ten years) should be robust to climate change in the long-term future.

1.41. In some cases there will be a clear timescale for a suggested adaptation measure. For example where there is a clear benefit in acting immediately,

[4] Climate change and local communities: How prepared are you? An adaptation guide for local authorities in the UK. UKCIP report (2003), UKCIP, Oxford.

opportunity to act immediately (which will also depend on project planning timescales) and where the technology/understanding exists, then clearly service providers should aim to 'act now'. However, in other circumstances several timescales may apply. For example, there may be cases where the service provider should act now where possible, but also think about how to incorporate suggested actions for responding to climate change into future plans. Furthermore, there may also be a need to keep a 'watching brief' to ensure that, as new levels of understanding of climate change and possible adaptation measures emerge, standards and procedures can be updated accordingly.

Timescales

- **Act now**
  When there are current problems. Where a service provider is already experiencing problems, for example, with flooding, overheating of buildings, weather-related maintenance costs, or needs to upgrade infrastructure, make sure that new standards take future climate conditions into account. Communities already experience regular damage from severe weather and climate patterns – floods, droughts, storms, pest invasions, water shortages. Climate change will change the frequency and intensity of such events. It may be possible to save damage costs in the future by adapting to climate change now. Acting now can also provide 'no regret' solutions that can deliver benefits under present day climate as well as future climate scenarios.

- **Plan for the future**
  When fixed infrastructure is installed or developments are commenced with a lifetime of more than 20 years. For a small additional cost now, it may be possible to avoid major problems and costs in later years as the climate continues to change. Project planners must assess the plausible range of future scenarios to determine the best degree of future-proofing for fixed long-term installations.

  Where a service provider has responsibility for contingency planning. Climate change could increase the frequency of extreme weather events, such as urban flash flooding, storm surges, droughts and heat waves.

  When long-term policies are put in place. Long-term policies have a vital role in delivering climate change adaptation measures.

  If the service provider wishes to benefit from climate change. Not all effects of climate change will be negative. Warmer summers and winters could reduce heating costs and lead to a more outdoor lifestyle. A changing climate could also increase domestic tourism if traditional overseas destinations become too hot for comfort. Farmers may be able to grow new crops and explore new markets. Society could benefit if service providers proactively plan for these changes.

- **Keep a watching brief**
  When not enough is known. Adapting to climate change is not always a simple decision to change operating standards and design parameters. Climate and weather patterns have pervasive positive and negative effects on industries such as agriculture and tourism, on social well being and health and on ecosystems. To minimise the risk to services, organisations should keep up to

date about the impacts of climate change. For example, through ensuring staff attend training seminars and through working with professional bodies to embed climate change knowledge in service standards and procedures.

Scientific uncertainty and information availability

1.42. Good decision-making must be based on sound underlying information; however, information about climate change is relatively new and evolving and information about the impacts of climate change is even less well established. Research studies, which are seeking to understand the potential impacts of climate change, are themselves subject to methodological uncertainties. Therefore, whilst this report is based on the best available information, the uncertainties inherent in planning for climate change must be recognised.

1.43. Despite these uncertainties, decisions still need to be made. The paragraphs below discuss the approach taken to handling climate change related risks and uncertainties in decision-making.

Risk, uncertainty and decision making

1.44. Whilst the scientific understanding of climate change and the likely impacts arising is improving all the time, there is inevitably still some uncertainty and attendant risks attached. In most instances we have a reasonable understanding about the consequences of particular climatic events e.g. we know the consequences of flooding. The uncertainty is related to the probability and severity of potential events. A precautionary approach has been taken in preparing the guidance in order to reduce the risk of vulnerability of the East of England to adverse impacts.

1.45. This points to the necessity of making decisions that balance the risks of climate change impacts against other factors. For example, uncertainty could impact on spatial decisions that primarily address issues or risks associated with present or future levels of climate variability, climate extremes and or future climate change that have major social, environmental or economic implications.

1.46. But there are risks associated with all aspects of trying to predict the future. For example, it would be impossible to predict with any certainty what sort of economy the East of England will have in a hundred years time (the timescales being considered with respect to climate change). Yet it is still important to plan for future economic development. With respect to climate change, there is pretty good information available now as to what is likely to happen in broad terms over the next hundred years, even if some of the more detailed aspects still need to be refined. This suggests that the risk of uncertainty attached to climate change is no greater (and compared to some aspects the risk is probably less) than other aspects of society that guide our decision-making. The region should therefore plan for the future accordingly.

1.47. UKCIP recently published its recommended decision making framework for dealing with risk and uncertainty in such instances[5]. The iterative decision making framework involves detailed risk assessments. UKCIP recommend users should investigate a wider range of climate change scenarios than are set out in the UKCIP02 scenarios report[6]. UKCIP can provide advice on the use of scenarios.

1.48. Local decision-makers will undoubtedly wish to consider the cost implications of dealing with the impacts of climate change, especially when there are still some uncertainties about the effects of these impacts. It is often difficult to plan for issues such as the impacts of climate change when the benefits of investment now will not be seen for many years to come, particularly when there are often apparently more pressing immediate priorities to be dealt with. Nonetheless, we all have a duty to consider the longer-term and to safeguard the needs of future generations.

1.49. Whilst there is some risk and uncertainty surrounding climate change, this is being reduced as better information becomes available. However, the risk of not acting in good time remains. Failing to plan for the future could potentially increase risk and incur higher costs and more disruption as the climate changes and remedial maintenance and renewal is required. Timely investment should therefore help to avoid even greater costs being incurred in the future. Furthermore, many of the adaptation measures suggested make good sense in 'housekeeping' terms, and could lead to cost savings. The main message, therefore, is invest now to avoid even greater costs later.

1.50. Decision-makers will need to be particularly aware of not making decisions that could constrain or reduce the effectiveness of future options for adaptation. For example, allowing housing developments in areas vulnerable to flooding, which might prevent effective flood management in the catchment in the future, in line with *PPG25 Development and flood risk*. Local authorities are also required to report to Government on high level targets relating to development in floodplains, whereby they must report the occasions in which they ignore Environment Agency flood defence advice on planning applications.

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[5] Willows, R.I. and Connell, R.K. (Eds.). (2003). Climate adaptation: Risk, uncertainty and decision-making. UKCIP Technical Report. UKCIP, Oxford.

[6] Hulme M., Jenkins G.J., Lu X., Turnpenny J.R., Mitchell T.D., Jones R.G., Lowe J., Murphy J.M., Hassell D., Boorman P., McDonald R. and Hill S. (2002), Climate change scenarios for the United Kingdom: The UKCIP02 Scientific Report, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK. 120pp

1.51. There will be decisions that can be made now because they will lead to significant benefits that are unrelated to climate change. These can be described as 'low or no-regrets' measures. For instance, a decision to allow the sea to breach current sea defences, might be justified now on the basis of creating new salt marsh habitats, while in the long-term this might be a necessary adaptation to climate change.

Influence on legislation and regulations

1.52. There will be many other influences on decision-makers that will affect the scope and flexibility available in responding to the impacts. Some, such as the Strategic Environmental Assessment (SEA) Directive (2001/42/EC) and the Water Framework Directive (2000/60/EC) will require decision-makers at all levels to take into account sustainability issues. These are likely to lead to greater emphasis and support for addressing the impacts of climate change in the provision of services.

1.53. Others, such as building regulations and other existing standards, may in some instances, hamper decision-makers from taking a pre-emptive approach to planning for climate change impacts. It is important that such standards are reviewed to ensure that they are still appropriate and encourage decision-makers to make the necessary changes to adapt to climate change. Planning policy guidance and planning policy set out in development plans, should also play a more proactive role in promoting sustainable buildings, through, for example, promoting water efficiency.

Cross-sectoral impacts and partnership planning

1.54. This document provides guidance for individual service areas that are provided by local authorities and other bodies. However, adaptation to climate change within one service sector will, in some instances, have significant knock-on impacts for other sectors. For example:

- Adaptation measures such as managed realignment of the coast to deal with sea-level rises and coastal erosion could have implications for the provision of services and planning for the tourism sector, such as the need to relocate facilities, or the opening up of opportunities for new forms of eco-tourism.

- Planning for changes in the provision of water supplies, to take into account availability of water resources, may have an impact on the location and forms of business development that should be planned for in the region. Industries that consume large quantities of water may need to be guided towards, or even in some instances relocate, to locations that are better placed with respect to water supplies.

- Existing and planned transport infrastructure may need to be reviewed in the light of changing patterns of flood risk and in the light of adaptation measures introduced to reduce the risk of flooding in specific locations. For example, during heavy rain overflowing drains (the responsibility of local authorities) can disrupt roads and rail transport (the responsibility of highways planners, and rail transport infrastructure and service providers).

1.55. In addition, the issue of cross-sectoral impacts means that in many instances co-ordinated responses are required. For each service area, therefore, the key partners involved in delivering the service, or who have an interest in the service being delivered, are identified. All partners should work together to ensure that an integrated response to climate change impacts is prepared and implemented. Some examples of partnership working and the need for 'joined-up' thinking are illustrated in the case studies below.

Case study: The importance of partnerships for tackling flood risk in the Thames Gateway

Technical improvements for flood defence in the Thames Gateway are not enough according to Ian Christie of the New Economics Foundation and Local Futures writing in the Environment Agency's Environment Action journal – there is a need for close liaison with plans for new homes and business development in the Thames Gateway area of East London, and for the communication on flood risk with local communities. A member of the Environment Agency team working in the Thames Gateway area notes that the Agency is "establishing a proactive dialogue with Government, the big developers and partnerships, giving us an opportunity to ensure that sustainable defences are 'designed in' at the outset, so that we won't have to come back and retrofit defences in 20 or 30 years".

Summarised from: 'A hard rain' by Ian Christie Environment Action, January 2003, flood supplement.

Case study: A joined up approach to drainage issues

A joined up approach is needed to tackle drainage issues, for example, when the M74 was first upgraded the drainage system was designed to use the existing Railtrack drains – without consulting Railtrack. The drainage capacity was insufficient to cope with the extra runoff, which resulted in a significant section of the West Coast main line being washed away shortly after the motorway upgrade was completed.

The Impacts of Climate Change: Implications for DETR, 2001. Sarah Thompson, In House Policy Consultancy, DETR.

Case study: The Wash Banks Flood Defence Scheme - partnership working to achieve coastal defence

'Coastal squeeze' is the process by which coastal habitats and features are lost or 'drowned', as they are trapped between coastal defences (or natural geological features) and rising sea levels. The presence of defences, and/or the speed of sea level rise, often means that coastal habitats cannot migrate landward fast enough, hence leading to loss of the existing ecosystem. Managed realignment schemes, i.e. the breach of seaward defences to allow saltmarsh and mudflats to develop, provide not only an essential sea defence but also overcome the problem of coastal squeeze by reinstating valuable inter-tidal habitats. An example of such a project is the Wash Banks Flood Defence Scheme which involved partnership working between the Environment Agency, RSPB, HM Prison North Sea Camp and English Nature and was funded by grant aid from Defra and the Lincolnshire Flood Defence Committee.

Protecting the Lincolnshire Wash Coast: The Wash Banks Scheme. Published by the Environment Agency, English Nature, RSPB and HM Prison Service.

2. CLIMATE CHANGE IN THE EAST OF ENGLAND

2.1. One of the biggest challenges of addressing climate change is that it inevitably requires decision-makers to deal with risk and uncertainty, given that it is not possible to give firm predictions on future climate. Not only is it difficult to predict what changes will occur to climate, and what impacts these will bring, but the changes and impacts are likely to vary depending upon our ability and willingness to control the emissions which are causing climate change.

Global climate change

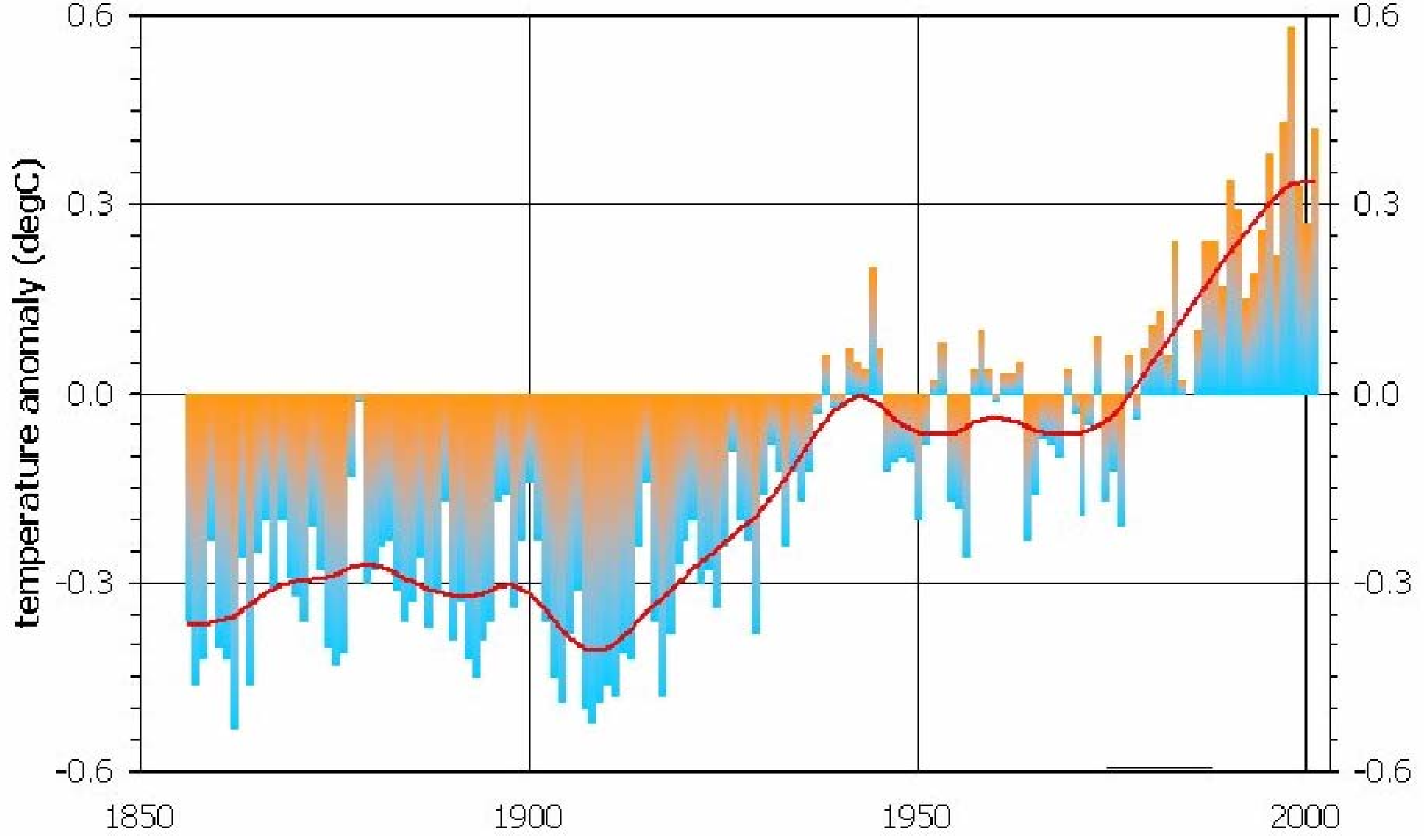
2.2. Global temperature has risen by about 0.6°C since the beginning of the twentieth century, with about 0.4°C of this warming occurring since the 1970s. 1998 was the single warmest year in the 142-year global instrumental record and 2001 was the third warmest (**Figure 2.1**). This warming could have been due to a number of causes, some human in origin and some natural. It is known that the Earth's climate changes substantially between an ice age and an inter-glacial period, but these changes occur over time-scales of a thousand years or more. The Earth's climate also varies naturally, as a result of interactions between the ocean and the atmosphere, which causes variations in climate from year-to-year, from decade-to-decade and from century-to-century. Reconstructions of Northern Hemisphere climate over the past 1,000 years reveal such variability. The warming observed over the past 100 years is larger than these natural variations in climate, suggesting that the recent rise in temperature cannot be solely due to natural variability of the climate system.

2.3. So what is causing the warming? There is new and stronger evidence to show that most of the warming observed over the last 50 years is attributable to human activities[7]. *Climate Change Scenarios for the United Kingdom* (Hulme et al., 2002) indicates that this change cannot be accounted for by natural variability alone. Modelling of natural factors (such as changes in the energy output of the sun and explosive volcanoes) shows that these factors can only explain some of the decade-to-decade changes in climate. For example, warming during the early twentieth century, but not the warming observed over the last 40 to 50 years (**Figure 2.2a**).

2.4. Over the last several hundred years, human activities have also affected climate. Increased concentrations of greenhouse gases such as carbon dioxide, methane and low-level ozone trap more energy in the lower atmosphere and thus warm climate. Changes in such human factors were used to drive a model, which shows that the recent rise in temperatures is

[7] IPCC, 2001: Climate Change 2001: Synthesis Report. A contribution of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change.

well replicated (**Figure 2.2b**). When both human and natural factors are put together, the model produces a good simulation of global temperature over a 140-year period (**Figure 2.2c**). This provides evidence that humans are playing a major role in causing recent global climate change.



Note: Individual bars show annual values as deviations from the 1961-1990 average.
The curve emphasises variations over timescales of at least 30 years.

Living with Climate Change in the East of England

Figure 2.1: Global average surface temperature (1860 - 2001)

Source: from UKCIP02 Scientific Report. The data set is maintained by the Hadley Centre and The Climate Research Unit at UEA

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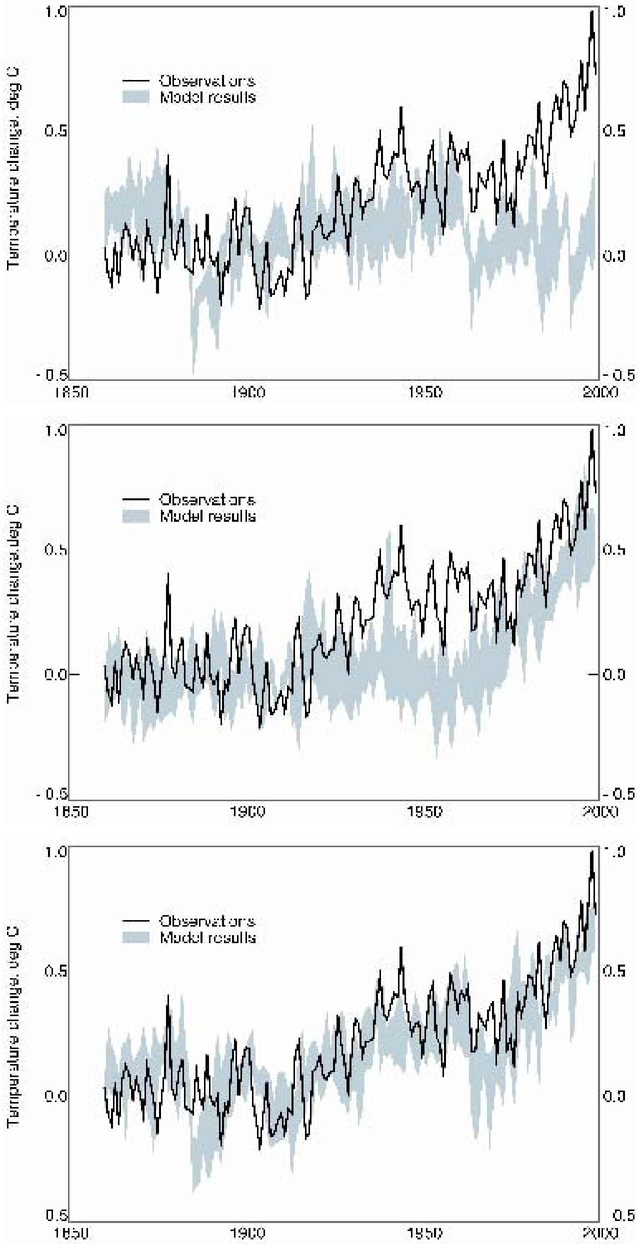

a) taking into account natural factors

b) taking into account human factors

c) taking into account both sets of factors

Living with Climate Change in the East of England

Figure 2.2
Observed changes in global-average temperature from the 1880-1920 average compared to model simulations

Source: Peter Stott, UKCIP02 Scientific Report

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Climate change in the East of England

2.5. For the purposes of this study, use has been made of the UKCIP02 climate change scenarios[8] to provide an understanding of the changes that could potentially be experienced in the East of England. The scenarios reflect a range of possible future emissions, based on results from a set of experiments using the most advanced climate modelling capabilities. The actual level of emissions and hence climate change will depend on actions taken globally to limit emissions (or otherwise).

2.6. For this study the 'Low Emissions' and 'High Emissions' scenarios have been considered, as they provide a good range of potential climate changes:

Low Emissions (increase in global temperature of 2.0^{o}C by the 2080s);

High Emissions (increase in global temperature of 3.9^{o}C by the 2080s).

2.7. Even if global emissions of carbon dioxide eventually fall below today's level, as assumed in the UKCIP02 Low Emissions scenario, the future rate of global warming over the present century, may be about four times that experienced during the twentieth century. If the emissions rate increases to approximately four times today's level – the High Emissions scenario – the future warming rate may be about eight times that experienced during the twentieth century.

2.8. The UKCIP02 study uses these scenarios to provide information on a range of climate change variables. These are grouped into seasonal changes, daily changes and changes in extreme events and marine and coastal changes.

2.9. The UKCIP02 scenarios present UK wide data at a 50km resolution. It is therefore possible to see the range of changes that might take place in the East of England. The data is also presented in three 30-year time periods centred on the 2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100). The changes in climate for each of these periods are calculated as the changes in 30-year average, with respect to the model simulated climate of the baseline period, 1961-1990. A summary of some key changes facing the East of England is provided below.

Temperature changes

2.10. The East of England region is forecast to get warmer under all the scenarios, to some degree. These changes are summarised in **Table 2.1a**. Temperature increases will be greatest in summer under the High Emissions scenario; by the 2080s we may see increases of up to 5^{o}C. Under the Low Emissions scenario there will still be increases in summer temperatures of

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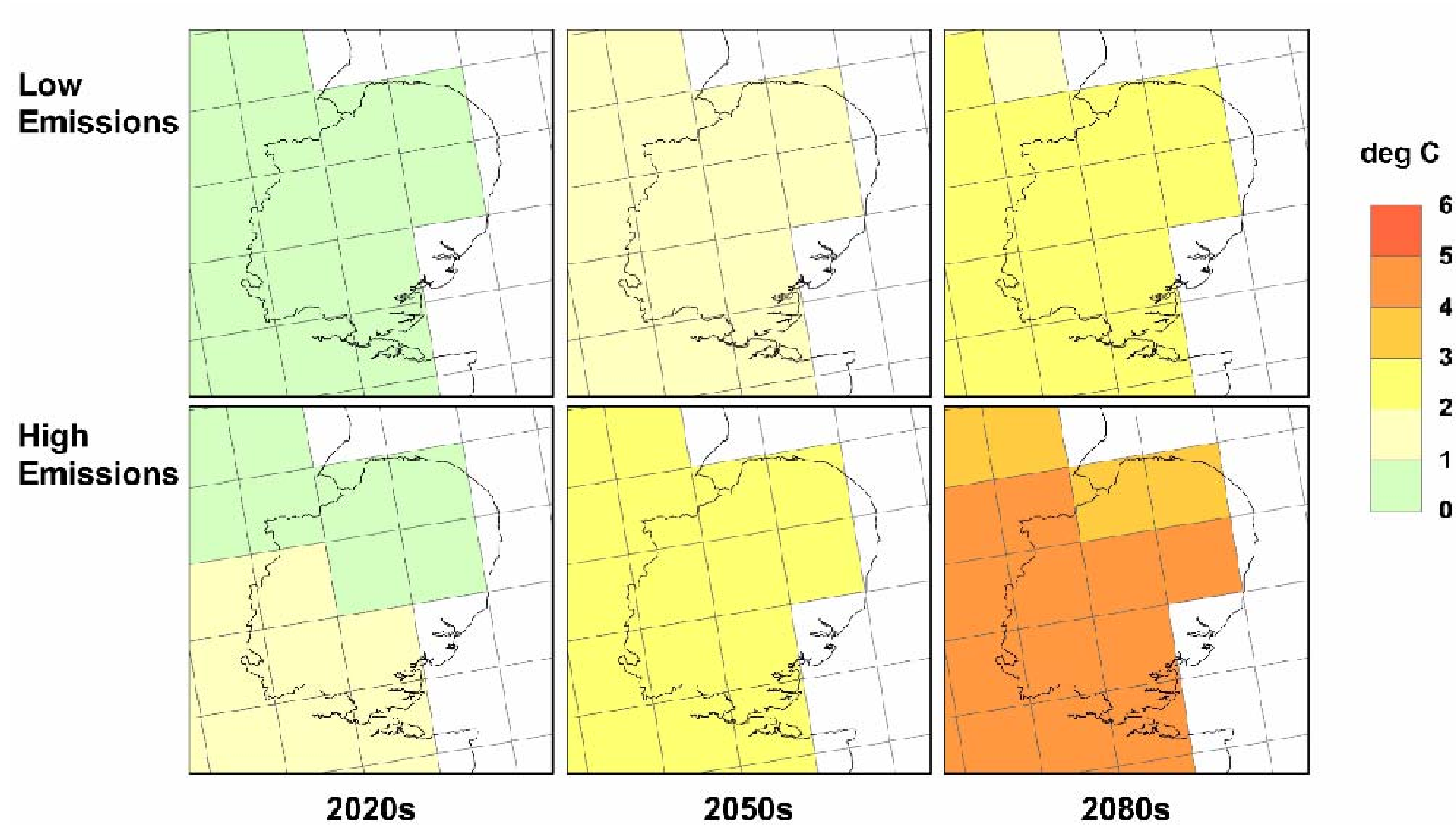
8 Hulme M et al. (2002), *Climate change scenarios for the United Kingdom: The UKCIP02 Scientific Report*, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

between 2 and 3°C. Changes in average annual temperature are shown in **Figure 2.3**. The number of 'extremely warm' days[9] in summer will also increase.

[9] Extremely warm days have been defined using the 90th percentile daily-average temperature modelled for the baseline period 1961-1990, i.e. the daily average temperature which is exceeded, on average, on 10% of days.



Living with Climate Change in the East of England

Figure 2.3: Change in average daily temperature - annual

Source: UKCIP02 Scenarios, unpublished maps

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2.11. Temperature changes will lead to a lengthening of the thermal growing season[10], of up to 100 days under the High Emissions scenario by the 2080s. It is important to note however, that this definition is dependent only on temperature and does not take account of water availability nor day-length and will not necessarily lead to year round plant growth. The number of heating degree days – which relate daily temperature to the demand for energy to heat buildings and to maintain a comfortable minimum temperature[11] will also be affected by temperature changes and will see a decrease. Conversely the number of cooling degree-days – which relate daily temperature to the demand for energy to cool buildings and to maintain a comfortable maximum temperature[12] - will see an increase.

Table 2.1a: Key climate changes in the East of England (under low and High Emissions scenarios) by the 2080s – temperature related

Variable	Summary of changes	
	Low Emissions scenario	High Emissions scenario
Seasonal temperature	• Annual warming by the 2080s of between 2-2.5^{o}C • Summer temperature increases between 2-3^{o}C	• Annual warming by the 2080s of between 3.5-4.5^{o}C • Summer temperature increases of up to 5^{o}C

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[10] Thermal growing season – the length of the thermal growing season is defined as the longest period within a year that satisfies the twin requirements of: (i) beginning at the start of a period when daily–average temperature is greater than 5.5C for five consecutive days; and (ii) ending on the day prior to the first subsequent period when daily–average temperature is less than 5.5C for five consecutive days.

[11] Heating degree days – The number of heating degree days in a year gives an indication of the amount of time, and by how much, the temperature is below a given baseline. HDD are important because organisations have a legal obligation to maintain a minimum temperature in a building. The method used by UKCIP is that adopted by the Met. Office. The baseline standard is a daily–average temperature, Tmean – usually estimated as the average of the minimum and maximum temperatures for that day – of 15.5C. Therefore, HDD=15.5 – Tmean, and is summed for all days in a year, ignoring negative values. For example, if Tmean on one day is 10.5C, then there are 5 heating degree–days for that day. The formula for HDD is correct for cases when both the maximum and minimum are below the base. If this is not the case, various weighted increments are used to correct the basic equation.

[12] Cooling degree days – Cooling degree days perform a similar function to HDD. There is no officially designated base temperature; in the UKCIP study, 22C has been used on the basis of building energy management practice. Thus, CDD=Tmean–22 which is summed for all days in the year, ignoring negative values. The formula holds when both the maximum and minimum temperatures are above 22C; in other cases weighted increments are used.

Variable	Summary of changes	
	Low Emissions scenario	High Emissions scenario
Temperature extremes	• Number of 'extremely' warm days increases, especially in summer and autumn (an increase of up to 14 'extremely' warm days in summer) • Number of very cold days decreases, especially in winter	• Number of 'extremely warm' days increases, especially in summer and autumn (an increase of up to 30 'extremely' warm days in summer) • Number of very cold days decreases, especially in winter
Thermal growing season	• Increases by between 45 and 55 days	• Increases by up to 100 days
Heating degree days (an indication of the amount of time, and by how much, the temperature is below a given baseline)	• Decreases in heating degree days of between 20-25%[13]	• Decreases in heating degree days of between 40 and 45%[14]
Cooling degree days (which relate daily temperature to the demand for energy to cool buildings and to maintain a comfortable maximum temperature)	• Increases in cooling degree days of between 40 and 150 days[15]	• Increases in cooling degree days of between 80 and 200 days[16]

Precipitation changes

2.12. Rainfall patterns will change, with summers getting drier and winters wetter, leading to a slight decrease in annual rainfall. The frequency of

[13] Compared to a baseline for the south of England of 2100–2300 HDD/year– this baseline is not available for the East of England, but the south of England baseline still gives a rough indication of the magnitude of the increase.

[14] As previous.

[15] Compared to a baseline of 310–330 CDD/year days in the south of England – this baseline is not available for the East of England, but the south of England baseline still gives a rough indication of the magnitude of the increase.

[16] As previous.

'intense' precipitation events in winter will increase[17], although they will decrease in frequency in summer. Soil moisture, which is a product of rainfall and evaporation, is set to decrease in summer and autumn under the High and Low Emissions scenarios and will also decrease in winter under the High Emissions scenario. These changes are summarised in **Table 2.1b.** Percentage changes in average winter and summer precipitation are shown in **Figures 2.4** and **2.5**.

[17] A measure of change in intense rainfall days per season is derived from quantile analysis. This method allows the definition of 'intense' to vary across the country. For example, under baseline conditions, an intense winter day's precipitation is between 35 and 45 mm in northwest Scotland, but only about 20 mm in southeast England.

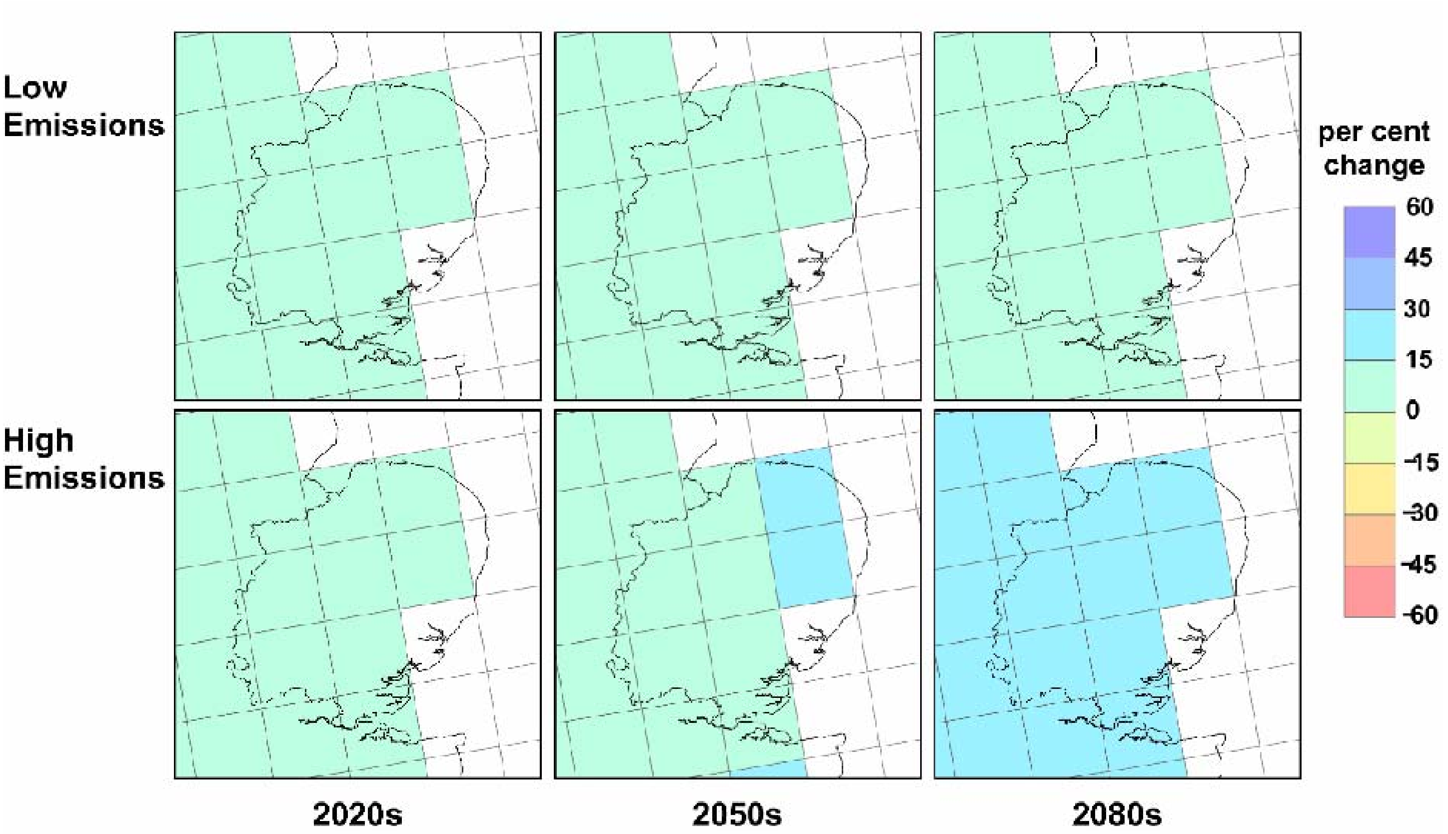

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Figure 2.4: Percentage change in average winter precipitation

Source: UKCIP02 Scenarios, unpublished maps

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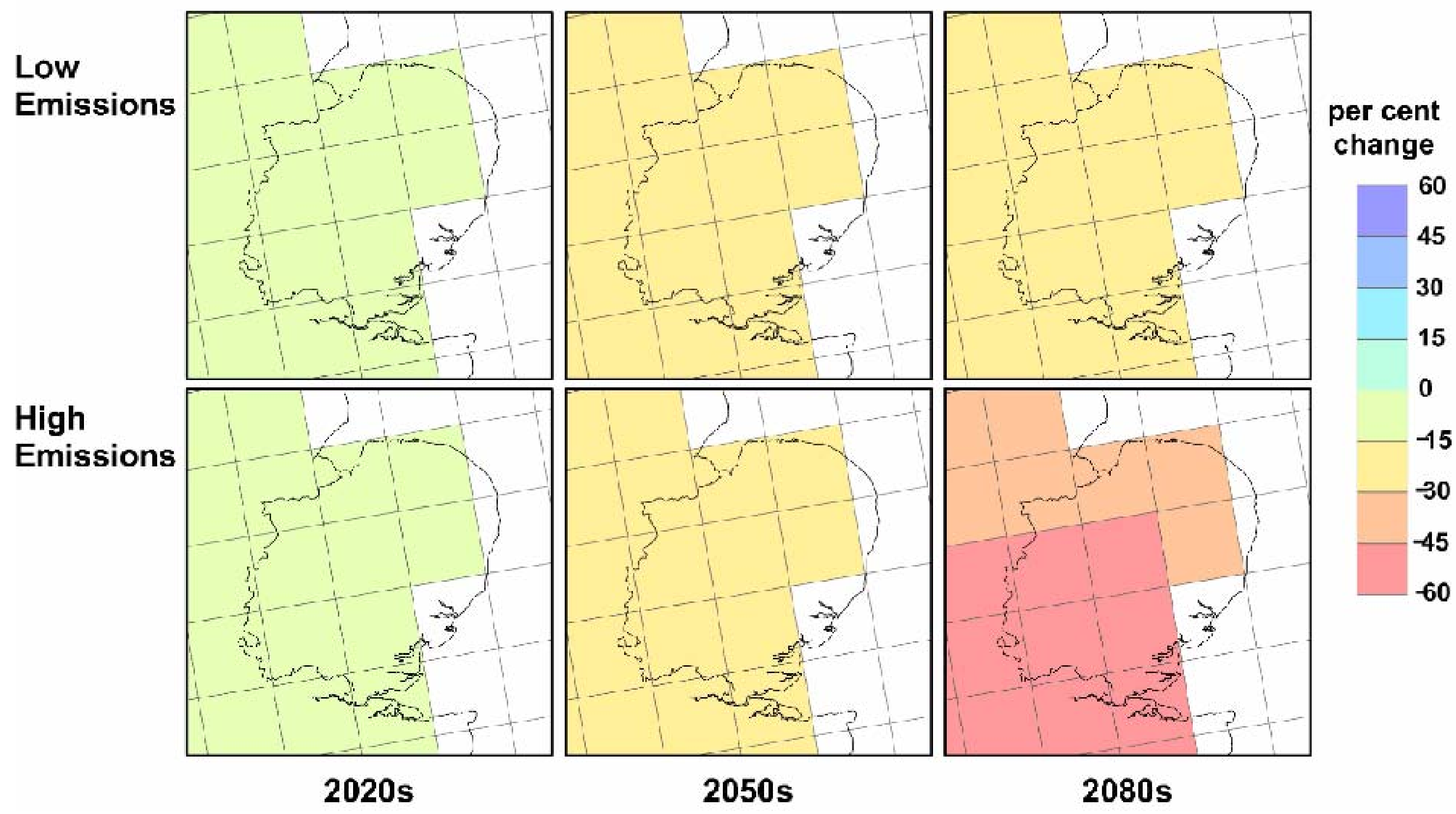

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Figure 2.5: Percentage change in average summer precipitation

Source: UKCIP02 Scenarios, unpublished maps

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Table 2.1b: Key climate changes in the East of England (under Low and High Emissions scenarios) by the 2080s – precipitation related

Variable	Summary of changes	
	Low Emissions scenario	High Emissions scenario
Seasonal precipitation	• Wetter winters, between 10-20% wetter • Drier summers, between 20-30% drier • Drier overall annually, between 0 and 10%	• Wetter winters, between 25-35% wetter • Drier summers, between 40-60% drier • Drier overall annually between 0 and 10%
Precipitation intensity	• Increases in winter (around 0.25-0.75 more days of 'intense' rainfall in winter)	• Increases in winter (around 0.75-1.25 more days of 'intense' rainfall in winter)
Soil moisture	• Decreases in summer and autumn soil moisture of between 10-30%	• Decreases in summer and autumn soil moisture of between 30-50% • Up to 10% drier under the High Emissions scenario in parts of the region in winter

Changes in sea level

2.13. Regional changes in sea level are likely to occur. The sea level in the East of England, is predicted to rise due to three factors: isostatic subsidence (on-going readjustment of the land to the de-glaciation that followed the last ice age – as a result much of southern Britain is sinking whilst much of northern Britain is rising relative to the sea), climate-induced glacial melting and thermal expansion of ocean water. In the East of England a sea level rise of between 22cm and 82cm is predicted to occur, depending on the emissions scenario used.

2.14. Extreme sea levels due to storm surges are expected to increase in size and frequency. The data shows that simulated changes in the 50-year return period water levels, taking into account possible increased storminess, increased sea level and vertical land movements, are by 2080 between 1 and 1.4 m higher than experienced currently in the East of England. However, there are high levels of uncertainty associated with these predictions due to the assumptions used in the modelling. The regional model used in the UKCIP02 scenarios cannot produce simulations of surge height directly. Instead atmospheric winds and pressures have been used to drive a separate high resolution (30km) model with an ocean component. Different patterns and magnitude of change in surge height would be produced by using changes in climate extracted from another model, or by applying them to a higher resolution (12km) surge model. Earlier modelling work using a 12km surge model found the 50-year return period surge height off Southeast England to be much less. Figures relating to frequency and size of storm surges are presented in **Table 2.1c** below, and in **Figure 2.6a and b**.

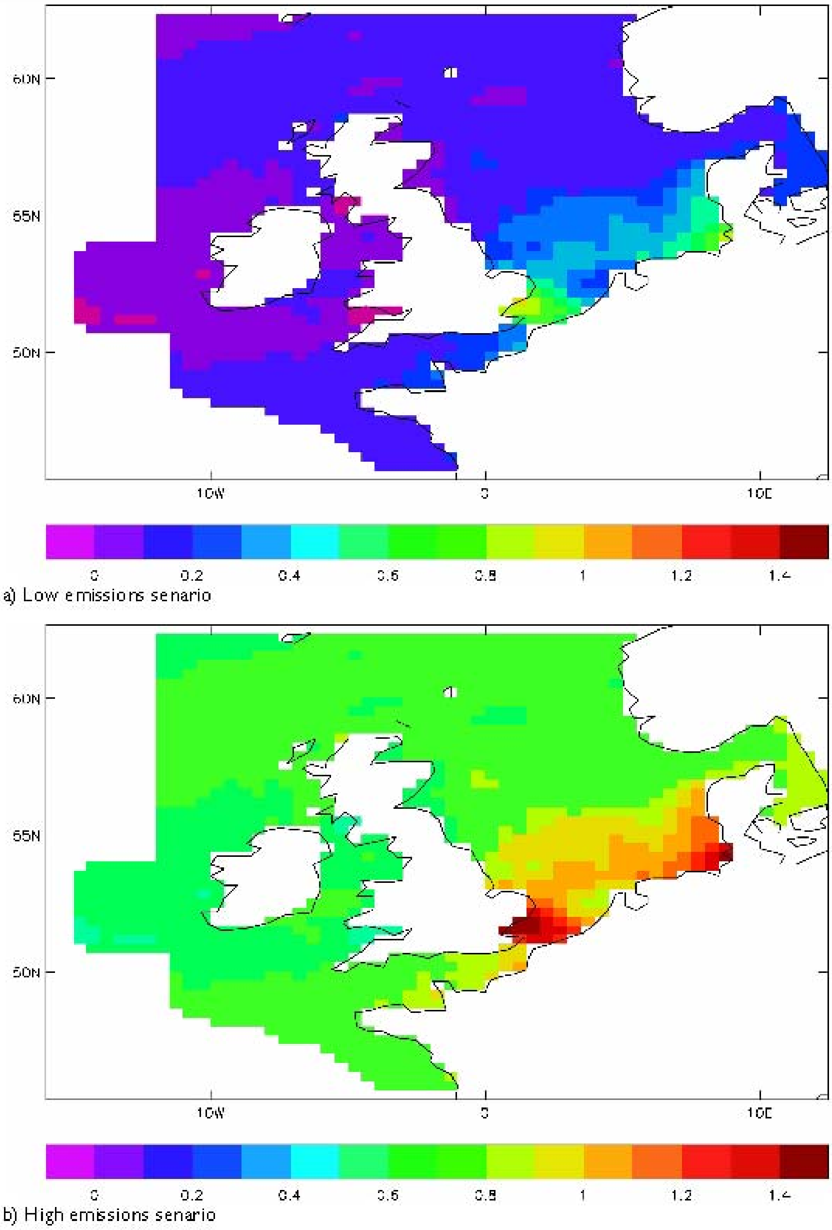

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Figure 2.6
Change in 50 year return period surge height (metres) for the 2080s

Source: Shennan, 1987 from UKCIP02 Scientific Report

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Table 2.1c: Key climate changes in the East of England (under Low and High emissions scenarios) by the 2080s – sea level

Variable	Summary of changes	
	Low Emissions scenario	High Emissions scenario
Sea level change	• Net sea level rise of approximately 22 cm (taking into account the effects of vertical land movement)	• Net sea level rise of approximately 82 cm (taking into account the effects of vertical land movement)
Extreme sea levels (storm surges)	• 50 year return surge height will increase by up to 1 m • Present 'once-in-50-year' storm surge will occur once every 10 years • Although high level of uncertainty in these predictions	• 50 year return surge height will increase by up to 1.4 m • Present 'once-in-50-year' storm surge will occur more often than once per year • Although high level of uncertainty in these predictions

Seasonality and variability

2.15. The East of England will also see changes in seasonality and variability. Seasonality is a measure of seasonal difference, for example between summer and winter. Seasonality will increase in terms of precipitation and temperature. Inter-annual variability provides an indication of the variation in seasonal temperature or precipitation that can be expected to occur from year-to-year as the climate warms. In the East of England, summer and autumn temperatures will become more variable as will winter and spring precipitation. Understanding the likelihood of experiencing anomalous seasonal temperatures and levels of precipitation together can be useful. For example, the occurrence of high temperatures in a summer of low precipitation, enhances drought conditions, while a warm and wet winter can result in building and flood damage. Winter depressions will also become more frequent leading to possible increased storminess, although there is a relatively low level of confidence associated with this result. Similarly winter wind speeds may increase somewhat, but there is, again, a high level of uncertainty associated with this result.

Table 2.1d: Key climate changes in the East of England (under Low and High Emissions scenarios) by the 2080s – seasonality and variability

Variable	Summary of changes
Seasonality	• Precipitation: greater contrast between summer (drier) and winter (wetter) seasons • Temperature: summers warm more than winters

Variable	Summary of changes
Variability	• Years as warm as 1999 (1.2°C warmer than average) become very common • Summers as dry as 1995 (37% drier than average) become very common • Winter and spring precipitation becomes more variable • Summer and autumn temperatures become more variable
Storm tracks	• Winter depressions become more frequent leading to possible increased storminess, but high uncertainty in this result
Windiness	• Slightly stronger winds (up to 10% stronger) may be experienced during winter, but again, high uncertainty in this result.

In summary, the East of England will experience:

- Hotter drier summers; milder wetter winters
- Significant decrease in soil moisture content
- Extreme high temperatures more frequent
- Extreme winter precipitation more frequent
- Increase in thermal growing season
- Net sea level rise and increase in sea storm surge height.

3. CLIMATE CHANGE SUB-REGIONS

3.1. The impacts of climate change are likely to vary across the region, depending upon the natural characteristics of the area affected (e.g. whether it is low-lying, or has scarce water resources) and the vulnerability of human assets affected (e.g. patterns of development). The adaptation measures, which local authorities and other service providers will need to plan for, are also likely to differ across the region (although of course some adaptation responses will be applicable throughout). We have sought to map this variation with reference to 'climate change sub-regions', which were developed as part of the Stage 1 study, to structure guidance on adaptation measures for climate change which need to be undertaken at the regional level.

3.2. The proceeding sections of this guidance, setting out guidance for local authority service providers and other service providers (Sections 4 and 5), use these sub-regions to indicate where different adaptation measures might apply in terms of local level decisions.

3.3. The sub-regions reflect both intrinsic natural character (informed by English Nature's 'Natural Areas') and human issues, such as the pattern of development, future development policies and economic conditions and also the climate change pressures facing the areas, such as coastal flood risk. The sub-regions help to distinguish between issues that affect specific areas.

3.4. Five climate change sub-regions have been identified:

The Coast.

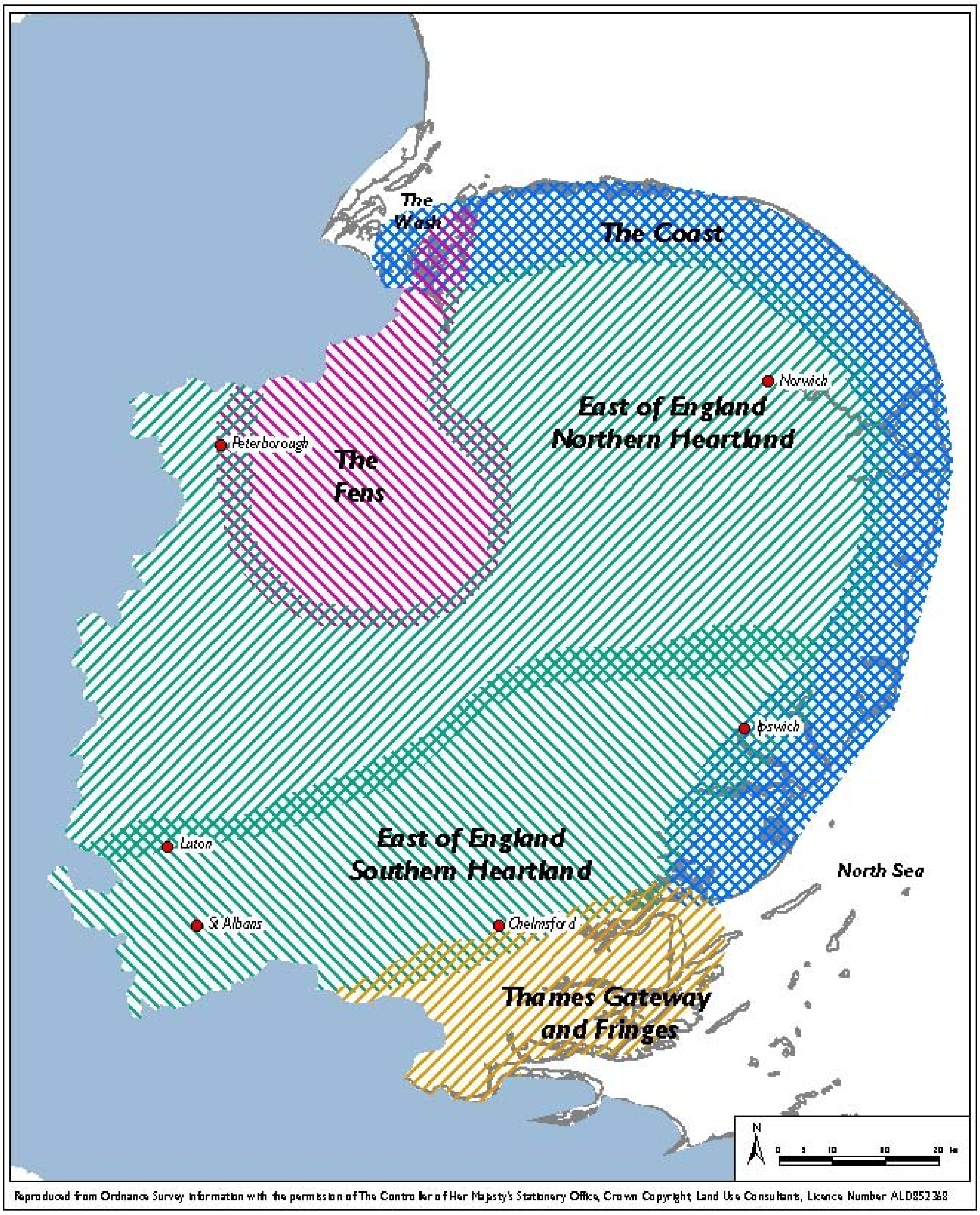
The Fens.

The Thames Gateway and Fringes.

The Southern Heartland.

The Northern Heartland.

3.5. These are shown on **Figure 3.1**. The key characteristics and climate change vulnerabilities of each sub-region are summarised below.



Living with Climate Change in the East of England

Figure 3.1
Climate Change Sub-Regions

Note: Boundaries are indicative only

Source: Land Use Consultants

Key
- East of England Northern Heartland
- East of England Southern Heartland
- Thames Gateway and Fringes
- The Coast
- The Fens
- Major Towns
- Coastline

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September 2003

The Coast

3.6. The Coast broadly comprises the southern part of the Wash, Natural Areas of North Norfolk, The Broads, Suffolk Coast and Heaths and the northernmost part of the Greater Thames Estuary. The natural character of The Coast is quite varied, mainly low-lying, containing for example the extensive dune systems to the north, and the lowland heath to the south. It is a very dynamic part of the East of England region, with strong coastal processes at work. The Coast is home to some of the region's most important wildlife habitats (e.g. intertidal mudflats especially important for waders).

3.7. In terms of human activity, The Coast is characterised by relatively remote rural and coastal communities, interspersed by larger towns such as Great Yarmouth and Lowestoft. Pockets of the sub-region are relatively wealthy (e.g. North Norfolk), but much of the sub-region is in significant need of regeneration, particularly the larger urban communities. Tourism is an important industry (although declining in some parts), as is agriculture and forestry, offshore oil and gas, transport, and some manufacturing.

3.8. In climate change terms, The Coast, along with The Fens, is most vulnerable to sea level changes, storm surges and saline intrusion. These impacts will have specific implications for very many of the services provided by local authorities and other service providers in this sub-region, for example, in relation to infrastructure related services and emergency services. In terms of flood risk management, where priority setting and decisions are taken at the national level, in line with Defra policy guidance, it is likely that there will be considerable pressure for managed realignment. It should be noted however that managed realignment may be carried out only when it is acceptable on technical, economic, environmental and social grounds.

3.9. The sub-region is also likely to be subject to a loss of habitats, either through 'coastal squeeze', as habitats are squeezed against hard sea defences, through flooding of coastal habitats or directly through erosion. This will place specific requirements on those involved in habitat protection and management in the sub-region.

3.10. Agricultural systems may also be subject to change. As certain systems of farming may be lost while others become more suitable, such as livestock grazing using coastal marshes that were once arable land.

The Fens

3.11. A single Natural Area of the same name neatly defines the Fens. It is very low-lying, with large slow-flowing rivers and drains and some flooded gravel pits. Small, scattered areas of relict fen and marsh can be found, but it is dominated by intensive agriculture.

3.12. The population density of The Fens is very low, with a few small communities and towns such as Wisbech, and on its edge King's Lynn and Peterborough. These communities are in need of economic regeneration.

3.13. The Fens, along with the coast, are perhaps the part of the region most vulnerable to climate change, because so much is already below sea level, and depends upon pumping out of water to remain dry. The impacts likely to be of most significance, are coastal and fluvial flooding, saline intrusion, impacts facing agriculture, including soil moisture availability and effects of increased temperatures. Again these impacts will have specific implications for the services provided by local authorities and other service providers in the sub-region.

3.14. The significant changes, which may occur in terms of flooding and agricultural systems, may well have impacts for the Fenland habitat, which will similarly have implications for those involved in habitat protection and management in the sub-region.

East of England Northern 'Heartland'

3.15. The East of England Heartland is a broad region that we have divided into two. The issue of water resource availability distinguishes the two parts of the 'Heartland'. The Northern Heartland comprises the Natural Areas of Breckland, West Anglian Plain and East Anglian Chalk, Bedfordshire Greensand Ridge, and the northern part of the East Anglian Plain. This part of the Heartland does not have the potential water resource supply issues of the Southern Heartland. The character of this sub-region is very varied ranging from the extensive areas of dry lowland heath and extensive pine forest of Breckland to the lowland oaks and mixed deciduous woodlands of the West Anglian Plain.

3.16. The three main settlements in the sub-region are Bedford, Cambridge and Norwich. Cambridge in particular, but also Norwich, are experiencing significant development pressure. Other areas, such as Breckland, on the other hand, are in need of regeneration. The sub-region is quite rural in character, with the exception of the main settlements.

3.17. In terms of climate change impacts, this sub-region is less vulnerable than many of the others, with fluvial flooding and impacts facing agriculture including soil moisture availability and effects of temperature perhaps being the most significant. This area is also likely to be less prone to subsidence due to the lesser presence of clay soils.

3.18. Generally speaking the impacts in this sub-region are unlikely to place many sub-region specific requirements on local authority and other service providers. Many of the impacts which will have implications for service providers in this sub-region will result from the changes in temperature, rainfall patterns and water availability, which are likely to require similar adaptation responses across the East of England region as a whole.

East of England Southern 'Heartland'

3.19. The East of England Southern Heartland is distinguished from its northern counterpart by its potential for increasing pressure on water resources. It comprises the western part of the Northern Thames Basin, the Chilterns, and the southernmost part of the East Anglian Plain. It is characterised by the chalk hills of the Chilterns and related chalk streams, which become tributaries of the Thames and the lowland areas to the north of London.

3.20. This part of the East of England is perhaps the most under pressure for development, as it includes the commuter belt of London and many of the towns of Hertfordshire, which are performing well in economic terms. It also includes Stansted airport, which is potentially the subject of considerable growth in the future. There are pockets in need of regeneration, such as Luton and Harlow.

3.21 The sub-region faces impacts on agriculture including soil moisture availability and the effects of temperature on agricultural production, and most importantly deficiencies in water resources. Due to the water supply issues facing the sub-region, agricultural systems are likely to need to adapt. Similarly landscapes and habitats are also likely to be affected by water availability and also by temperature rises. Also To an extent the sub-region is also subject to risks from fluvial flooding.

3.22 The risk of subsidence on clay and/or peaty soils is also an important issue in this region. Subsidence will have implications for highways maintenance by local authority and others involved in maintaining the road and rail networks, and also for those managing properties, for example, local authority property services, and water services responsible for mains leakage.

Thames Gateway and Fringes

3.23 The Thames Gateway falls into the Natural Areas defined by the Greater Thames Estuary and the easternmost part of the Northern Thames Basin. It is therefore highly influenced by coastal processes. It is home to important wetland habitats. Regeneration policies for Thames Gateway are the most significant influence on this area, as there is likely to be major housing and economic growth, with associated transport and servicing infrastructure, over coming decades. London (into which the Thames Gateway policy area extends) heavily influences the sub-region.

3.21. In climate change terms, the sub-region is particularly vulnerable to water resource deficiencies, sea level changes, and fluvial flooding. This sub-region is also likely to be at risk from subsidence.

3.22. Many of the adaptation responses applicable in this sub-region will be similar to those in the Coast and Fens sub-regions. However, this sub-region will face additional pressures due to the major development proposed in the area, which will evidently affect the appropriate and even possible adaptation responses. Therefore there will be particular pressures in relation to vulnerability of properties and infrastructure, which it will be very important for local authority property services and highways maintenance, amongst others, to respond to. The water supply issues facing this sub-region will also be very significant in terms of driving adaptation responses on the part of water service providers.

SUSTAINABLE COMMUNITIES PLAN

3.23. On 5th February 2003, the Deputy Prime Minister launched and published the Sustainable Communities Plan[18] confirming and describing plans for growth and regeneration in England, including significant additional housing development in the South-east for the period up to 2031.

3.24. With particularly strong growth in the South-east and contrasting issues of urban regeneration in the north, a large-scale plan for ensuring the sustainability of large-scale development and regeneration is vital. The Sustainable Communities Plan is the Government's strategic response to this need. It is an ambitious, long-term plan for putting sustainable development at the heart of initiatives to tackle both the provision of affordable homes and, elsewhere, the dereliction of empty properties. Three growth areas - the Thames Gateway, Milton-Keynes and the South Midlands and the London-Stansted-Cambridge Corridor – will affect the East of England. The Sustainable Communities Plan sets out to deliver the following in these growth areas:

Table 3.1: Additional Growth Planned to 2031

Growth Area	No. Additional Homes	No. Additional Jobs	Regions Affected
Thames Gateway	Not stated*	300,000	East of England, South East, London
Milton Keynes and the South Midlands	Up to 370,000	Up to 300,000	East of England, East Midlands, South East
London-Stansted-Cambridge Corridor	Up to 500,000	Not stated	East of England, London

***** The Sustainable Communities Plan does not separately identify a figure for homes in the Thames Gateway, but makes reference to London and the growth areas having the potential to accommodate an additional 200,000 homes above levels currently planned in regional planning guidance.

3.25. Although the growth planned above will be distributed across a number of regions, it is likely to place additional pressure on the services to be provided in the East of England. Particularly in the Thames Gateway and Fringes and Southern Heartland climate change sub-regions, which may exacerbate the impacts of climate change. Further pressure is also likely to result from any proposed development relating to growth of the region's major airports, such as Stansted, Luton and Alconbury, which may arise

[18] Sustainable communities: building for the future – Office for the Deputy Prime Minister 2003

from the Government's consultation on the future development of air transport in the South-east[19].

3.26. The Sustainable Communities Plan stresses the importance of delivering sustainable forms of development, including such measures as energy and water efficiency. The impacts of climate change will need to be taken into account in this process. Regional Planning Guidance (RPG14) for the East of England is currently being prepared which is taking into account the major growth planned for the region, and will set policies as to where and how development in the growth areas and other parts of the region should be delivered.

[19] The future development of air transport in the UK: South East, DfT, February 2003

4. ADAPTATION RESPONSES FOR LOCAL AUTHORITIES' SERVICE PROVISION

4.1. The impacts of climate change in the East of England are likely to have significant economic and operational impacts on local authority services and on infrastructure provision in the region. A series of tables (**Tables 4.1 - 4.17**) set out the impacts on local authority Services and possible responses. In most areas this will require local authorities to work with the statutory agencies and other stakeholders. One key role that local authorities should be playing in relation to climate change, which is overarching and not specifically noted in relation to specific services, is the need to proactively raise awareness and provide information to local communities which will be impacted on by climate change.

4.2. Given the large and varied character of the East of England, the magnitude and type of adaptation responses required will, in some instances, vary across the region. Where different responses are required they are listed for one or more of the 5 climate change sub-regions defined for the East of England, namely the Coast, Fens, Northern Heartland, Southern Heartland and the Thames Gateway (as described in Section 3 this report).

4.3. An indication is given in the tables of the time frame for the suggested responses. Three categories of time frame are shown (which are defined in Section 1 of this report):

Act now.

Plan for the future.

Keep a 'watching brief'.

4.4. In many cases, an indication is given, that climate change adaptation measures should be addressed in various plans and strategies prepared by local authorities. **Appendix 2** sets out basic information on these plans and strategies, including how they should incorporate considerations of climate change.

4.5. The key sources of information used to prepare the guidance for local authorities are:

ERM Potential UK adaptation strategies for climate change, technical report, May 2000

Climate change action plan, Aberdeen City Council, May 2002

Climate Change and local communities - How prepared are you? An adaptation guide for local authorities in the UK. UKCIP, IDEA, LGA, Cosla and Welsh Local Government Association, July 2003.

TRANSPORT INFRASTRUCTURE

Key issues for adaptation

- This service area faces real resource issues.
- There are extensive potential impacts on roads, footpaths, rights of way, bridges and associated drainage, arising from more extreme weather events.
- For example, storm events and wetter weather could lead to flooding of infrastructure, while hotter weather could lead to buckling or melting of road surfaces.
- In the south of the region, investment needed to strengthen infrastructure at risk from subsidence in clay and/or peaty soil areas will be significant.
- Effective liaison with the rail industry is essential.
- Failure to undertake investment could lead to major disruption on the road network, inconvenience and possible safety hazards.

4.6. The potential impacts of climate change on the roads, footpaths, rights of way, bridges, and associated drainage that is maintained by local authorities are extensive and there are real resource implications for service managers. Where the possible impacts might result in blocked roads or severe damage there will also be traffic management issues.

Case study: Increased precipitation and structural stability

There was a noticeable increase in the number of earthwork failures following the particularly wet winter of 2000/2001.

Prioritising Future Construction Research and Adapting to Climate Change: Infrastructure (Transport and Utilities), 2002, M.I. Wilson and M.H. Burtwell (TRL Limited) for the CRISP Commission

4.7. There is also potential for climate impacts to disrupt the rail system, which will then have an additional knock on effect on the road system, requiring a traffic management response. Effective liaison with rail industry is therefore essential.

4.8. The potential impacts and suggested actions for adapting to these impacts are set out in **Tables 4.1** and **4.2** below.

Case study: Road traffic accidents during storms

In the October 1987 and January/February 1990 storms, a total of 99 deaths were reported. 57 deaths involved vehicles with 47 deaths caused by road traffic accidents as a result of falling trees.

Health Effects of Climate Change in the UK, 2002. Department of Health.

4.9. Section 5 provides more detailed responses applicable to other partners involved in rail and road transport service provision (e.g. Network Rail and the Highways Agency), which should also help to inform local authorities in formulating transport infrastructure adaptation responses.

Case study: Increased precipitation and accidents

Statistical analysis shows that, without other changes, an increase in precipitation will lead to an increase in road accidents. For example, in 1994, 36.2% of road traffic accidents occurred when the road was wet or covered in snow or ice (DTLR, 1996).

Prioritising Future Construction Research and Adapting to Climate Change: Infrastructure (Transport and Utilities), 2002, M.I. Wilson and M.H. Burtwell (TRL Limited) for the CRISP Commission

Assessing and mitigating the effects of climate change on urban drainage systems

AUDACIOUS (Adaptable Urban Drainage – Addressing Changes in Intensity, Occurrence and Uncertainty of Stormwater) is a cross-disciplinary project bringing together hydrologists, building drainage and sewerage engineers, health, social and infrastructure economic specialists. They are developing tools and procedures for the assessment and mitigation of the effects of climate change on urban drainage systems. This will lead to the development of new flexible and adaptable approaches, suitably positioned and integrated to meet the needs of water service providers and the stakeholders within the urban landscape.

Building knowledge for a changing climate. The impacts of climate change on the built environment, 2003. UKCIP and EPSRC.

Table 4.1: Highways / drainage maintenance & traffic management

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All sub-regions	More frequent extreme weather events and in particular fluvial and groundwater flooding will cause traffic disruption in the short-term and add to costs in the long-term.	Respond to more frequent fluvial and groundwater flooding	• Continue to maintain highways and update maintenance systems.	Act now	• Environment Agency • Highways Agency • Landowners
			• Identify, catalogue and prioritise all highways, footpaths, rights of way and bridges that are at risk from more frequent fluvial, coastal, and groundwater flooding.	Plan for the future	• Environment Agency • Highways Agency • Landowners
			• Work with the Environment Agency to map areas at risk from flooding.	Plan for the future	• Environment Agency
			• Plan to re-site infrastructure as necessary and plan routes to minimise disruption.	Plan for the future	• Environment Agency • Highways Agency
			• Take account of the increasing intensity of future precipitation events in maintaining and increasing the capacity of drainage along highways and footpaths, and in maintaining embankments and bridge piers, and increase gully emptying activity.	Plan for the future	
			• In the longer-term put in place a programme to increase the resilience of highways, footpaths, rights of way and bridges to flood damage and subsidence. This should include the consideration of soft engineering solutions to flood defence e.g. the use of vegetated strips	Plan for the future	• Highways Agency • Landowners

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
			to ameliorate flooding events and the use of floodplain woodland for water holding capacity.		
	The adverse effects of more extremely hot days in summer (resulting in melting of tarred road surfaces, buckling concrete surfaces) may be balanced by reduced costs as a result of warmer winters with fewer frosty days and less snow (resulting in less frost damage to road surfaces and less frequent need to clear snow and to salt roads)	Respond to the increasing frequency of very hot days and the decreasing frequency of frosts / icy conditions and declining snowfall	• Take account of increasing number of very hot days when planning road maintenance programmes and where possible ensure that road surfaces are brought up to the current British Standard which was revised after the very hot summer of 1995. Take into account the declining frequency of snowfall, frosts and ice in allocating resources to snow clearing and salting roads and the design of highways and footways. Need to ensure sufficient flexibility in budgets so that adequate capacity does remain to deal with severe weather.	Act now	
	Increased temperature could cause service disruption and heat stress to travelling public.		• Avoid exposed places and provide shade or cooled waiting areas.		• Transport service providers e.g. bus companies
	Increasing frequency of drought and hot days will also impact on vegetation on roadside verges. Some species of trees will be damaged by drought increasing the risk of wind throw in storms. Grass fires may increase as a result of prolonged dry weather	Respond to the increasing risk of grass fires on verges in dry and hot weather	• Put in place management programmes and select planting to reduce risk of fires on verges.	Act now	• Wildlife Trusts
		Respond to the increasing risk of wind throw on trees next to roads.	• Put in place long-term management plans and programmes for roadside trees, including felling and replacement policy for dangerous trees.	Act now	• Wildlife Trusts

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
	An increasing growing season will impact on costs of maintaining roadside vegetation.	Respond to the impact of an increased growing season and milder temperatures on the growth of vegetation on roadside verges	• Ensure the allocation of resources to the maintenance programme for roadside verges, takes into account the lengthening of the growing season and the need to cut vegetation over a longer time period, while ensuring that biodiversity is not unduly affected. • Use slower growing plants in landscape schemes.	Plan for the future	• Wildlife Trusts
Southern Heartland Thames Gateway	Increase in subsidence as a result of changes in soil moisture is likely to be a significant impact in the Southern Heartland and Thames Gateway as result of the presence of clay soils	Monitor and respond to increased risk of subsidence	• Identify, catalogue and prioritise all highways, footpaths, rights of way and bridges that are at risk from subsidence in clay soil areas.	Act now	• Highways Agency • Landowners
			• Put in place programme to strengthen all highways, footpaths, rights of way and bridges that are at risk from subsidence in clay soil areas.	Plan for the future	• Highways Agency • Landowners

Table 4.2: Traffic management liaison with the Strategic Rail Authority (SRA)

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	The Strategic Rail Authority (SRA) will face a similar range of impacts on railways as are detailed above on roads. Any disruption of rail routes will impact on traffic management. Additional impacts on railways are the likely increasing risks of subsidence and landslips, caused by drought, followed by extremely heavy rainfall. Disruption to overhead electricity lines from wind throw of trees.	Set up effective liaison arrangements with the Strategic Rail Authority and Rail operators to deal with disruption to railways or highways	• Have emergency plans to manage road traffic in the event of a major disruption to rail services.	Act now	
Coastal, Fens and Thames Gateway	Sea level rise and the increasing risk of coastal flooding and storm surges will be additional impacts on railways in these climate change sub-regions	Set up effective liaison arrangements with the Strategic Rail Authority and Rail operators to deal with disruption to railways or highways	• Have emergency plans to manage road traffic in the event of a major disruption to rail services.	Act now	

PLANNING, BUILDINGS AND ESTATES

Key messages for adaptation

- Local authority properties and housing stock will require investment to adapt to climate change conditions e.g. measures to increase flood resilience, ventilation and water efficiency.
- Extreme events may result in costly damage, therefore it is important to retrofit existing buildings where possible to minimise vulnerability. It is equally important to ensure new build incorporates climate change 'resistant' features.
- Planning policies must influence location and design of new buildings, to minimise vulnerability to climate change.
- Adaptation of the service area of Parks and Estate Management to climate change will place a significant cost burden on local authorities.

4.10. Some of the most extensive potential impacts of climate change are likely to be on planning, buildings and estates. Buildings and estates are designed to be operational over a long time period, so knowledge of future climatic conditions is essential. Adapting to, and designing for, climate change is very important for managers, as this infrastructure will need to function under a new climate. A key consideration for managers when planning for climate change should be the fact that taking action now to adapt new buildings will minimise the need for costly retrofitting in the future.

4.11. **Table 4.3** sets out potential impacts for local authority owned properties other than housing. The considerations and responses covered here are relevant to asset managers, managers of particular facilities e.g. schools, those with responsibility for maintenance and improvement and those commissioning new buildings.

Case study: Sustainable building techniques: The Brancaster Millennium Activity Centre

The National trust is promoting sustainable building design and construction techniques such as the use of materials and layout of electrics and services that are resistant to flooding and enable quick recovery such as at the Brancaster Millennium Activity Centre in North Norfolk.

The National Trust: Guidance on flooding, rivers and floodplain management. December 2000. Peter Nixon, Director of Estates.

4.12. The physical impacts on buildings and requisite response and the design criteria for new buildings described in Table 4.3 are relevant to all types of buildings and can be translated across to housing (covered in the **Table 4.4**).

Case study: Imaginative solutions for cooler buildings

There are significant opportunities for improving the design of new buildings so that they can cope more effectively with very hot summer weather. This includes the use of natural ventilation, heat exchanges with cooler water below ground or in waterways, and use of chillers connected to energy-efficient combined heat and power systems. For example, the new GLA building in London uses a borehole groundwater cooling system. Renewable energy sources to power cooling systems could also be employed, including photovoltaic cladding on high quality buildings.

London's Warming: the Impacts of Climate Change on London: Summary Report, 2002. Commissioned by the London Climate Change Partnership.

4.13. Table 4.4 'housing' shows that there will be some potential benefits of climate change including lower heating requirements – this will impact on issues such as fuel poverty. The issue of how climate change impacts may constrain the location of new housing is also addressed.

Case study: Costs of adapting residential buildings to climate change

A study into potential UK adaptation strategies for climate change estimates the cost of meeting new building specifications that adapt residential buildings to climate change over the next 30 years to be in the range of £2,200 million to £15,400 million.

Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

Case study: The Star Yard Project - a sustainable home

The Star Yard Project is a new two storey wooden family house in East Anglia containing features to address regional climate change impacts and other ecological issues. Climate change features include:

- Cross ventilation, high envelope insulation, sunscreens and rain check layers for warmer, drier, summers and milder, wetter winters;
- Quick response breathing walls and rain protection openings to handle increased fluctuation in temperature and more erratic weather shifts;
- Appropriate foundation design for the altered water table;
- Stronger roofing, more flexible post and beam build, rapid rain dispersal, wind driven rain screen and raised building design for increased frequency of extreme events and stronger, more frequent winds with more violent precipitation.

Phase 1 construction costs are estimated at £512/m2, which falls within the £425 - £605/m2 range of construction costs estimated by the Royal Institute of Building Surveyors for a conventional building.

Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

4.14. The management of parks and estates belonging to local authorities (**Table 4.5**) will share some common themes with those listed under 'natural environment' (see later section) – these include the lengthening growing season and the impacts of drier, hotter summers and wetter, warmer winters on vegetation and particularly trees. Warmer temperatures are likely to lead to a more outdoor lifestyle putting greater demands on our green open spaces.

4.15. While the overall potential impacts of climate change on social services are likely to be limited, there are some key issues related to emergency planning and the care of people, particularly the elderly that are less able to cope with extreme heat, covered in **Table 4.6**. There are likely to be impacts on social services buildings and these are covered **Table 4.3**.

Case study: The costs of subsidence

Over the past 30 years, subsidence claims following summer droughts have been increasing steadily, accounting for a staggering £3.3 billion of insurance claims over the 1990s.

Climate change and local communities - How prepared are you? An adaptation guide for local authorities in the UK. 2003, UKCIP, I&DEA, LGA, COSLA and WLGA

Case study: Climate-proofing new buildings against subsidence

According to a recent study, climate-proofing new buildings in southern England against subsidence may only cost £32 million, compared to a possible annual cost of £200-400 million from damage claims if no action is taken.

Climate change and local communities - How prepared are you? An adaptation guide for local authorities in the UK. 2003, UKCIP, I&DEA, LGA, COSLA and WLGA.

Case study: Health implications of vulnerable structures

In the October 1987 and January/February 1990 storms, a total of 99 deaths were reported; building failures led to 13 deaths.

The predicted increase in the frequency of severe gales is likely to be associated with significant damage to buildings. Personal injury from flying debris is likely to increase. The need for a review of building regulations for roofs and other vulnerable structures is clear; with adequate planning many injuries and deaths might be prevented.

Health Effects of Climate Change in the UK, 2002. Department of Health.

Table 4.3: Property Services and Corporate Engineering (including Education and Social Service properties)

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	More frequent extreme weather events and in particular fluvial and groundwater flooding will add to costs resulting from damage to buildings.	Prepare for the potential impact of flooding and other extreme weather events on properties	• Train key staff on adaptation of buildings to climate change (NB this adaptation measure will help to address all the impacts on this service area).	Act now	• Building Research Establishment (BRE)
			• Work with the Environment Agency to identify, catalogue and prioritise all Council owned properties in areas at risk from extreme weather events.	Act now	• Environment Agency
			• Develop contingency plans and procedures for Council owned properties in areas vulnerable to flooding including: • Emergency warning procedures to property users • Provision of short-term measures/equipment to prevent flood waters entering properties • Recommendations for safeguarding Council owned assets within buildings • Evacuation or appropriate procedures for property users	Act Now	
			• Develop a prioritised programme of adaptation of Council owned properties in flood risk areas to make them more resilient to flood damage. This should include taking up opportunities created by major repairs and refurbishment.	Plan for the future	
			• Ensure that the design and siting of new Council buildings does not exacerbate flood risk and incorporates Sustainable Urban Drainage Systems (SUDS) where	Act now	

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
			appropriate. Include soft engineering solutions to reduce risks of damage during flooding e.g. woodland to increase water holding capacity of land		
	Greater frequency of intense rainfall and storms leading to water penetration and damage to the building fabric. This may caused damp, condensation and mould problems.	Adapt properties to the increasing frequency of intense rainfall and high winds	• Develop enhanced specifications for all new build and major repairs, improvements (particularly for roofs) to all Council properties to strengthen structures and prevent rain penetration and damage by high winds. Replace flat roofs with pitched roofs where possible. • Manage the internal environment.	Act now	• BRE • Construction Industry Research and Information Association (CIRIA)
	Temperature rise (decline in heating degree-days, increase in cooling degree-days) resulting in lower heating bills but increased demand for cooling and ventilation. Increased frequency of very warm days that may exceed the capacity of current building systems to maintain a comfortable internal temperature Fewer frosty days will mean fewer days lost during construction and maintenance	Adapt properties to the potential impact of higher temperatures	• Develop a prioritised programme to improve ventilation, cooling and shading in Council owned properties This should include taking up opportunities created by major repairs and refurbishment. There may be opportunities to use advanced technologies e.g. absorption chillers or to develop or link to district cooling networks. Other measures may include recessed windows, roof overhangs and shades. • Develop enhanced specifications for ventilation, cooling and shading in all new building commissioned by the Council.	Plan for the future Act now	• BRE • CIRIA
	The increasing frequency of drought will mean that measures to reduce water consumption will need to taken to conserve water resources.	Adapt existing properties and ensure all new properties conserve water resources	• Develop specifications for refurbishment of existing buildings and for new buildings that include water conservation measures such as dual flush toilets, reuse of grey water and collection and use of rainwater.	Act now	• BRE • CIRIA

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
			• Develop a programme to retrofit water conservation measures in existing building stock especially schools.	Plan for the future	
Coastal **Fens** **Thames Gateway**	In these climate change sub-regions, sea level rise and the increasing frequency of coastal flooding and storm surges, will present additional threats to property.	Prepare for the additional impacts of sea level rise, coastal flooding and storm surges on property	• Work with other stakeholders to develop and implement a management plan to reduce risks and potential damage to council owned properties in coastal areas giving consideration to the options of: • 'holding the line' • 'do nothing' • 'managed retreat' and relocation of services.	Plan for the future	• Environment Agency
Southern Heartland **Thames Gateway**	In these climate change sub-regions subsidence will be a risk. The increasing frequency of droughts will result in changes in soil moisture content, which on clay soils will cause subsidence.	Adapt properties to the potential impact of subsidence	• Put in place procedures for short-term measures to counter subsidence in at risk areas in extremely hot weather e.g. watering the foundations. • Carry out inspections, to ensure foundations are resilient.	Act now	
			• Develop a prioritised programme of adaptation of Council owned properties at risk from subsidence. This should include taking up opportunities created by major repairs and refurbishment	Plan for the future	
			• Develop enhanced specifications for the foundations of all new Council commissioned buildings to be built in areas where soil types and ground conditions might result in subsidence.	Act now	• BRE • CIRIA

Table 4.4: Housing*

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	More frequent extreme weather events and in particular fluvial and groundwater flooding, may threaten housing and reduce the options for siting of new housing on flood plains.	Plan for increasing flood risk to housing	• Put in place local planning policies (following PPG 25) that constrain the development of housing in flood plains and in areas at risk from flooding.	Plan for the future	
	Milder winters will reduce requirements for heating but greater attention will need to be given to cooling.	Adapt the housing stock to the impacts of climate change	• Ensure that maintenance and improvement programmes for the council housing stock take account of climate change impacts. This should include taking advantage of opportunities created by major repairs and refurbishment. Measures might include planting to create shade, adding canopies to provide shade, incorporating balconies and other external spaces passive cooling, rainwater and greywater recycling and improving insulation.	Plan for the future	
			• Provide information to private householders, that includes, advice on how to make their homes more resilient to climate change impacts. Include improving resilience to climate change impacts as a factor in local authority support to private householders.	Plan for the future	
			• Put in place local planning policies that encourage good design that takes account of the need for resilience to climate change impacts and the need to conserve water in all new housing. Policies might encourage high levels of insulation, passive solar design with	Act now	

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
			passive cooling, landscaping and planting that provides shade, incorporation of rain and grey water recycling.		
Coastal Fens	Sea level rise and more frequent extreme weather events such as coastal flooding and storm surges may threaten housing in some coastal settlements and reduce the options for siting of new housing.	Plan for the long-term impacts of sea level rise and coastal erosion and the increasing risks of coastal flooding and damage from storm surges on housing in coastal settlements	• Undertake a study of the potential long-term risks to housing from climate change and in particular from sea level rise and coastal erosion. Within Coastal Zone Management Plans ensure that there is full consideration of the implications for housing of: • 'holding the line' • 'do nothing' • 'managed retreat' and relocation of housing. • Put in place local planning policies that prevent the development of housing in areas at risk from sea level rise, coastal erosion and coastal flooding.	Act now Act now	• Environment Agency • Other social housing providers
Thames Gateway	Sea level rise, coastal flooding and storm surges will also impact on this sub-region. However a different response may be necessary here given the central government decision to direct major housing development to this area.	Ensure that developers contribute to the costs of flood and coastal defences Ensure new housing development in flood risk areas is adapted to flooding	• Put in place planning policies and utilise planning agreements to ensure developers contribute to the costs of flood and coastal defences. • Put in place planning policies and design guidelines to ensure new housing is adapted to flooding.	Act now Act now	

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
Southern Heartland and Thames Gateway	The location of new housing could also have significant impacts on water resources particularly as there is a likelihood of more frequent droughts in summer. Water resources are already constrained in these two climate change sub-regions.	Conserve and ration water resources	• Work with water companies to determine those areas where water supply will be constrained. Put in place local planning policies that restrict new housing development where they place unsustainable demand for water resources.	Act now	
			• Take action to ensure new homes incorporate measures to achieve water efficiency through promoting demand management measures and through working with relevant bodies to ensure climate change is incorporated into standards e.g. Building Regulations and Planning Policy Guidance.	Plan for the future	• Environment Agency (Anglian and Thames regions) • Water companies
		Maximise supply of water using novel solutions	• Work with water companies to bring forward new solutions to water supply e.g. desalinisation plants.	Plan for the future	

*For specific risks to buildings and adaptation responses see Property Services section above

Table 4.5: Parks and estate management

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Lengthened growing season, and need to irrigate in dry summers will result in significant rise in costs for bowling greens and other grass-surfaced leisure surfaces. Warmer summers will also place increased pressures on, and demand for, parks and open spaces.	Respond appropriately to the impact of lengthened growing season, drier summers and other climate change impacts	• Ensure that the allocation of resources to grounds maintenance programmes take account of the lengthening growing season e.g. cutting of lawns over a longer period each year (NB where parks and estates generate income from produce, longer growing seasons will increase income and provide benefits for local employment).	Act now	
	Some tree species will be under considerable pressure as a result of various climate impacts. Water logging of roots during some parts of the year and then drought in summer may cause the death of some species although others may thrive.		• Plan for and implement a gradual change to more drought resistant planting to cope with the increasing frequency of warm dry summers and droughts. In particular prepare a long-term plan for the replacement of trees killed by climatic effects, using those species better adapted to changing conditions	Plan for the future	• Wildlife Trusts • Woodland Trusts • Community Forests
			• Historical planting schemes, which were designed for tolerance to a colder climate, may become unviable in the future. Plan for and implement a gradual change to planting which is better suited to warmer climates.	Plan for the future	• Wildlife Trusts • Woodland Trusts • Community Forests
			• Creating well-shaded green spaces, particularly in urban areas will be necessary to maintain the quality of the environment in the face of increasing temperatures and more very hot days.	Plan for the future	

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
	Climate change will impact on the natural environment, for example leading to a change in climate space for species and natural migratory tendencies.		• Plan for wildlife corridors to allow natural migration.		
	Milder winters will result in the persistence of turf diseases.		• Further research is required to determine the impacts of climate change on this issue in order to determine appropriate actions.	Keep a 'watching brief'	
	Warmer summers and milder winters could lead to increased growth of noxious weeds.		• Monitor growth and ensure time and monetary resources are allocated to responding to increased growth of weeds.	Plan for the future/Keep a 'watching brief'	• Wildlife Trusts and other conservation organisations.
	Increased fluvial flood risk throughout region.	Design and manage council parks, estates and open spaces to reduce flood risk	• Where possible, when renewing or creating hard surfaced areas (car parks, sports courts etc.) specify permeable surfaces to reduce water runoff during intense rainfall.	Act now	
			• In areas at risk from flooding, consider the maintenance and use of sports fields, other green spaces and particularly woodlands as areas to absorb floodwaters.	Planning for the future	• Users of sports fields/ green spaces
	Damage resulting from extreme weather could also add to costs.		• Make provision for 'liabilities' resulting from falling trees / branches causing damage or injury.	Act now	
Coastal **Fens** **Thames Gateway**	Sea level rise and the increasing frequency of storm surges and coastal flooding will impact on parks and estates on the coast.		• Work with other stakeholders to develop and implement a management plan to reduce risks and potential damage to council managed parks and estates in coastal areas giving consideration to the options of:	Plan for the future	• Users of parks and estates

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
			• 'holding the line' • 'do nothing' • 'managed retreat'.		

Table 4.6: Social Services

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Overall impact limited. However, extreme weather events may result in an increased number of emergencies. Increased number of extremely hot days may place additional burdens on services for older people as a result of increased incidence of heat stress.	Address the resource implications of increased number of emergencies	• Integrate social service impacts into emergency planning considerations and ensure that adequate resources are allocated to social services to deal with their role in emergency procedures.	Act now	• Emergency Planning / emergency services
		Reduce the risks of heat stress for older people while in council care.	• Review cooling and heating systems in buildings catering for older people and particularly the ability to provide healthy internal temperatures on extremely warm days. Develop and implement plans to adapt buildings where necessary.	Plan for the future	• Health services
	Higher risk of skin cancer/sun burn due to hotter summers and increased outdoor recreation.	Reduce the risks of skin cancer	• Consider ways to increase awareness of dangers of exposure.	Plan for the future	• Health services
			• Provide more shade in public areas.	Act now	• Local authority Planning services

EMERGENCIES

Key issues for adaptation
• Flooding and storm surges are the most likely type of events that will require an emergency response. These events will place significantly higher demands on emergency services. • It is vital that effective emergency planning takes place and receives appropriate resources. This will place a significant cost burden on local authorities. However, failure to act could lead to higher than necessary damage to property with associated costs and could also pose a risk to human safety and health.

4.16. The impacts of climate change are already with us, with an increasing frequency of extreme weather events. Intense rainfall leading to flooding and storm surges, leading to coastal flooding, are two of the most likely type of events that will require an emergency response.

4.17. Since the 2000 floods there has been a national effort to improve the effectiveness of the emergency response. For example, the Environment Agency and local authorities are already working together with emergency services to undertake emergency exercises and prepare emergency plans as required through the 'Flood and coastal defence High Level Targets' developed by Defra[20]. Target 3 'Emergency exercises and emergency plans' formalises this requirement. In the future we are likely to have to deal with more events of this scale. The likelihood of both a longer duration and a wider geographical impact of extreme weather events mean that there needs to be better co-ordination of response but also greater local self-sufficiency.

4.18. **Table 4.7** sets out adaptation measures in relation to emergency planning, and **Table 4.8** sets out measures for the police and fire services.

4.19. Flood risk management and flood and coastal defence measures, which are referred to here and which have a great impact on emergency planning, are covered comprehensively in Section 5 of this report (Water services). The need for a co-ordinated approach by local authorities to flood risk management and flood and coastal defence measures is discussed later in this section (under Wider Co-ordination).

[20] Defra Flood and coastal defence High Level Targets were published in 1999 in response to concern that mechanisms were not in place to ensure that policy and approach were delivered by the operating authorities 'on the ground'. There are 14 targets, discussed further in Section 5 of this report.

Case study: The costs of flood events

The Association of British Insurers' (ABI) estimates that around one million properties are potentially at risk of flooding with a total insured value of £35bn. Further scenario-building suggested that losses of between £1bn and £2bn could be expected in the future. The week after the report was published storms (in 2000) causing the worst inland floods since the 1940's resulted in losses over £1bn in the UK.

Summarised from Association of British Insurers. General Insurance Research Report No.10: Inland Flood Risk - Issues Facing the Insurance Industry, 2000.

Table 4.7: Emergency Planning

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	There are likely to be significant increase in costs and demand for services as a result of extreme weather events and in particular groundwater and fluvial flooding. But other risks also need to be taken into account such as periods of extreme drought/ forest fires and storms	Reduce risks of loss of life during extreme weather events and be able to respond to increasing frequency of emergencies resulting from climate change	• Ensure that the allocation of resources for emergency planning match the changing level of risk associated with climate change.	Act now	• National government • Regional Assembly • Defra • Environment Agency
			• Ensure emergency equipment is updated to meet increased risk.	Act now	
			• Update the existing emergency plans to respond to increasing frequency and extent of extreme weather events and flooding.	Act now	• Defra • Environment Agency
			• Ensure that emergency control rooms are not at risk from flooding.	Plan for the future	
			• Carry out emergency planning exercises to practice and test procedures for evacuation of areas subject to flooding and storm events. Review plans in the light of experience gained during exercises.	Act now	• Defra • Environment Agency
	Future extreme weather events could be extended in time and the geographic area that is affected – requiring a co-ordinated response over a wide area and a greater degree of local self-sufficiency.	Improve regional and national co-ordination of emergency planning Marshal local	• Participate in regional and national planning and training for emergency response teams. Co-ordinate acquisition of specialist equipment and stockpiling of resources e.g. sandbags at a regional level.	Act now	

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
		resources and expertise to respond to emergencies Encourage self-help measures	• Parish Council can compile lists of 'emergency helpers' (e.g. medics, building contractors) and resources (e.g. owners of generators, boat owners). • The insurance industry has a role in encouraging their clients to purchase temporary flood defence equipment by offering lower premiums.	Act now Plan for the future	
Coastal **Fens** **Thames Gateway**	In addition be prepared for emergencies resulting from the increasing risk of storm surges and coastal flooding.	Reduce risks of loss of life during extreme weather events and be able to respond to increasing frequency of emergencies resulting from climate change	• As above and in particular, work with owners of caravan sites and holiday chalets to develop evacuation procedures in the event of emergencies.	Act now	• Defra • Environment Agency

Table 4.8: Police and Fire Service

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Extra costs due to dealing with the consequences of extreme weather events such as flooding and longer drier summers which may result in more frequent forest fires.	Prepare for the impact of increased frequency of flooding and other extreme weather events	• Work with other emergency services through the emergency planning process to take on board climate change concerns and consider the financial implications of changing weather patterns. A particular emphasis needs to be placed on the risks posed by widespread flooding.	Act now	

THE ECONOMY, LEISURE AND TOURISM

Key issues for adaptation

- Climate change will affect economic development and leisure and tourism in the East of England.
- Strategic economic development plans/strategies must respond to new opportunities created by climate change e.g. for tourism.
- Sea level rise and storm surges could constrain economic development in coastal areas. Local authorities must work with others to respond to these threats.
- Economic development in the Thames Gateway is being promoted through the central government decision to direct development to this area. This will require a response to ensure new business development contributes to flood risk management and adapts to flood risk as far as possible.

4.20. There are likely to be new opportunities and new risks for the economy associated with climate change impacts – both need to be addressed in economic development plans. Economic development in some parts of the region will be constrained in terms of location or requirements for (and additional costs of) climate resilient buildings. Local authority economic development sections, working with the RDA and others will have a key role in advising businesses on the opportunities and risks. **Table 4.9** sets out possible adaptation responses in relation to economic development and regeneration.

4.21. Climate change impacts are very likely to result in some positive benefits for leisure and tourism. A warmer climate and drier summers will lead to a more outdoor lifestyle and greater demand for outdoor leisure facilities. The benefits for the region’s coastal holiday resorts will however be tempered by the increasing risks posed by rising sea levels and increasing frequency of storm surges and coastal flooding. **Table 4.10** sets out possible adaptation responses in relation to this economic sector.

4.22. Section 5 provides guidance on adaptation measures for key business sectors (as per the East of England Development Agency’s Regional Economic Strategy). It also provides generic guidance relevant to all business domains, which will also help to formulate local authority climate change responses to inform economic development plans and to advise businesses.

Case study: Water quality in swimming pools

Climate change may lead to a need for increased attention to be paid to the quality of water in swimming pools.

Health Effects of Climate Change in the UK, 2002. Department of Health.

Table 4.9: Economic Development and Regeneration

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	New opportunities created by warmer, drier summers may increase demand for tourism and leisure services, but areas vulnerable to fluvial and groundwater flood risk will constrain development. Civil engineering companies and others in the environmental field could benefit from demand for climate change related technology. For example, technologies to reduce the impacts of climate change and adapt to climate change, for example flood control, cleaner technologies and low carbon products.	Respond to the opportunities created by the changing climate and the pressures that growth in demand for services will put on infrastructure Plan the response to the increased risks posed by climate change impacts on economic development	• Carry out Sustainability Appraisal/SEA of spatial and economic strategies and plans to ensure that current and longer-term climate change risks are taken into account in decisions about the location of economic development. • Work with other partners including the RDA to ensure that strategic economic development plans/strategies, take account of risks and new opportunities resulting from climate change impacts. • Work with other partners to put in place land use planning policies that address the climate change impacts on economic development.	Plan for the future Plan for the future Plan for the future	• Business networks • RDA • GO-East • Government Departments • Other local authorities, • RDA, • Regional Assembly • Business networks

Coastal
Fens
	Sea level rise and the increasing frequency of storm surges and coastal flooding will be a constraint on economic development in these sub-regions.
	
	Opportunities will be created for civil engineering companies involved in coastal defences.
		Plan the response to the increased risks posed by climate change impacts on economic development and respond to opportunities.	• Work with stakeholders to develop and implement strategies (within coastal zone management plans etc.) that detail appropriate responses to the threat posed by sea level rise. This includes consideration of options such as:
			  • 'holding the line' and seeking contributions from businesses for flood protection measures where appropriate.
			  • 'do nothing'
			  • 'managed retreat' and relocation of key businesses and communities.
				Act now/ plan for the future	• Businesses

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
Thames Gateway	Sea level rise, coastal flooding and storm surges will also impact on this sub-region. However a different response may be necessary here, given the central government decision to direct development to this area.	Ensure that developers contribute to the costs of flood and coastal defences Ensure new business development in flood risk areas is adapted to flooding	• Put in place planning policies and utilise planning agreements to ensure developers contribute to the costs of flood and coastal defences where appropriate. • Put in place planning policies and design guidelines to ensure new business development is adapted to flood risk, as far as possible.	Act now Plan for the future	• Building developers • House Builders Federation • Building developers • House Builders Federation

Table 4.10: Leisure and Tourism (including leisure centres and swimming pools)

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Warmer, drier summers could result in a significant boost to and changes in focus for tourism and demand for outdoor leisure facilities. This is also likely to be over an extended season.	Plan to maximise the opportunities for tourism and the leisure industry resulting from a warming climate and drier summers	• Commission research into the likely benefits and threats resulting from climate change impacts on tourism and leisure	Act now	• RDA • Tourist Board • Tourism industry
			• Review Tourism Strategies to ensure they take account of climate change impacts	Act now	• RDA • Tourist Board • Tourism industry
			• Review future provision of and funding for council owned leisure facilities to ensure that warming climate and drier summers and likely increased demand for outdoor leisure pursuits are taken into account.	Act now	
			• Work with stakeholders and the tourism industry to produce relevant information on the likely impact of climate change for tourism businesses.	Plan for the future	• Tourism industry
Coastal **Fens** **Thames Gateway**	Sea level rise and coastal erosion will have particularly adverse effects on coastal holiday resorts in the long-term. In the shorter-term they also face increasing levels of risk from coastal flooding and storm surges.	Plan to reduce the adverse impacts of climate change and particularly sea level rise and coastal erosion on tourism and leisure facilities in coastal resorts	• Work with stakeholders to develop and implement strategies (within Coastal Zone Management Plans etc.) that detail appropriate responses to the threat posed by sea level rise. This should include consideration of options such as: • 'holding the line' • 'do nothing' • 'managed retreat' and relocation of facilities	Plan for the future	• Tourism industry
		Reduce risks to holiday makers	• Consider placing restrictions on the use of holiday accommodation and caravans	Act now	• Tourism industry

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
		and visitors from coastal flooding and storm surges	during the winter in areas at risk of coastal flooding and storm surges through planning conditions and licensing.		• Caravan park owners

WASTE AND POLLUTION

Key issues for adaptation

- The impact of climate change is likely to be marginal on waste collection, disposal and recycling. But local authorities must ensure that waste contractors take into account the impacts of climate change – in particular warmer temperatures and increased risk of flooding – in the design and management of waste facilities.
- Climate change has implications for pollution control and monitoring – local authorities must consider appropriate responses in relation to air pollution through Air Quality Management Strategies, and should seek to reduce air pollution from motorised transport.
- Responding to impacts on watercourses and groundwaters requires close working with other partners, such as the Environment Agency.
- Environmental health services may be affected. At this stage the impacts are not certain, but local authorities should review policy and keep a 'watching brief' in order to respond appropriately.

4.23. Climate change is likely to make some chemical processes more active through warmer temperatures and pollutants more mobile because of more frequent intense rainfall.

4.24. This will mean greater care will be required in dealing with waste and particularly organic wastes, including prompt and more frequent collections and better design of waste management facilities. It provides another reason for minimising these wastes. Guidance on adaptation measures in relation to waste management is set out in **Table 4.11**.

4.25. Climate change is likely to exacerbate air pollution problems resulting from traffic and congestion, increasing the need to restrain the use of motorised transport and particularly private cars. There are also considerable pollution problems associated with flooding, the frequency of which is likely to increase with climate change (**Table 4.12**).

4.26. Pests and some diseases are also likely to become more active in the warming climate increasing public health risks. Potential adaptation measures for environmental health are set out in **Table 4.13**.

Case study: Increases in food poisoning

Food poisoning is associated with warm weather. The predicted increase in UK temperatures is likely to be accompanied by an increase in cases of food poisoning by anything between 4000 and 14,000 extra cases. This significant effect might be largely prevented by improvements in food storage, preparation and hygiene close to the point of consumption.

Health Effects of Climate Change in the UK, 2002. Department of Health.

Table 4.11: Waste Disposal, Collection and Recycling

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Impact of climate change on the service likely to be marginal overall. Some impacts resulting from increasing temperature and increasing frequency of extremely hot days on handling and disposal of putrescible materials, e.g. odour and vermin control.	Minimise health and pollution risks associated with waste and waste management facilities resulting from climate change impacts	• Ensure that waste contractors take into account the impact of general warming and the increased frequency of extremely hot days in the design and management of waste sites, civic amenity sites etc. with particular reference to putrescible materials and vermin control. The Environment Agency could address these issues in licenses. • Consider the need for more frequent collections of some kinds of wastes and the need for more frequent street cleaning.	Act now	• Waste contractors • Environment Agency •
	Increasing frequency of intense rainfall could increase leaching at landfills.	Minimise health and pollution risks associated with waste and waste management facilities resulting from climate change impacts	• Ensure waste contractors consider the increased risk of flooding (and where appropriate sea level rise) within Environmental Impact Assessments for new waste management facilities, especially landfill sites. • Ensure allocation of sites for waste management facilities in Local Waste Plans take account of flood risk, especially of landfill sites.	Act now Plan for the future	• Waste contractors • Environment Agency

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
			• Existing waste management sites should, where appropriate, incorporate flood risk management to prevent pollution, especially of landfill sites.	Plan for the future	

Table 4.12: Pollution control and monitoring

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Increased summer temperatures and extremely hot days will exacerbate air pollution.	Reduce the risk of increased air pollution resulting from climate change impacts	• Model potential increases in the main air pollutants under the climate change scenarios envisaged. Liaise with the Environment Agency. Take into account when designating Air Quality Management Area's.	Plan for the future	• Environment Agency
			• Integrate climate change considerations into existing Air Quality Management strategies.	Plan for the future	
			• Employ Transport Plans and Section 106 agreements to ensure the adoption of Travel to Work Plans to reduce air pollution from motorised transport.	Act Now	
	Flooding can result in contamination of watercourses and mobilisation of contaminants.	Reduce the risk of water contamination resulting from flooding	• Work with other stakeholders to promote SUDS where appropriate	Act now	• Developers • Construction industry • Environment Agency
			• Work with Environment Agency and other stakeholders to reduce risk of pollution during flooding through River Basin Management Plans.		• Environment Agency
	Reduced flow in other watercourses could also increase concentration of contaminants to unacceptable levels and result in eutrophication / algal blooms in water.	Maintain acceptable levels of water quality in rivers and watercourses	• Work with the Environment Agency and farmers to reduce agricultural run off and improve storage of slurry. • Work with the Environment Agency to control polluting discharges to watercourses and groundwaters.	Act now	• Environment Agency • Farmers and land managers • Industrial companies

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
	Warmer temperatures and intense rainfall associated with climate change could mobilise pollutants on contaminated land	Control release of pollutants from contaminated land	• Build climate change impacts into contaminated land strategies. • Ensure developers take into account climate change impacts in devising approaches to dealing with contaminated sites.	Plan for the future Pan for the future	• Environment Agency • Developers

Table 4.13: Environmental Health

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Warmer summers and very hot days could result in increased problems with vermin and food poisoning.	Reduce the risks to public health resulting from the impacts of climate change.	• Undertake a review of environmental health policy to determine where there is a need for changes to current practice such as the level of inspection of food processing plants, restaurants and other premises serving food, etc.	Plan for the future	• Health service
	Flooding can result in foul sewage being released into the environment causing health risks.		• Undertake a review of environmental health policy to determine where there is a need for changes to current practice such as clear up after flooding.	Plan for the future	• Environment Agency
Fens, Coast and Thames Gateway	In the longer-term diseases such as malaria may become a public health problem. The areas most at risk are those adjacent to salt marshes.		• Work with health services to monitor incidence of malaria.	Keep a 'watching brief'	• Health service

THE WIDER ENVIRONMENT

Key issues for adaptation

- Climate change poses significant challenges for conservation of the natural environment. Local authorities (and all parties involved) must recognise the dynamic processes being driven by climate change and respond to these when drawing up strategies and when managing sites.
- Historic buildings are particularly susceptible to the impacts of climate change e.g. from subsidence, penetration by heavy rain and damage from flooding and extreme weather events. Local authorities must work with others to identify threats and develop and implement strategies for protection.

4.27. Both the natural and historic environment will face some severe challenges from climate change. The traditional approach of conserving designated sites will not always be a practical option.

Case study: Costs of recreating coastal habitats

A study into potential UK adaptation strategies for climate change estimates the cost of safeguarding nature conservation objectives by re-creation of all designated habitats in coastal areas to be in the range of £160 million to £1.400 million.

Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

4.28. Adaptation responses for the natural environment will need to recognise the dynamic processes that are being driven by the changing climate. Providing space to adapt, stepping stones for species to migrate and realising the opportunities for the creation of new habitats, as others are lost, will be some of the approaches that need to be considered (as set out in **Table 4.14**).

4.29. Impacts on historic buildings are likely to be more severe than on more modern buildings. The many coastal sites in the region are likely to present the biggest challenges. Potential adaptation measures in relation to the historic environment are set out in **Table 4.15**.

4.30. Local authorities will need to work closely with the statutory agencies to devise appropriate strategies and programmes for adaptation.

4.31. Section 5 sets out adaptation responses, in relation to nature conservation and the historic and archaeological environment, aimed at heritage and habitat management and protection service providers, such as English Heritage, the National Trust, English Nature and the Wildlife Trusts. This guidance (**Tables 5.10 and 5.11**) will also help to inform local authorities' responses and deepen understanding of the need for co-ordinated responses.

Table 4.14: Conserving the natural environment

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	The philosophy of conserving designated sites as the way of conserving habitats and species is likely to be significantly challenged by a number of climate change impacts including warmer, drier summers and other variables. Habitats will be lost or significantly altered as a result of climate change impacts. There will also be opportunities to recreate/create some habitats.	Adapt nature conservation policy and practice to the challenges created by climate change	• Review Biodiversity Action Plans, Development Plans, Landscape and Land Management Strategies to ensure all potential climate change impacts on the natural environment are taken into account. Adopt adaptation measures that recognise the dynamic nature of climate change processes.	Plan for the future	• Wildlife Trusts • Conservation groups • Landowners
			• Evaluate the increase in areas around designated sites to increase connectivity of habitat to allow natural migration	Plan for the future	• Environment Agency
			• Participate in specific initiatives for integrated land and habitat management.	Act now	
		Plan for the long-term conservation of species and their habitats over wide geographic areas.	• Use the county level biodiversity records services to monitor climate change impacts (following the example of Hampshire).	Act now	
			• Educate the general public about the dynamic processes involved in adapting to climate change.	Act now	• The public
Coastal **Fens** **Thames Gateway**	The impacts of climate change on the natural environment are likely to be most dramatic in coastal areas with some habitats being lost and new habitats being created as result of sea level rise and coastal erosion.	Plan for the adaptation of coastal habitats to climate change impacts	• Assess the impacts of sea level rise and the design of sea defences on coastal habitats and the options for protection, relocation or abandonment of some areas or creation of new habitats e.g. salt marshes, coastal grazing marshes.	Plan for the future	• Wildlife Trusts • Conservation groups • Farmers and land managers

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
			• Implement measures for habitat management through Integrated Coastal Zone Management Plans.	Plan for the future	• Environment Agency • Other stakeholders involved in preparation of Coastal Zone Management Plans (CZMPs)

Table 4.15: Historic environment

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	The costs of conserving historic buildings, structures and sites are likely to increase with subsidence caused by drier summers, penetration by heavy rain and potential damage resulting from flooding and extreme weather events. Warmer temperatures will also increase risks of damage by pests.	Alleviate the impacts of climate change on the historic environment	• Work with English Heritage, the National Trust and other stakeholders to survey the elements of the historic environment that are or will be at risk from climate change impacts and develop and implement a strategy to conserve them. • See Table 5.11 provides more detailed advice on suggested actions for heritage management and protection.	Plan for the future	• English Heritage • The National Trust • Civic Society

Coastal
Fens
Thames Gateway
	The historic environment in coastal areas will face increasing risks of damage from changes in coastal processes.	Alleviate the impacts of climate change and particularly the processes of coastal change on built heritage and the historic environment	• Work with English Heritage, the National Trust and other stakeholders to assess and put in place programmes to mitigate the impacts on sites at risk from changes in coastal processes through actions such as:
			  • supporting English Heritage in collecting data and producing comprehensive records of sites that are likely to be lost
			  • In extreme circumstances considering moving particular building or structures of particularly high archaeological/heritage value.
				Act now	• English Heritage
					• The National Trust
					• Civic Society

WIDER CO-ORDINATION

Key issues for adaptation

- A co-ordinated response for flood prevention and coastal management is particularly important.

4.32. Throughout the guidance for local authorities reference has been made to the need for a co-ordinated response between local authorities, the statutory agencies, infrastructure providers and other stakeholders. Two areas where a co-ordinated response is particularly important are highlighted below:

Co-ordination of flood prevention (**Table 4.16**).

Co-ordination of coastal protection (**Table 4.17**).

Case study: Partnership working to reduce flood risk

Scottish Water has identified and analysed flooding mechanisms for over thirty clusters of property flooding. This analysis has highlighted the complex interdependency between the various types of infrastructure that either stores or moves stormwater, and has also demonstrated that responsible agencies and stakeholders must work together effectively to reduce flood risk to an acceptable level. Scottish water and Glasgow City Council are already working together towards integrated solutions and are sharing information from sewer models and river catchment studies.

Building knowledge for a changing climate. The impacts of climate change on the built environment, 2003. UKCIP and EPSRC.

4.33. Section 5 of this report sets out in more detail who the key partners are in the provision of flood prevention and coastal management.

Case study: Costs of flood damage

A recent report suggests that if no allowance is made for climate change, damage from river flooding could increase by half and coastal flooding by four times, equating to an extra £1.1 billion in annual damages by 2075.

Climate change and local communities - How prepared are you? An adaptation guide for local authorities in the UK. 2003, UKCIP, I&DEA, LGA, COSLA and WLGA

Ipswich Borough Council Drainage and Flood Defence Policy - a proactive approach to flood risk

A number of features in the urban environment, such as increasingly dense house building, shared surface roads with very low kerbs, disabled access requirements with very low thresholds, coupled with climate change and rising sea levels, are leading to a need for much more drainage input into development control.

Ipswich Borough Council are responding to these pressures through the development of a

'Drainage and Flood Defence Policy'. The policy notes that without adequate measures being taken, many properties are likely to suffer flooding, which could place costly post-flood responsibilities on the Council. Ipswich Borough Council is therefore taking a pro-active approach, through for example, the promotion of Sustainable Urban Drainage Systems (SUDS) to help alleviate flood risk.

Summarised From the 'Ipswich Drainage and Flood Defence Policy', 2002. Ipswich Borough Council.

Table 4.16: Co-ordination of flood prevention

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	The response to the climate change impacts resulting in fluvial flooding will require co-ordination across local authority boundaries	A co-ordinated response to flood prevention	• Work with the statutory agencies and other local authorities to develop and implement co-ordinated strategic approaches to flood prevention through such mechanisms as: • Catchment Flood Management Plans • Integrated Catchment Management Plans • River Basin Management Plans. • Sharing of data and information systems.	Act now	• Environment Agency

Table 4.17: Co-ordination of coastal protection

Climate change sub-regions affected	Most significant likely climate change impacts on this service	Objective	Suggested Actions	Time Frame	Key Partners
Coastal **Fens** **Thames Gateway**	The response to sea level rise and coastal erosion resulting from climate change will require co-ordination across local authority boundaries	A co-ordinated response to coastal protection and management	• Work with the statutory agencies and other local authorities to develop and implement co-ordinated strategic approaches to coastal protection and management through such mechanisms as: • Flood and Coastal Defence Strategies • Shore Line Management Plans • Coastal Zone Management Plans. • Sharing of data and information systems.	Act now	• Environment Agency

5. ADAPTATION RESPONSES FOR OTHER AGENCIES' SERVICE PROVISION

5.1. This section of the guidance sets out possible adaptation responses for a range of other agencies and organisations. These include agencies and organisations involved in the following areas:

Water services (including water resources and supply, water quality, sewerage, flood risk management and flood and coastal defence).

Energy services (including gas and electricity supply).

Transport services (including road and rail networks).

Nature conservation.

The historic and archaeological environment.

Agriculture, fisheries, woodland and forestry.

Health services.

Economic sectors.

5.2. The guidance (presented in **Tables 5.1** to **5.15**) sets out the issues pertaining to each area of service provision and appropriate adaptation responses. Under each area of service provision the guidance specifies which sub-regions it is relevant to. Where 'all sub-regions' is indicated, this may be followed by several other specific sub-regions, which indicate where the guidance is *particularly* relevant.

5.3. Each suggested response is linked to a set of key partners who should be involved in taking the response forward and an indication is given of the timeframe for the suggested responses. Three categories of time frame are used (which are defined in Section 1 of this report):

Act now

Plan for the future

Keep a 'watching brief'.

5.4. Much of this section of the guidance builds on the specific guidance targeted at local authorities (Section 4) and will be very relevant to local authorities, particularly in identifying areas where co-ordination with other service providers is essential.

WATER SERVICES

> ***Key issues for adaptation***
>
> - Water availability is likely to be affected, particularly during the summer, requiring a range of demand and supply-side management measures.
> - An increased level of fluvial and coastal flood risk will require a range of responses building on existing initiatives, including effective flood warning systems, careful consideration of appropriate flood defence measures and a close dialogue with developers.
> - Water quality could be affected requiring a range of responses, from specific measures to modify water treatment plants and sewage systems, to wider measures to improve river basin management.

5.5. Temperature increases, changes in precipitation and increased climatic variability, will have implications for water resources and hence water service providers. Key areas of impact in relation to water services are the impacts of climate change on water availability and flood risk management. The following service areas are covered in this section of the guidance:

- Water resources and supply.
- Water quality.
- Sewerage.
- Flood risk management and flood and coastal defence.

Baseline conditions

Water resources and supply

5.6. In terms of water resource infrastructure, the East of England is served by an extensive public water supply system. The natural resources of the rivers and groundwater are supplemented by artificial storage in major reservoirs and transfers of various kinds, including transfers from outside the region. In addition to the large public supply reservoirs there are also many smaller farm storage reservoirs throughout the region. This network of storage and transfers has evolved in line with rising water demand over the last century[21].

[21] Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

5.7. A key consideration in determining the need for measures to deal with water availability and potentially the need for new infrastructure or demand management measures, is Environment Agency data at the regional strategic level on summer surface water availability and groundwater availability[22]. This shows that the south-eastern part of the region is already suffering from a lack of summer surface water resource availability i.e. summer surface water is already fully committed to existing abstractions and the environment. Licensed abstraction levels are considered to be unsustainable (i.e. the combination of licensed surface and/or groundwater abstractions exceed the assessed limit, beyond which environmental damage may occur. Action to resolve the problems may involve changes to both surface and/or groundwater licences in the longer term).

The remainder of the region has no additional summer surface water available (i.e. summer surface water is already fully committed to existing abstractions and the environment and no significant further resource is available, however, in most catchments existing abstractions do not cause widespread environmental problems). For most of the region further water service is available in principle. However storage reservoirs would be needed to make year round use of this water.

In terms of groundwater availability, the southeastern quarter again has an unsustainable abstraction regime. Much of the remainder of the region has no additional water available (i.e. groundwater resources are broadly in balance, but there is no significant further resource available, although existing abstractions do not cause widespread environmental problems). There are pockets where there is water available (however, any new or additional abstraction will be subject to local appraisal of need and impacts). This information will be reviewed in detail at the local level by the CAMS process over the next five years

Flood risk management and coastal defence

5.8. Parts of the region are already subject to flood risk, although, it should be noted that the indicative flood plain map produced by the Environment Agency does not take into account existing flood defences. The Fens are the largest contiguous area of fluvial floodplain, and many of the rivers flowing into the Fens have sizeable floodplains. The Internal Drainage Boards (IDBs) have a key role in managing the extensive low-lying areas of

[22] The Environment Agency has prepared a series of maps which provide an indication of present water resource availability, in terms of summer surface water and groundwater, which is based on an assessment of needs for environmental assets. This information is presented in the Environment Agency 25 year strategies for the Thames and Anglian regions – *Water resources for the future: A strategy for the Thames region March 2001* and *Water resources for the future: A strategy for the Anglian region March 2001*.

farmland in the area. There are also smaller areas of fluvial floodplain throughout the region, much of which is defended by fluvial flood defences. Parts of the coast and a large area inland from The Wash are subject to coastal flooding. Defra estimates that there are around 283,000 residential properties and 14,000 commercial properties at risk from fluvial or coastal flooding in the Anglian region, 305,000 ha of Grade 1 and 2 agricultural land at risk of fluvial flooding, and 54,000 ha at risk from coastal flooding[23].

5.9. Information on coastal defence policy is set out in Shoreline Management Plans (SMPs). SMPs are produced via a partnership of interests and set out strategic coastal defence measures. The coastline of the East of England is split into five sections, each with its own SMP. Defence decisions are broadly split into 'hold the line', 'managed retreat' and 'do-nothing', which are defined below. However, these plans will be reviewed shortly and will take account of new information on coastal processes, climate change/sea level rise and associated planning considerations. Therefore the decisions set out in the current plans may well change, and could be influenced by decisions made in relation to climate change.

Water quality

5.10. The Environment Agency measures both the chemical and biological quality of watercourses. The General Quality Assessment (GQA) scheme is used to assess the quality of rivers, to monitor trends over time and to compare rivers in different areas. The general chemistry component of the GQA is made up of six grades (A to F) defined by standards of dissolved oxygen, biochemical oxygen demand and total ammonia. Biological assessment is classified by six grades ranging from (a) to (f), with (a) being very good. This is based on monitoring invertebrates, which live on the riverbed.

5.11. When tested for chemical quality only a very small number of short stretches of the rivers and canals in the East of England were found to be grade F (Environment Agency database, 1998). The majority of rivers were classified as A, B or C, with especially high quality rivers found in Norfolk.

5.12. The biological assessment of river water quality provides a broad measure of pollution. While the majority of rivers in the East of England were classed as 'Very good' or 'Good', poorer water quality was identified around urban areas and below significant discharges. Two stretches of rivers and canals tested were classified as 'Bad', however over 80% of watercourses tested were (c) 'Fairly Good' or above.

[23] National appraisal of assets at risk from flooding and coastal erosion, including the potential impact of climate change. DEFRA, July 2001

Responsibilities for providing water services and adapting services to climate change

5.13. A number of stakeholders are involved in providing 'water services' and in order to make it clear who is involved, a summary of responsibilities is provided in Boxes 1-3 below.

Box 1: Water resources and water supply responsibilities

The Environment Agency has a duty to secure the proper use of water resources in England and Wales. It monitors water in the environment, and issues 'abstraction licences' to regulate who can take water from the environment. These specify the amount of water someone can take from a location over a period of time. They also have long term regional strategies for Water Resources that look 25 years ahead and consider the needs of both the environment and society. These strategies include sections on climate change, considering the potential impacts that climate change may have and necessary adaptation measures.

The Environment Agency oversees the planning of public water supplies through co-ordination with the water companies. For example:

- The water companies submitted water resources plans to the Environment Agency in 1999. These plans provided a clear picture of how the water companies planned to manage public water supply to 2025. Since then water companies have submitted annual reviews to the Agency, which the Agency monitors and uses to identify key issues to be kept under review. Water companies are now preparing new plans that will be submitted in April 2004, rolling forward plans to 2030.

- Water companies are required to agree a detailed, publicly available drought plan with the Environment Agency, (it will soon be a statutory requirement under the new Water Act) setting out the range of drought situations that may occur, and the range and sequence of actions a company would expect to take at different stages in a drought.

Case study: Water supply costs during the 1995 heat wave

The extremely hot summer of 1995 was about 3°C warmer than average with only a third of the average rainfall. This resulted in additional costs of water supply of about £280 million.

Climate change and local communities – How prepared are you? An adaptation guide for local authorities in the UK. 2003, UKCIP, I&DEA, LGA, COSLA and WLGA

Case study: Costs of delivering water supplies

A study into potential UK adaptation strategies for climate change estimates a range of costs for developing water supplies to meet a shortfall of between 5% and 20% in England and Wales by 2030, as follows:

- Conjunctive use schemes - £1,300 million to £ 44,500 million

- Bulk transfer - £5 million to £3,300 million
- Reservoir development - £30 million to £900 million
- Desalination - £40 million to £440 million

Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

Case study: National Trust water conservation measures

To combat the problem of pressure on water resources, the National Trust is committed to demand management, whilst also exploring rainwater harvesting, dirty water re-use, and the more productive use of private water supplies.

The National Trust: Climate Change: An update on recent work by the Trust and key issues. 2000.

Box 2: Water quality and sewerage responsibilities

Defra is the government department with responsibility for the quality of all water - drinking as well as natural surface and groundwaters.

The Environment Agency implements Government policy and is responsible for maintaining or improving the quality of fresh, marine, surface and groundwater in England and Wales. The Environment Agency, within a regulatory framework, ensures that the right environmental and discharge standards are set and enforced. In terms of diffuse pollution, the Environment Agency has little control, but the Water Framework Directive may offer fresh opportunities for controlling risks from diffuse sources.

The Drinking Water Inspectorate, which is part of Defra, has overall interests for regulating the quality of drinking water that is put into the supply network, with local authority Environmental Health Departments having local responsibility.

The water industry (water and sewerage companies) is responsible for the supply of drinking water and the collection, treatment and disposal of sewage. The high standards, they must meet, are set by UK law and European Community Directives.

Box 3: Flood risk management and flood and coastal defence responsibility

Flood risk management is the preferred term used by the Environment Agency for inland fluvial flood risk management, whilst flood and coastal defence refers to both defence from flooding from the sea and measures to protect the land against erosion and encroachment by the sea ('coast protection').

Defra has overall *policy* responsibility for flood risk management and flood and coastal defence in England and provides grant aid to the flood and coastal defence operating authorities (Environment Agency, local authorities and internal drainage boards) to support their investment in capital works. Defra does not build defences, nor direct the authorities on what specific projects to do. The works programme to manage risk is driven by the operating authorities.

The Environment Agency

The Environment Agency is the principal flood defence operating authority in England and Wales. Generally speaking, the EA is responsible under the Water Resources Act 1991 for managing flood risk arising from designated "main" rivers and the sea. The EA is also responsible for flood forecasting and flood warning dissemination, and for exercising general supervision over matters relating to flood defence.

Local authorities

Local authorities have powers to undertake flood defence works under the Land Drainage Act 1991, on watercourses which have not been designated as main and which are not within internal drainage board areas; maritime district councils have powers to protect the land against coastal erosion under the Coast Protection Act 1949. Defra provides grant aid to local authorities for flood defence works and coast protection works.

Internal drainage boards

Internal drainage boards (IDB's) are statutory bodies, empowered under the Land Drainage Act 1991, to undertake flood defence works for watercourses which have not been designated as "main", in specified districts with special drainage needs. The IDB's in the East of England have a key role in managing the extensive low-lying areas of farmland in the area.

Defra grant aids IDB capital flood defence works. Special rates are available for works to implement water level management plans (WLMPs) in internationally important conservation areas (SPAs, SACs and Ramsar sites[24]) and in areas of national importance (e.g. Sites of Special Scientific Interest (SSSIs). This is in recognition of the fact that IDBs are partly funded by private landowners while the works in question provide benefits nationally. The balance of IDBs' costs of work after grant has to be met by local agricultural drainage ratepayers whereas the capital expenditure of the Environment Agency and local authorities is largely met from the public purse.

Case study: Loss of 'natural' coastal defences

Essex saltmarshes account for 10% of the national resource, and between 1973 and 1998 around 950Ha (26% of the total were lost (in that county)). Overall Essex and Suffolk have lost an area equivalent to 750 football pitches in 25 years.

Summarised from Coastlines: Issue 2 November 2003an Environment Agency Anglian Region Publication

Case study: A new approach to coastal defence

The Environment Agency recognises the need for an integrated approach to coastal management. The Agency is already using a partnership approach at a pilot coastal farm scheme in Essex. The Abbott's Hall estate– a 700-acre coastal farm adjacent to the northern shore of the Blackwater Estuary in Essex – has been purchased by the Essex Wildlife Trust with funding from WWF-UK. In partnership with these organisations, as well as English nature, the Agency is using part of the estate for a managed re-alignment scheme, creating salt marshes and mudflats. Overall the scheme is costing in excess of £3 million. The estate has been protected by a sea wall for centuries, but the low-grade agricultural land made it hard to justify the continued expenditure on sea defences. Mud flats and saltmarshes act to absorb energy from incoming waves, so dampening the effect they have further inland. Sacrificing the poorly used land to the sea should help to prevent surges in the tide flowing up the neighbouring estuaries, which could easily damage local towns. The Agency hopes the managed realignment at the site will provide information for similar sites elsewhere.

The Guardian, reporting after the breach of the sea wall had taken place in 2003, notes that local councils in the south and east of England are preparing themselves for big floods, and trialing ways of mitigating the effects of sea level rise. The preferred defence against rising water levels appears to be using the idea tested at Abbotts Hall farm. However a spokesperson for Essex county council

24 **Ramsar Convention**: An international **convention** originally agreed in Ramsar in 1975. It aims to stem the progressive encroachment loss of **wetlands** and promoting the wise use of wetland wildlife. It requires the designation of Wetlands of International Importance (also known as Ramsar sites).

flood defence committee recognises the need for a strategic approach to managed realignment.

Summarised from 'Who needs Essex anyway?' Alok Jha, The Guardian, 12th June 2003 and Proposed managed re-alignment scheme Abbotts Hall, Essex. Local Action Eastern, Issue 6, July 2002.

Case study: Joined up thinking for flood risk management

The Environment Agency believes that the way ahead for flood defences involves 'holistic' approaches that rest on 'joined-up' understanding of complex river and tidal systems and on realism about where we can site homes and other infrastructure in the future.

Environment Action, January 2003, flood supplement.

Some key factors influencing water service providers responses to climate change

5.14. It is important to note that there is already much being done by water service providers to adapt to climate change. For example, as noted above the Environment Agency's 25 year Water Resource Strategies are already considering the potential impacts of climate change on water supply. Similarly water companies are preparing drought plans; these represent a mechanism that will help to ensure that the potential impacts of climate change are taken into account in future planning.

5.15. In terms of flood risk management and coastal defence, the flood defence operating authorities have been set High Level Targets by Defra. These are intended to facilitate a more certain delivery of Defra's national policy aim and strategy for flood and coastal defence in England. The targets were published in November 1999 and took effect from 1 April 2000 and generally relate to the provision and collection of information, the preparation of policy statements and ensuring arrangements are in place to gather details about the status of flood defences and allow for their inspection. The aim is to encourage, share and build on best practice and achieve a greater consistency in approach by all authorities in their flood defence activities. Again, such measures ensure that mechanisms are already in place to consistently factor in and address the implications of climate change and necessary responses. Indeed in some cases the predicted effects of climate change are already being factored in.

Case study: Sea level rise is factored into coastal flood defences

The Environment Agency already includes an allowance of 6mm sea level rise per year for new flood defences.

Coast lines: An Environment Agency Anglian Region Publication, Issue 1 April 2003.

5.16. The Water Framework Directive is the most substantial piece of EC water legislation to date, and will have significant implications for water service providers. The Directive requires all inland and coastal waters to reach "good status" by 2015. As the Competent Authority for England, the Environment Agency will establish a river basin district structure within which demanding environmental objectives will be set, including ecological targets for surface waters. The Directive seeks to integrate surface and groundwater and water quality and quantity, as well as moving towards joining up the management of water with other policy sectors that have an impact on the water environment. Through River Basin Management Plans, decisions will be made at basin level about what measures need to be used to tackle pollution. River Basin Management Plans will guide all activities in relation to water for public water supply, irrigation, the environment and flooding and as such, provide great scope for incorporating climate change adaptation measures into river basin planning.

Key impacts and adaptation responses

5.17. The Stage 1 report sets out a detailed discussion of possible impacts on water services, particularly in relation to water supply and flood risk management; key issues in relation to local service provision include:

- Climate change is likely to cause demand for water to increase, particularly in the summer.
- There is uncertainty over the implications for water availability for public water supply systems, but especially under the UKCIP02 High Emissions scenario there may be adverse impacts on availability[25].

Case study: Protecting private water supplies

Norfolk contains the highest number of private wells for domestic supply of any county in the country. These supply very small quantities and are not significant on a catchment scale but do have to be protected against 'derogation' by licensed abstractions.

Steve Dines, Senior Technical Specialist (Abstraction Licensing), Environment Agency Anglian Region

- Water infrastructure may not be able to cope with long dry spells in summer and there may be shortages of water available for direct summer abstractions.
- Combined potential supply pressures and demand increases could lead to supply deficits especially in the southeastern part of the region.

[25] For further information see UKWIR Report (2002): Effect of Climate Change on River Flos and Groundwater.

Case study: Water meters – facilitating demand management

The Environment Agency believes that metering will reach between half and three-quarters of households in the East Anglian region by 2025. This is an important demand management measure, which should help to adapt to water shortages which are likely to arise as a result of climate change.

Water Resources for the Future: A Strategy for Anglian Region, 2001. Environment Agency.

- Increased climatic variability and increased winter rainfall could put pressure on drainage systems.

Case study: Sustainable Urban Drainage Systems

Sustainable Urban Drainage Systems (SUDS) control surface water runoff as close to its origin as possible before it enters a watercourse. This involves moving away from conventional piped systems and toward engineering solutions that mimic natural drainage processes and minimise adverse effects on the environment. SUDS may take the form of infiltration systems whereby water is soaked away into the ground or they may be attenuation systems, which release flows gradually to watercourses or sewers. Both types of system involve storing water underground or in open landscaped basins. These systems will become increasingly important as the effects of climate change are felt, potentially leading to increased rainfall in winter and the potential for flash floods.

Summarised from Ipswich Drainage and Flood Defence Policy, 2002. Ipswich Borough Council.

- Coastal and fluvial flooding will have impacts on most other aspects of local service provision identified in this guidance, such as transport infrastructure, buildings and estates management, emergency planning, the economy, etc.
- Existing flood risk management measures will face increased pressure and the costs of flood damage to built property, without increased defences, could be significant.

Case study: The costs of flood damage to the insurance industry

A report by the Association of British Insurers identified that total claims in the order of £50 - £120 million are made per annum as a result of flood damage.

http://www.ciria.org.uk/water_rp676.htm - Inland Flood Risk - Issues Facing the Insurance Industry, 2000.

- Water quality could be affected in several ways, for example, by lower precipitation rates combined with higher temperatures, leading to increased concentration of pollutants in raw water sources; pollution from storm events affecting water supply and groundwaters; and salt water intrusion into vulnerable aquifers.
- Impacts on sewerage could affect water quality and there could be sewage overflow during extreme events.

5.18. **Tables 5.1 - 5.4** identify possible adaptation measures, for local level adaptation in relation to the key service providers.

Case study: Soft sea defences bringing environmental benefits
"We have realised that salt marshes are an incredibly effective defence and perhaps offer us a long-term solution to the problem of coastal flooding. By generating new areas of salt marsh we can use nature to tame the sea".
David Rooke, the Environment Agency's Head of Flood Defence.
Along Freiston Shore on the Lincolnshire coast, soft sea defences have been used to calm the sea. The sea has been allowed to reclaim nearly 80 hectares of farmland, creating saltmarshes. This area of saltwater shallows absorbs the energy of the waves and significantly cuts the risk to human communities of coastal flooding. The area is also an RSPB nature reserve boasting record numbers of breeding Avocets, last seen in this part of Lincolnshire over 100 years ago.
Environment Action, January 2003, flood supplement.

Case study: Costs of strengthening and adapting coastal defences
A study into potential UK adaptation strategies for climate change estimates the cost of strengthening and adapting current coastal defences in England over the next 50 years to be approximately £790 million.
Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

Case study: Costs of strengthening and adapting fluvial flood defences
A study into potential UK adaptation strategies for climate change estimates the cost of strengthening and adapting current fluvial defences in England over the next 50 years to be approximately £390 million.
Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

Table 5.1: Water resources and supply

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions, in particular: Thames Gateway Coast Southern Heartland	Water resource availability may be adversely affected by climate change. Temperature increases, lower summer precipitation and increased climatic variability will affect water resource availability. The prolonged summer season and variable precipitation – with high Soil Moisture Deficit (combined with possible reduced winter recharge to groundwater) could make the area vulnerable to more frequent and severe droughts. Likely to be an increased demand for water for public use as well as for livestock and agriculture.	The following suggested actions will help to address the range of impacts identified:		
		• Improve river basin management by implementing the Water Framework Directive. • Set out a sustainable framework for action by organisations – including water companies and planning authorities.	Plan for the future	• Defra • Environment Agency (Thames and Anglian regions) • Water companies • Local authority services: environment
		• Implement demand management measures to promote increased domestic efficiency (including improved domestic appliances, tap restrictors, cistern dams, rainwater collection techniques). Push for the incorporation of innovative demand management mechanisms in new development.	Act now	• Environment Agency (Anglian and Thames regions) • Water companies • Local authority services: planning and environment, housing, property and parks and estate management
		• Implement demand management measures to promote increased industrial and agricultural efficiency in water use, including variable tariffs.	Act now	• Environment Agency (Anglian and Thames regions) • Water companies • Local authority services: planning and environment,

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Raise public awareness of the need to manage demand.	Act now	• Environment Agency (Anglian and Thames regions) • Water companies • Local authority services: environment, housing, property and parks and estate management
		• Promote water conservation measures such as use of grey water and rain water harvesting.	Act now	• Environment Agency (Anglian and Thames regions) • Water companies • Local authority services: environment, housing, property and parks and estate management
		• Take action to ensure new homes incorporate measures to achieve water efficiency through promoting demand management measures and through working with relevant bodies to ensure climate change is incorporated into standards e.g. Building Regulations and planning policy guidance.	Act now/Plan for the future	• Environment Agency (Anglian and Thames regions) • Water companies • Local authority services: housing, property and parks and estate management

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Implement leakage control measures.	Act now	• Environment Agency (Anglian and Thames regions) • Water companies
		• Ensure that the abstraction of water is sustainable.	Act now/Plan for the future	• Environment Agency (Thames and Anglian regions) • Water companies
		• Undertake supply side measures (e.g. reservoirs, conjunctive use schemes, bulk transfer schemes, desalination plants). Pumping water is very energy intensive - it is therefore important that 'smart' solutions are found for water transfers, for example, making better use of rivers and canals.	Plan for the future	• Environment Agency (Anglian and Thames regions) • Water companies • Local authority services: planning
	There are several thousand sources of private drinking water supply in the region. These may become less reliable as fluctuations in the water table become greater.	• Identify those at risk. Consider whether changes in abstraction licenses are required.	Plan for the future/Keep a 'watching brief'	• Environment Agency (Anglian and Thames regions)
	The loss and physical change to the environment, caused by changes in water availability may affect habitats and species.	• Contribute to the implementation of the UK BAP and England Biodiversity Strategy, with further conservation of SSSIs.	Act now/plan for the future	• Environment Agency (Thames and Anglian regions) • Local authority services: planning and environment
Thames Gateway Southern Heartland	Housing developments will place increasing pressures on existing and future water supply.	• Ensure that new developments have adequate water supply. • Ensure that new developments include highest standards of water efficiency to	Plan for the future	• Defra • Environment Agency (Anglian and Thames regions)

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		reduce demand increase and minimise the need for new supply side measures.		• Water companies • Local authority services: planning
		• Plan for supply-side measures as necessary (see above). Pumping water is very energy intensive - it is therefore important that 'smart' solutions are found for water transfers, for example, making better use of rivers and canals where this can be done without adverse environmental impact.	Plan for the future	• Environment Agency (Thames regions) • Water companies • Local authority services: planning
		• Local authorities should implement more stringent regulations regarding the location of new developments.	Act now	• Local authority services: planning

Table 5.2: Water Quality

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Higher summer temperatures coupled with lower summer precipitation will increase the concentration of pollutants in raw water sources. Groundwater and surface water sources will both be affected.	• Improve river basin management by implementing the Water Framework Directive	Plan for the future	• Defra • Environment Agency • Local authority services: Planning and Environment • Other stakeholders
		• Consider whether current controls are sufficient, for point and diffuse sources of pollution.	Keep a 'watching brief'	• Defra • Environment Agency
		• Modify water treatment plants to enable them to cope with higher concentrations of contaminants in the water supply.	Plan for the future	• Water companies
		• Develop riparian corridors as water quality buffer/filter strips.	Act now	• Environment Agency (Thames and Anglian regions) • Water companies • Land owners, including nature conservation organisations • Local authority services: planning
	There are several thousand sources of private drinking water supply in the region. Depending on their location some will be at risk of being polluted due to the fact that there will be less dilution as summer precipitation rates decrease.	• Identify those at risk and consider appropriate measures to protect water quality.	Plan for the future/Keep a 'watching brief'	• Environment Agency (Thames and Anglian regions) • Local authority: Environmental Health

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions, in particular: **Fens** **Thames Gateway** **Coast**	Wetter winters and the associated increase in flood risk, could lead to more pollution from storm events affecting water supply	• Undertake pollution prevention measures on land susceptible to flooding.	Act now	• Environment Agency (Thames and Anglian regions)
		• Improve flood plain/ river catchment management.	Act now	• Environment Agency (Thames and Anglian regions) • Water companies • Land owners, including nature conservation organisations • Local authority services: planning
Coast **Fens** **Thames Gateway**	Risk of salt-water intrusion into vulnerable aquifers.	• Improve coastal and estuarine flood risk management measures.	Plan for the future	• Defra • Environment Agency (Thames and Anglian regions)
		• Review abstraction management plans for coastal areas, which show a greater awareness of all parties.	Plan for the future	• Environment Agency (Thames and Anglian regions) • Water companies • Local authority: planning and/or environment department

Table 5.3: Sewerage

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Possible sewage overflow during extreme storm events.	• Upgrade infrastructure to cope with overflows.	Plan for the future	• Environment Agency (Thames and Anglian regions) • Water companies

Table 5.4: Flood risk management and flood and coastal defence

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions, in particular	Increased fluvial flood risk due to increased precipitation and extreme events including intense precipitation and storm surges.	• Improve and provide cost-effective flood warning systems.	Act now/Plan for the future	• Defra • Environment Agency (Thames and Anglian regions) • Local authority services: emergency planning
		• Discourage inappropriate development in areas at risk from flooding.	Act now/Plan for the future	• Defra • Office of the Deputy Prime Minister (ODPM) • Regional Assembly • Environment Agency (Thames and Anglian regions) • Local authority services: planning
		• Undertake inland fluvial flood risk management, taking into account the costs and benefits of different measures.	Plan for the future	• Defra • Environment Agency (Thames and Anglian regions) • Local authority services • Internal Drainage Boards

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
Fens **Thames Gateway** **Coast**	Increased coastal flood risk due to increased precipitation and sea-level rise, and extreme events including intense precipitation and storm surges	• Improve and provide cost-effective coastal flood warning systems.	Act now/Plan for the future	• Defra • Environment Agency (Thames and Anglian regions) • Local authority services: environmental health
		• Discourage inappropriate development in areas at risk from coastal flooding and encroachment by the sea.	Act now/Plan for the future	• Defra • Environment Agency (Thames and Anglian regions) • Local authority services: planning
		• Undertake coastal flood risk management, taking into account the costs and benefits of different measures.	Plan for the future	• Defra • Environment Agency (Thames and Anglian regions) • Local authority services
		• Assess the risk of coastal erosion and encroachment by the sea and consider how resources should be inputted into coastal protection.	Plan for the future	• Defra • Local authority services

Sources of information

Defra (Dec 2002) The Environment Agency's Objectives and Contributions to Sustainable Development: Statutory Guidance
Environment Agency (March 2001) Water Resources for the future: A strategy for the Anglian Region, Environment Agency, Peterborough.
Environment Agency (March 2001) Water Resources for the future: A strategy for the Thames Region, Environment Agency, Peterborough.
ERM (May 2000) Potential UK adaptation strategies for climate change, technical report.

LUC (Feb 2003) Living with climate change in the East of England: Stage 1 Interim Report; Guidance on Spatial Issues

ENERGY SERVICES

Key issues for adaptation

- Key adaptation responses relate to the impacts of climate change on energy infrastructure e.g. power stations and pylons.
- Energy providers may need to adapt to changing patterns of seasonal energy demand, for example, in terms of network capacity.
- Climate change may create new opportunities for renewable energy e.g. energy crops. Use of on-site renewable energy will increase resilience to disruption of supply.

Baseline conditions

5.19. In terms of energy infrastructure, the East of England has several coastal facilities, including a combined cycle gas turbine (CCGT), a wind farm and two nuclear power stations. There are also two power stations in the Thames Gateway (one oil/coal fired and one CCGT). Other CCGT power stations are located throughout the west of the region. Transmission lines and substations are located throughout the region.

5.20. Electricity generating projects in the region using renewable energy sources are estimated to total 239 M (July 2003) and a further 375 MWe capacity is under development or in proposal/planning stages

5.21. In terms of renewable resources, the eastern region has adopted a challenging target of achieving 14% of the region's electricity from renewable sources by 2010. There is a strong focus on wind energy to achieve this ambitious target, followed by biomass, and with the extra being produced from other renewable resources. Over 39% of the renewable energy installed capacity in the East of England is from three biomass plants and in order to reach the biomass target, 140,000 hectares of land would need to be used for energy crops[26].

Responsibilities for providing energy services and adapting services to climate change

5.22. Private companies generate, distribute and supply electricity in the UK. National Grid Transco owns and operates the high voltage transmission system in England and Wales, taking electricity from generating stations and interconnectors and transmitting this to electricity distribution companies and some industrial customers. National Grid Transco is the sole holder of a licence for electricity transmission in England and Wales and has a statutory duty to develop and maintain an efficient and economical system of

[26] http://www.renewableseast.org.uk/facts_reee.asp

electricity transmission and to facilitate competition in the supply and generation of electricity. National Grid Transco must offer to connect customers to the system, as this is the main factor in creating the demand for new power lines and infrastructure. The National Grid is made up of some 7000-km of overhead line, 21,000 pylons, 650 km of underground cable and more than 300 substations. National Grid Transco also runs Britain's natural gas transportation system.

5.23. Ofgem regulates Britain's gas and electricity industries. Ofgem's role includes making gas and electricity markets work effectively, regulating monopoly businesses, securing Britain's gas and electricity supplies and meeting social and environmental responsibilities.

5.24. A range of other partners will also need to be involved to ensure that energy services take appropriate measures to adapt to climate change. For example, the Environment Agency will have a key role to play in decisions relating to flood risk management and coastal defence, which will evidently affect energy infrastructure in areas vulnerable to fluvial and coastal flooding. Other measures, such as encouraging businesses and home owners to incorporate energy efficient cooling, in new and existing buildings, would involve a wide range of partners, such as local authority planning and environment services, electricity companies and developers. These partners are identified in the tables below.

Key impacts and adaptation responses

5.25. Energy services may be affected by climate change in a number of ways. Impacts may include affects on infrastructure, for example damage to overhead power lines and damage to power stations during flood events and storm surges in coastal locations. It is also possible that supply of heating fuels (e.g. heating oil, solid fuel and liquid petroleum gas) could be disrupted – this would be a particular issue for rural areas.

Case study: Adapting energy infrastructure

Northern Ireland Electricity is currently strengthening their infrastructure, in response to the 1998 floods and storms.

Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

5.26. Loss of energy supplies can also have serious knock on impacts, some of which are life threatening e.g. vulnerable people suffering from heat stress in summer or inability to keep warm in winter.

5.27. Climate change may also affect the demand for energy, with changes in seasonal demand as changes occur in heating and cooling requirements. In particular, very hot periods could dramatically increase peak demands for electricity in summer, as many homes and workplaces adopt short term and inefficient methods of cooling.

Case study: Energy savings

The mild winter of 1995 led to net energy savings of about £350 million.

Climate change and local communities – How prepared are you? An adaptation guide for local authorities in the UK. 2003, UKCIP, I&DEA, LGA, COSLA and WLGA

5.28. Climate change may also create new opportunities for renewable energy. In particular the increasing number of sunny days could make solar energy technologies more attractive. Conditions could also change to favour the growing of some energy crops but there is still a high level of uncertainty here. More distributed energy supply and more on-site generation in industry would increase resilience to disruption by climate change impacts. This would include using renewable technologies and combined heat and power.

Case study: International wind energy company based in the East of England

Dr Ian Mays, Visiting Professor at University of Hertfordshire (UH) and Managing Director of St Albans based international wind energy company, Renewable Energy Systems (RES) has won a prestigious Royal Academy of Engineering Silver Medal for his pioneering work in creating commercially viable wind farms.

"In his very successful business life, Dr Mays has a compelling vision of a future UK with up to 20 percent of its energy generated by wind turbines. His company specialises in optimising the output and cost-effectiveness of projects and arranging wind farms to harmonise as far as possible with the environment. RES has completed 27 wind farms, including King Mountain in Texas in 2001, at the time the world's largest installation with 214 large 1.3 MW turbines."

One reason that RES looked to the international market was the difficulty in developing projects in the UK. " Getting planning consent has been very difficult here, despite the more positive energy policy." he says. " Going offshore helps to increase the available wind resource but as you would expect, such projects are more expensive to build. We should make good use of both and I expect we will end up with a mixture of the two in the end."

Dr Mays has been a leading advocate of wind power as past President of the European Wind Energy Association and past Chairman of the British Wind Energy Association.

Extract from "Visiting Professor Honoured", Horizon: News of the University Hertfordshire*, Issue 41, October 2003*

5.29. Many of the measures here may also impact on levels of greenhouse gas emissions but while the importance of energy services in reducing emissions is self-evident – this is not the subject of this guidance.

5.30. **Tables 5.5 and 5.6** identify possible adaptation measures in relation to electricity and gas suppliers.

Table 5.5: Electricity

Climate Change sub-region affected	Most significant likely climate impacts on service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Milder climate likely to affect demand for energy – likely reduction in heating overall but increased demand for cooling/air conditioning and likely surges in demand for cooling on extremely hot days.	• Review projection of demand in relation to likely climate scenarios – consider impact on business and capacity of network.	Plan for the future/Keep a 'watching brief'	• Electricity companies • Office of Gas and Electricity Markets (OFGEM) • Housing/property services • Local authority services: Planning
		• Work with businesses and homeowners to promote passive / energy efficient cooling in new and existing buildings.	Plan for the future	• Local authority services: Planning and environment • Electricity companies • Developers • Businesses and homeowners
	Government likely to continue to promote increasing level of renewable energy. Opportunities for renewable energy may increase e.g. solar power and biomass energy crops	• Encourage incorporation of solar technologies into new developments.	Plan for the future	• Electricity companies • Local authority services: Planning and environment, property services and housing • Businesses • Home owners and social housing providers • Relevant Non-Government Organisation's (NGO's)
		• Look at potential of energy crops as conditions change	Keep a 'watching brief'	• Defra • Farmers and land managers
			Plan for the future	

Climate Change sub-region affected	Most significant likely climate impacts on service	Suggested Actions	Time Frame	Key Partners
		• Encourage the growth of distribution and on-site generation to improve security of energy supply		• Businesses • Local authorities
	Extreme weather events are likely to damage overhead power lines and pylons and may also affect storm drainage and sewers, which are already susceptible to flooding, thus impacting on underground cables and pipes. Such impacts may lead to increased disruption to supply.	• Undertake a review of the grid and ensure that future design specifications and capital investment are sufficient to cope with likely extreme weather events. Work with Emergency Planning authorities to develop response to disruption of supply	Act now	• National Grid • Electricity companies • Local authority services: Planning • Emergency Planning • OFGEM • National Grid • Electricity companies • Local authorities services: Emergency planning
	Drying out of soil may limit the cooling of underground electricity cables	• Review current specifications for underground cables.	Plan for the future	• National Grid • OFGEM • Electricity companies
Southern Heartland	Clay shrinkage and subsidence may also have a negative impact on power networks.	• Review current specifications for underground cables.	Plan for the future	• National Grid • OFGEM • Electricity companies
Coast	Coastal Energy Infrastructure (nuclear and CCGT power stations, wind farms, grid) vulnerable to inundation and storm surges.	• Work through CZMPs and other mechanisms to develop a coherent response to the threat posed to coastal energy infrastructure.	Act now	• National Grid • Electricity companies • Local authority: Planning and environment • Environment Agency • Other stakeholders involved in developing CZMP's
	Rising sea levels may increase the number of underground	• Review current specifications for underground cables.		• National Grid • OFGEM

Climate Change sub-region affected	Most significant likely climate impacts on service	Suggested Actions	Time Frame	Key Partners
	cable faults.			• Electricity companies
	Energy infrastructure on the coast may be affected by coastal erosion.	• Work through CZMPs and other mechanisms to develop a coherent response to the threat posed to coastal energy infrastructure.		• National Grid • Electricity companies • Local authority: Planning and environment • Environment Agency • Other stakeholders involved in developing CZMP's

Table 5.6: Gas Suppliers

Climate Change sub-region affected	Most significant likely climate impacts on service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Gas pipes threatened by subsidence/drying of ground.	• Undertake a review of current infrastructure and ensure that future design specifications and capital expenditure are sufficient to withstand likely extreme weather events.	Plan for the future	• Planning authorities • Energy companies
	Lower demand for gas likely in warmer climate.	• Review projection of demand in relation to likely climate scenarios – consider impact on business.	Plan for the future	• Energy companies

TRANSPORT SERVICES

Key issues for adaptation

- The rail sector is the most sensitive to climate change, with road transport third most sensitive, after air transport.
- A wide range of adaptation measures will be needed to adapt road and rail infrastructure including road surfaces and rail tracks, earth structures, bridges and gantries to the effects of climate change (for example, changes in rail track specifications to prevent buckling in warmer summer temperatures).
- Adaptation measures will need to include the use of more durable materials, 'climate change proofed' designs and improved drainage, amongst others.
- Climate change could lead to increased risk of road accidents, from both wetter winter and warmer summer conditions, which will require measures such as clearer signage.
- There may be some benefits for transport services e.g. less need for salting and gritting, which should be reflected in budgets.

5.31. Given the long lead-time associated with new infrastructure development, it is important that design of new transport infrastructure incorporates, where possible, measures necessary to adapt to climate change. According to research by

CRISP[27], the rail sector is the most sensitive to climate change, with road transport third most sensitive, after air transport. The relevant service providers are very much aware of the potential impacts of climate change and are taking action. For example, The Highways Agency carried out an initial scoping study in 2001, but feels that further research is needed. Similarly Network Rail is considering the impacts of weather on the railway. London Underground is undertaking considerable work to address the implications of flooding from the rising water table, and surface and sub-surface rivers. However, all these transport service providers agree that there is a need to carry out further research into the possible implications of climate change on built transport infrastructure.

Case study: Adapting road infrastructure

The Highways Agency are considering the implications of climate change on road infrastructure. They are already experiencing the need to adapt road infrastructure to the effects of climate change.

Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM

Baseline conditions

5.32. Like most regions, the East of England has extensive transport infrastructure, which is very important for the social and economic functioning of the region. The region has several airports, including Stansted and Luton, several major coastal ports, including the Haven Ports complex, which comprises Felixstowe, Great Yarmouth and Lowestoft further up the coast. Rail infrastructure is typically north south orientated and includes rail links between Lowestoft, Ipswich and London along the coast, which may be particularly vulnerable to coastal flooding. In terms of road infrastructure there is also key infrastructure located along the coast, including the A12 from Great Yarmouth down through Colchester to London.

[27] Wilson, M. I. & Burtwell, M. H. (2002) Prioritising future construction research and adapting to climate change: Infrastructure (transport and utilities)

Responsibilities for providing transport services and adapting services to climate change

5.33. A number of key partners are involved in delivering transport services. In terms of the rail network, the Strategic Rail Authority (SRA) sets the overall strategy for the railways whilst the Office of Rail Regulator (ORR) sets targets for delivery. The provision of the railway network and rail services in Britain is a joint effort by several companies. 26 train operating companies run the passenger trains, with the freight trains being run by specialist freight operators. Network Rail are responsible for the infrastructure. This includes:

- The track
- Signalling systems
- Bridges
- Viaducts
- Tunnels
- Level crossings
- Stations.

5.34. Network Rail has significant assets; in addition to the infrastructure, it also owns an average 50-metre strip of land on either side of the tracks. In terms of adapting to climate change, Network Rail, with its responsibility for infrastructure, has a particularly significant role to play.

5.35. In terms of the road network, the Highways Agency is responsible for operating, maintaining and improving the strategic road network in England on behalf of the Secretary of State for Transport. The Highways Agency has a large landholding, consisting of highways and motorways, as well as land adjacent to the road surface and additional land for implementing mitigation measures, such as screening. County Councils or Unitary Authorities are responsible for local roads, in their function as 'Highways Authority' for a locality. As such they are responsible for maintaining the condition of public roads, including carrying out repairs to the road surface, verge trimming, winter maintenance, highway flooding and so on. They may also be involved in the provision of new local roads.

Air transport

5.36. Air transportation is planned and managed outside of regional or local level decision structures and therefore is not covered in this guidance as such. However, climate change may have impacts on air travel, for example, through potential disruption during stormy conditions. Therefore it is advisable for businesses and other users to reduce their reliance on this mode of transport. This is evidently a situation where adaptation to climate change will also have positive effects in terms of mitigating against climate change, as air transport is a key source of greenhouse gas emissions. Measures to decrease air travel will help to achieve the aim, set out in the Regional Environment Strategy for the East of England, which seeks that '*unsustainable modes of transport, in particular travel by car and by plane, should be catered for on the basis of need, not demand and appropriate demand management measures considered to encourage a switch to other modes*'.

Key impacts and adaptation responses

5.37. Key potential impacts on road and rail transport infrastructure include:

- Impacts from sea level rise and storm surges and fluvial flooding on both rail and road networks.
- The impacts of increased storminess and wind speeds on the road and rail network, for example in terms of closure of bridges, loss of overhead power lines to trains, blockage of rail tracks and roads by fallen trees and floods.
- Increased risks of landslips affecting embankments and tunnel portals.
- Flooding of tunnels and need for dewatering of tunnels.

Case study: Identifying potential risk areas for earth structures

Recent work by London Underground has identified potential risk areas for earth structures up to 2035 due to changes in wet and dry conditions arising from changes in climate. It has also identified options for controls and mitigation. The impact on underground tunnels and foundations is also being investigated as the deep clays change in moisture content due to the impact of rising water tables. London Underground is a world leader in this area and advice has been requested from other cities.

The Impacts of Climate Change: Implications for DETR, 2001. Sarah Thompson, In House Policy Consultancy, DETR.

- Corrosion and weathering of structures, road surfaces and rail tracks, from temperature changes and changes in rainfall and flooding.

Case study: Hot weather causes delays on Britain's railways

In August 2003, Britain reached the highest heat peak since records began. This led to a number of problems, not least long delays on the rail network due to fears that tracks could buckle in the heat and derail the trains. Passengers were delayed for over an hour or trains cancelled completely. 110mph speed limits were cut to 60mph on many lines with some lines in Northamptonshire being reduced to just 20mph.

Summarised from Metro, Tuesday August 5th, 2003.

- Impacts of changing groundwater levels on structural stability of roads and rail tracks.
- Knock-on effects of impacts on London's transport network, including the Tube.

Case study: Intensive rainfall affecting London's mainline railway stations

The intensive rainfall event of 7th August 2002, when over an inch (25mm) of rain fell on London in one half-an-hour period, led to five of the capital's mainline railway stations being closed due to floods at peak rush hour time.

London's Warming: the Impacts of Climate Change on London: Summary Report, 2002. Commissioned by the London Climate Change Partnership.

- Possible increases in road accidents in wetter conditions and also hotter weather.

5.38. **Tables 5.7 and 5.8** identify possible adaptation measures for those organisations responsible for the rail and road networks in the East of England.

Case study: The cost of rail delays The floods of Autumn 2000 affected many parts of the UK. One example of this is the time lost due to flooding at Stroud's Bridge, on the rail link between Oxford and London between 13^{th} and 18^{th} December 2000. The financial loss to Railtrack due to time delay penalties as a result of this one disruption has been estimated to be at least £1.2million. **London's Warming: the Impacts of Climate Change on London: Summary Report, 2002. Commissioned by the London Climate Change Partnership.**

Table 5.7: Rail network

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Potential increased storminess and wind speeds, creating operating difficulties for high-speed electric rail lines.	• Undertake investment into adapting high-speed electric rail lines where necessary.	Plan for the future	• Network Rail • Strategic Rail Authority • Train operating companies
		• Consider how specifications for construction need to be revised to factor in impacts on high speed electric rail lines and retrofit where necessary.	Plan for the future/Keep a 'watching brief'	• Network Rail • Strategic Rail Authority • Train operating companies • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
		• Wind proof key structures.	Plan for the future	• Network Rail • Strategic Rail Authority • Train operating companies

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	Increased winter precipitation and possible increased storminess could increase disruption of the transport network: closure of bridges in high winds, the loss of overhead power lines to trains, blockage of rail tracks by fallen trees, floods and snow drifts.	• Increase in the resilience of existing transport systems to increases winter precipitation and potential increased storminess by adapting bridges, overhead power lines etc. – need an integrated approach to the development of such systems.	Plan for the future	• Network Rail • Strategic Rail Authority • Train operating companies
		• Undertake more work on design of drains, construction of better insulated structures, the influence of wind forces on bridges, etc. (the CRISP commission refers to this need).	Plan for the future/Keep a 'watching brief'	• Network Rail • Strategic Rail Authority • Environment Agency • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
		• Wind proof key structures.	Act now/Plan for the future	• Network Rail • Strategic Rail Authority • Train operating companies
		• Consider past weather related events and records of the effects on infrastructure, and review the effects in other areas of the world that have climates similar to that anticipated.	Keep a 'watching brief'	• Network Rail • Strategic Rail Authority • Train operating companies • Environment Agency
		• Implement SUDS throughout catchments to help alleviate impacts on drains.	Act now/Plan for the future	• Local authority services: planning and environment

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
				• Environment Agency
	A rise in precipitation levels will increase the risk of landslips – railways are prone to these as they are often built in embankments.	• Reinforce vulnerable slopes and keep them maintained.	Act now	• Network Rail • Other landowners with vulnerable land adjacent to railways
		• Improve drainage systems to prevent saturation of the soil.	Act now/Plan for the future	• Network Rail • Environment Agency
	Increased precipitation could cause damage to tracks, trains, signals and other infrastructure through corrosion.	• Use more durable materials e.g. corrosion resistant metals.	Act now/Plan for the future/Keep a 'watching brief'	• Network Rail • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
	Increases in precipitation could pose problems for the performance of ballast (which provide structural support to rail tracks). An increase might increase the migration of fine sediments, which can lead to structural instability. A rise in groundwater levels could also lead to a reduction in the structural performance.	• Take into account potential impacts of increased precipitation and temperature increases on ballast in design and assessment of structures.	Plan for the future/Keep a 'watching brief'	• Network Rail • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
	Milder wetter winters could lead to possible reductions in winter maintenance costs for structures and rail tracks.	• Make any necessary changes in budgets to respond to possible reductions in winter maintenance costs	Plan for the future/Keep a 'watching brief'	• Network Rail
	Increased summer temperatures may cause buckling of electric rail lines.	• Undertake investment into adapting networks where necessary to prevent	Plan for the future	• Network Rail

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	Milder winters may reduce delays due to icing of points.	buckling and other damage to electric lines caused by increased summer temperatures. • Research alternative materials, less prone to buckling.	Plan for the future/Keep a 'watching brief'	• Network Rail • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
		• Consider how specifications for construction need to be revised to factor in climate change to prevent buckling and other damage to electric rail lines caused by increased summer temperatures – retrofit where necessary.	Keep a 'watching brief'	• Strategic Rail Authority • Network Rail • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
	Increased summer temperatures could affect overhead lines (increased sag).	• Consider how specifications for construction need to be revised to factor in climate change to respond to potential increased sag of overhead lines due to warmer temperatures – retrofit where necessary.	Keep a watching brief	• Strategic Rail Authority • Network Rail • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions, in particular: **Coast** **Thames Gateway** **Fens**	Sea level rise, and storm surges as well as saturated fluvial catchments caused by increased precipitation, will increase flood risk on railway lines and could cause damage e.g. instability, corrosion. Flooding of circuits can lead to a 'red signal' before the track is flooded to any depth and can cause serious delays.	• Consider how specifications for construction need to be revised to factor in the potential increased flood risk on railway lines caused by climate change – retrofit where necessary.	Keep a 'watching brief'	• Network Rail • Environment Agency • Local authority services: planning and environment (although may have little say over large infrastructure projects). • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
		• Ensure that current and future rail networks can cope with wetter winters and more extreme events - retrofit existing infrastructure where necessary.	Act now/Plan for the future/Keep a 'watching brief'	• Network Rail • Environment Agency • Local authority services: planning and environment (although may have little say over large infrastructure projects) • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Strengthen coastal and river flood defences.	Act now/Plan for the future	• Environment Agency
		• Locate new infrastructure away from high-risk areas – decision-making processes should be tightened.	Act now/Plan for the future	• Local authority services: planning and environment (although may have little say over large infrastructure projects) • Network Rail • Environment Agency
		• Consider the need for re-routing.	Plan for the future	• Network Rail • Environment Agency
		• Implement better drainage systems.	Act now/Plan for the future	• Network Rail • Environment Agency
	Increased flooding of sub-aqueous rail tunnels. An increase in precipitation will increase the risk of failure of cuttings and retaining walls located at and around tunnel portals.	• Reinforce vulnerable slopes and keep them maintained (N.B. this could be through use of vegetation).	Act now/Plan for the future	• Network Rail • Other landowners with vulnerable land adjacent to railways
		• Improve drainage.	Act now/Plan for the future	• Network Rail • Environment Agency
All climate change-sub regions, in particular: Coast Thames Gateway	Flooding and drainage issues could cause scouring around bridges from faster river flows, which could cause collapse.	• Take into account potential risk of scouring around bridges in design and assessment of structures.	Act now/Plan for the future	• Network Rail • Environment Agency?
All climate change sub-regions, in particular: Thames Gateway Southern Heartland	Knock-on effects of the impacts on London's rail network, such as delays on trains running from the East of England to London terminals. Flooding of the Tube will affect people from the	• Be aware of the potential disruption to regional services that may be caused by disruption of London's rail network/Tube network. Be prepared to respond to these, e.g. through	Plan for the future	• Network Rail • Train operating companies

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	East of England who travel to London.	provision of alternative bus services.		
Thames Gateway Southern Heartland	Clay shrinkage due to temperature increases and decreased soil moisture could impact on structures on which the rail network is reliant, including bridges, tunnels, embankments and cuttings.	• Undertake investment into adapting networks where necessary to clay shrinkage. • Consider how specifications for construction need to be revised to factor in clay shrinkage – retrofit where necessary. E.g. more reinforcement of bridges and tunnels.	Plan for the future Plan for the future	• Network Rail • Network Rail

Table 5.8: Road network

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	A rise in precipitation during winter months could increase the risk of landslips, which could block important road links.	• Reinforce vulnerable slopes and keep them maintained.	Act now/Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management
		• Improve drainage systems to prevent saturation of the soil.	Act now/Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management • Environment Agency
	Wetter winters could lead to more accidents.	• Consider necessary changes to current specifications for road surfaces.	Plan for the future/Keep a 'watching brief'	• Highways Agency • Local authority services: Highways maintenance and traffic management • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
	Increased flooding of sub-aqueous road tunnels. An increase in precipitation will increase the risk of failure of cuttings and retaining walls located at and around tunnel portals.	• Take into account the potential risk of increased flooding of sub-aqueous road tunnels and the risk of failure of cuttings and retaining walls around tunnel portals in design and assessment of structures.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Reinforce vulnerable slopes and keep them maintained (N.B. this could be through the use of vegetation).	Act now/Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management
		• Improve drainage systems.	Act now/Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management • Environment Agency
	Increases in precipitation could pose problems for the performance of subgrade, which provides structural support to roads. An increase might increase the migration of fines, which can lead to structural instability. A rise in groundwater levels could also lead to a reduction in the structural performance. Temperature increases could also affect subgrade.	• Take into account the potential impacts of increased precipitation on the performance of subgrade used in roads in design and assessment of structures.	Plan for the future/Keep a 'watching brief'	• Highways Agency • Local authority services: Highways maintenance and traffic management
	Potential increased storminess could affect signs, gantries and lighting columns.	• Take into account potential impacts of potential increased storminess on signs, gantries and lighting columns in design and assessment of structures.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management
	Less salting and gritting is likely to be needed on the roads, as the winters get warmer and wetter. This could lead to complacency and not being adequately prepared when gritting is needed.	• Have adequate structures in places ready for gritting – need accurate forecasting and rapid implementation.	Act now/Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	Milder wetter winters could lead to possible reductions in winter maintenance costs for structures and highways.	• Make necessary changes in budgets.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management
	Increased summer temperatures could lead to road surface asphalt melting and loss of 'micro texture' through polishing by traffic in dry, dusty weather.	• Consider how specifications for construction need to be revised to factor in the potential for surface asphalt melting and loss of 'micro texture' through polishing by traffic in dry, warm summers – retrofit where necessary.	Plan for the future/Keep a 'watching brief'	• Highways Agency • Local authority services: Highways maintenance and traffic management • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
		• Alter asphalt composition.	Plan for the future/Keep a 'watching brief'	• Highways Agency • Local authority services: Highways maintenance and traffic management • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
	Higher temperatures could also have implications for driver safety, as concentration is impaired.	• Increase safety measures e.g. clear signs.	Act now	• Highways Agency • Local authority services: Highways

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
				maintenance and traffic management
	Higher temperatures could increase the incidence and rate of concrete deterioration.	• Take into account potential increase in the incidence and rate of concrete deterioration in design and assessment of structures.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management
	Stresses induced by higher wind speeds and wider annual temperature ranges e.g. expansion of joints.	• Take into account stresses induced by higher wind speeds and wider annual temperature ranges e.g. expansion of joints in design and assessment of structures.	Plan for the future/Keep a 'watching brief'	• Highways Agency • Local authority services: Highways maintenance and traffic management • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP
All climate change sub-regions, in particular: Coast Thames Gateway Fens	Sea level rise, and storm surges as well as saturated fluvial catchments caused by increased precipitation, will increase flood risk on trunk roads and could cause damage.	• Consider how specifications for construction need to be revised to factor in increased flood risk associated with climate change - retrofit where necessary.	Plan for the future/Keep a 'watching brief'	• Highways Agency • Local authority services: Highways maintenance and traffic management • Environment Agency
		• Improve design and maintenance of roads in areas at risk.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management • Environment Agency
		• Locate new infrastructure away from	Plan for the future	• Highways Agency

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		high-risk areas – decision-making processes should be tightened.		• Local authority services: Highways maintenance and traffic management • Environment Agency
		• Consider the need for re-routing.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management • Environment Agency
		• Implement better drainage systems.	Act now/Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management • Environment Agency
	Flooding and drainage issues could cause scouring around bridges from faster river flows, which could cause collapse.	• Take into account potential increased scouring around bridges in design and assessment of structures.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management • Environment Agency • British Waterways
Thames Gateway Southern Heartland	Clay shrinkage due to increased temperatures and decreased soil moisture could impact on structures on which the road network is reliant, including bridges and tunnels.	• Undertake investment into adapting networks against clay shrinkage where necessary.	Plan for the future	• Highways Agency • Local authority services: Highways maintenance and traffic management

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Consider how specifications for construction need to be revised to factor in implications of clay shrinkage – retrofit where necessary. E.g. more reinforcement of bridges and tunnels.	Plan for the future/Keep a 'watching brief'	• Highways Agency • Local authority services: Highways maintenance and traffic management • Research bodies e.g. the Construction Research Innovation Strategy Panel, Engineering and Physical Sciences Research Council, UKCIP

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NATURE CONSERVATION

Key issues for adaptation

- Habitats and species may be affected
  - by direct loss e.g. from sea level rise
  - and through physical change to the environment resulting from changes in water availability and temperature increases.
- The response to changes in habitats and species brought about by climate change will largely depend on attitudes, as it does at present, but will become even more important – what should we try to save, and what should we allow to migrate, evolve and change?
- Climate 'spaces' will shift, and some species will see an increase in climate space and others a decrease. Policy and management must be developed in harmony with the natural dynamics of ecosystems.
- Climate change should present challenges and opportunities for creation of new habitats.

Baseline conditions

5.39. The East of England has a rich natural heritage, with a large number of internationally and nationally designated wildlife sites, and nationally designated landscapes. Some of the largest designated areas are located on the coast, including The Wash and Norfolk Coast Special Area of Conservation (SAC). Other important areas include the Brecks Special Protection Area (SPA). The Broads are also designated as a National Park, which is the only wetland based National Park in the UK. The North Norfolk coast and Suffolk coast are both designated as Areas of Outstanding Natural Beauty (AONBs) on account of their landscape value. English Nature and the Countryside Agency have split the whole of England down into joint character areas, which represent areas with similar landscape and habitat types. English Nature has also delineated natural areas, which are less detailed and just look at areas in terms of similar habitats.

Responsibilities for providing nature conservation services and adapting services to climate change

5.40. English Nature is the Government funded body whose purpose is to promote the conservation of England's wildlife and natural features. This is achieved by taking action directly and by working through and enabling others. There are many others involved in protecting and managing nature conservation, including non-governmental organisations, such as the Wildlife Trusts and also local authority services, through both actively managing land in their ownership and by playing an advisory/co-ordination role, for example through involvement in the preparation of biodiversity action plans.

Key impacts and adaptation responses

5.41. The Stage 1 report sets out in detail the range of impacts which climate change may have on nature conservation in the region. These impacts can be summarised as:

- Habitats and species may be affected by direct habitat loss (e.g. due to flooding) and also by the effects of temperature increases and changes in precipitation. Some species will experience a loss or reduction of suitable climate space, whilst others will see an increase in climate space.

> **Case study: A dynamic approach to nature conservation policy**
>
> Nature conservation policy is currently a 'static' mechanism that denies the dynamic nature of ecosystems and species' populations. With the onset of climate change, areas delineated for protection will migrate and so policy approaches will also need to change.
>
> In Scotland, the definition of Special Protection Areas (SPAs) has been decoupled from Site of Special Scientific Interest (SSSI) boundaries. For example, the Western Isles SPA's classified for the Corncrake, a protected species of bird, extend beyond the notified SSSI boundaries in these localities. This approach to a broader definition of the relevant area to protect a species or habitat has the added benefit of enabling active management to encourage the migration of species, or expansion/restoration of key habitats under climate change.
>
> **Summarised from Climate Change and UK Nature Conservation: A review of the impact of climate change on UK species and habitat conservation policy. 2000. Funded by DETR.**

- Salt marshes will be under pressure, with certain drought sensitive species facing extinction.
- The response to coastal flood risk will also have a major bearing on salt marshes: 'holding the line' against sea level rise would place all the region's salt marshes at risk.
- The Fens face major changes due to sea level rise leading to reversion to wetlands and salt marsh, depending on the management response to flood risk.
- Lowland heath may be threatened by land use changes more than direct effects of climate change.
- Opportunities for re-creation of grazing marshes as farmers abandon land vulnerable to flooding.
- Opportunities for creation of other habitats.
- Species found in cereal field margins will continue to find suitable climate space in the region.

- Some woodland species e.g. beech woodland are expected to lose ground in the East of England, whilst others may gain ground e.g. Lime, Sycamore and Holly.
- Reduced summer rainfall and increased temperatures, in conjunction with increased demand for water resources, could have a detrimental effect on river and wetland ecology.
- The increase in frequency of extreme events, such as storms and droughts, may increase the likelihood of local extinctions.
- Pests and diseases are likely to become more prevalent due to warmer summers and milder winters, which could affect some plant species, particularly trees which are likely to become more drought stressed in summer and susceptible to attack.
- Establishment of young trees and survival of urban trees is likely to be particularly affected.
- A shortened period for recharge of groundwater supplies and lower precipitation in summer could affect habitats, particularly wetland and riverine habitats by limiting water availability.

5.42. **Table 5.9** identifies possible adaptation measures in relation to habitat management and protection in the East of England.

Case study: Accommodating ecosystem dynamics through agri-environment schemes

Measures within agri-environment schemes could be used to help 'fixed' systems of nature conservation adapt more readily to climate change. For example, stewardship scheme agreements could be used to provide buffer zones around protected sites or to create stepping-stones for movement of species and habitats.

Summarised from Climate Change and UK Nature Conservation: A review of the impact of climate change on UK species and habitat conservation policy. 2000. Funded by DETR.

Table 5.9: Nature conservation - Habitat management and protection

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Overall habitats and species may be affected by direct loss and through physical change to the environment resulting from changes in water availability and temperature increases. (These impacts are detailed in the Stage 1 Report).	• Ensure detailed management plans and guidelines are drawn up for habitat managers – need to consider the individualistic responses of species to climate change and how this will be reflected in community dynamics and ecosystem function.	Plan for the future	• English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts. • Environment Agency
		• Ensure policy builds on the natural dynamics of ecosystems and incorporates buffer zones around designated areas.	Plan for the future	• Defra • English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts. • Environment Agency
		• Strengthen nature conservation outside of designated areas.	Act now & plan for the future	• English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts. • Environment Agency
		• Allow natural migration processes to operate where possible.	Plan for the future	• English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts. • Environment Agency

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Include climate change responses in Biodiversity Action Plans.	Plan for the future	• English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts. • Environment Agency
	Warmer summers and milder winters could lead to increased growth of noxious weeds.	• Monitor growth and ensure time and monetary resources are allocated to responding to increased growth of weeds.	Plan for the future/Keep a 'watching brief'	• Wildlife Trusts and other conservation organisations. • Environment Agency
	Increased flood risk from rivers and streams could have detrimental effects on ecology and soils.	• Ensure river basin management plans implemented through the Water Framework Directive consider the implications of climate change on flood risk and the associated impacts on ecology and soils.	Act now	• ODPM • Defra • English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts • Environment Agency
		• Developing incentive schemes for land managers to facilitate flood relief measures as well as developing visions for floodplain restoration to deliver BAP targets.	Act now/Plan for the future	• English Nature • Defra • Environment Agency
	Lowland woodlands may suffer from an increased frequency of drought conditions and some woodland may be exposed to increased storm damage.	• Implement strategies to cope with the nature conservation implications of climate change on lowland forests e.g. strategies to plant new more suitable species of trees in areas adversely affected by lack of water.	Plan for the future	• English Nature • Forestry Commission • NGO's e.g. Wildlife Trusts • Local authority services: Environment

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
				and planning • Environment Agency
Coast **Fens** **Thames Gateway**	Coastal and wetland habitats could be particularly affected due to potential "coastal squeeze".	• Achieve a shift from 'coastal defence' to 'coastal management' all organisations should work towards this aim.	Plan for the future	• English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts • Environment Agency
		• Promote the integration of 'biodiversity' into SMPs to help meet UK Biodiversity targets for coastal habitats.	Plan for the future	• English Nature • Local authority services: Environment and planning • NGO's e.g. Wildlife Trusts • Other stakeholders involved in Coastal Zone Management Plans e.g. Environment Agency

Sources of information

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LUC (Feb 2003) Living with climate change in the East of England: Stage 1 Interim Report; Guidance on Spatial Issues

THE HISTORIC AND ARCHAEOLOGICAL ENVIRONMENT

Key issues for adaptation

- English Heritage is currently considering the impacts of climate change on the historic and archaeological environment, which encompasses both built heritage and parks and gardens and other 'outdoor' sites.
- Due to the sensitive nature of the resource, adaptation measures must be undertaken carefully.
- Responding to climate change may lead to an increase in maintenance costs. For example, rainwater disposal systems on buildings may need to be redesigned and updated, whilst storms may cause costly structural damage.
- There is a wealth of historic sites on the coast and these sites will be subject to increased coastal flood risk, whilst inland properties may be at increased risk of fluvial flooding. Such risks will be hard to respond to, as it may not always be appropriate to defend sites, and acceptance of some losses may be necessary.

Baseline conditions

5.43. The East of England has a rich historic legacy, reflected in the many Scheduled Ancient Monuments (SAMs), English Heritage sites, historic towns, National Trust sites, cathedrals and Heritage Economic Regeneration areas. These are scattered throughout the region, with numerous sites found on the coast.

Responsibilities for managing and protecting the historic and archaeological environment and adapting services to climate change

5.44. English Heritage is a key partner in managing the historic and archaeological environment and must play a strong role in ensuring this service area adapts to climate change. English Heritage is the Government's statutory adviser on the historic environment. It is funded in part by the Government and in part from revenue earned from the historic properties it manages and other services. English Heritage works in partnership with the central government departments, local authorities, voluntary bodies and the private sector to conserve and enhance the historic environment, broaden public access to the heritage and increase people's understanding of the past.

5.45. Other key partners include the National Trust, which owns and manages a large number of historic properties and parks and gardens and local authority heritage services, which play a key role in providing advice on heritage issues, updating records and promoting heritage.

Key impacts and adaptation responses

5.46. The historic and archaeological environment is likely to be affected by climate change in a number of ways. English Heritage is currently undertaking research into climate change and the historic environment, which provides a useful overview of potential impacts. This research is still at an early stage and whilst it provides a good basis for developing adaptation strategies, further, more detailed research is required. Potential impacts include:

- Potential damage from mobilised contaminants attacking foundations.
- Increased risk of subsidence.
- Historic sites subject to fluvial and coastal flood risk.
- Changes in soil moisture levels and water table height and chemical/biological processes may damage buried sites; wet-dry cycles will be most damaging.

Case study: Coastal survey of the historic environment

English Heritage, in collaboration with County Council archaeologists, has undertaken a survey of the East Anglian coast to record the historic environment of the two areas, including archaeological sites, historic buildings and historic landscapes. This work has been carried out because English Heritage is aware that the historic environment is at risk from climate change, in particular sea level rise and enhanced erosion due to increased storminess. The two regions were selected due to their vulnerability to climate change within the context of England as a whole. The surveys will provide data on the historic environment to feed into the next generation of Shoreline Management Plans.

Personal comment Peter Murphy, Regional Advisor for Archaeological Science, English Heritage, 5th January 2004

- Changes in wind speeds/gustiness could lead to erosion of dry sites e.g. barrows. The UKCIP02 scenarios show slight increases in average wind speeds in some seasons, but modelling inconsistencies mean that only a low level of confidence can be attached to these results.
- Structural damage from extreme storm events, including erosion damage.

5.47. **Table 5.10** identifies possible adaptation measures in relation to heritage management and protection in the East of England.

Case study: Managing historic properties

The National Trust is becoming increasingly active in developing and promoting measures to adapt to climate change. The Trust is aiming for climate change to be taken into account in property management plans. They are encouraging this through discussions with key parties such as property managers.

The National Trust Environment Officer for the Thames and Solent Region is currently providing guidance for the Trust to increase awareness of the likely impacts of climate change and how these will affect the Trust and its properties, as well as potential adaptation measures that could be implemented.

Personal comment. with Alison Jennings, National Trust, 26th August 2003

Case study: Sustainable building techniques - The Brancaster Millennium Activity Centre, Norfolk

Situated on the North Norfolk Coast at Brancaster Staithe, The Dial House comprises a vernacular Grade II listed building group owned by The National Trust. In 1997 The Trust, with the benefit of grant aid from The Millennium Commission, embarked on the development of the site. The brief required the conservation of the fabric and the conversion and extension of the buildings to provide a living and teaching environment for up to 50 residential visitors. The development was carried out using materials, construction methods and energy resources of minimal environmental impact. The work was undertaken in sustainable new and reclaimed materials. The centre, completed in autumn 1998, employs a heat exchanger drawing its primary heat source from the mud in the adjacent tidal creek, solar panels, photo voltaic cells and wind power. The conversion and ongoing servicing, as well as the location of the building, is drawn on as a positive teaching tool to illustrate the relationship between man and the natural environment. IT installations provide a continuing monitor of energy consumption from the various renewable resources available.

The development was designed to minimise the effects of tidal inundation due to rising sea levels. For example, the design and furnishings allow a swift clean up after a flood event, and all vulnerable services and materials have been installed above high watermark.

http://www.paulbancroftarchitects.com/brancasterCENTRE.htm
The National Trust: Climate Change: An update on recent work by the Trust and key issues. 2000.

Case study: The National Trust's Sustainable Urban Drainage System Policy

The National Trust is promoting Sustainable Urban Drainage Systems by specifying previous materials for roads and car parks in built areas to allow slow infiltration of rainfall avoiding flash run-off from hard surfaces, for example, at Dunham Massey, an early Georgian property in Cheshire.

Summarised from The National Trust: Guidance on flooding, rivers and floodplain management. December 2000. Peter Nixon, Director of Estates.

Table 5.10: The historic and archaeological environment - Heritage management and protection

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Changes in seasonal temperatures will have implications for ventilation and heating.	• Respond to the lesser need for heating.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
		• Review ventilation requirements.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
	Changes in seasonal rainfall may mean that current rainwater disposal systems are inadequate.	• Undertake careful research and planning into new designs.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
		• Plan for adequate maintenance, which will be extremely important.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
	Extreme winter precipitation is likely to become more frequent and may cause damage to structures.	• Undertake careful research and planning into new designs for rainwater disposal systems, as current systems may not be adequate.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Plan for adequate maintenance, which will be extremely important.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
		• Ensure disaster planning is undertaken.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
	Potential structural damage from extreme storm events.	• Consider the need to consolidate ruins.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
		• Plan for increased monitoring and maintenance.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
		• Recognise and plan for the increased need for shelterbelts.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
	Water table chemistry may change due to mobilisation of salts and pollutants, which could alter preservation conditions and cause damage to foundations.	• Undertake research into deterioration.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Undertake regular testing of soils (especially for historic plant collections).	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
	Changes in relative humidity may cause damage to brickwork.	• Plan for and undertake increased monitoring.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
		• Undertake improvements to building ventilation.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
	Pests are likely to become more prevalent due to warmer summers - termites would be a particular problem.	• Undertake increased monitoring and research.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
		• Implement more stringent pesticide regimes if necessary, as plant collections likely to be increasingly susceptible to pests.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
		• Re-use site materials in preference to import.	Act now/Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
	Increased solar radiation could	• Plan for increased maintenance and	Plan for the future	• Local authority

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	affect preservation.	monitoring of filters.		services: Heritage services • English Heritage • National Trust
		• Undertake risk assessment to ascertain whether current regimes are sufficient.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
		• Plant trees to provide shade.	Act now/Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
All climate change sub-regions, in particular: Coast	Historic sites will increasingly become subject to fluvial and coastal flooding and coastal storm surges.	• Undertake regular risk assessments/ surveys.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust • Environment Agency
		• Prioritise sites and accept that loss may have to occur.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust • Environment Agency
		• Undertake flood remediation studies.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust • Environment Agency

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions, in particular: Southern Heartland Thames Gateway	Changes in soil moisture, which could lead to subsidence and dewatering of buried archaeology and also affect planting e.g. in historic gardens. May also be more damaging wet-dry cycles.	• Monitor buried sites. Further actions to mitigate are likely to be needed at the regional level rather than site level.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
		• Research the possibility for actions to mitigate against subsidence.	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
	Water supply issues for plants and water features.	• Undertake improved soil husbandry and regular soil testing (especially for historic plant collections).	Plan for the future/Keep a 'watching brief'	• Local authority services: Heritage services • English Heritage • National Trust
		• Irrigate where necessary.	Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust
		• Adapt planting by using species with lower water requirements.	Act now/Plan for the future	• Local authority services: Heritage services • English Heritage • National Trust

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LUC (Feb 2003) Living with climate change in the East of England: Stage 1 Interim Report; Guidance on Spatial Issues

AGRICULTURE, FISHERIES, WOODLAND AND FORESTRY

Key issues for adaptation

- Agriculture is an important economic activity in the East of England. It is likely to face considerable impacts from climate change. Key implications revolve around increased temperatures and hence an increased thermal growing season, but a decrease in water availability which may constrain opportunities. Flood risk will also have a significant bearing on agriculture and forestry.
- Adaptation in the types of crop varieties grown will be required – taking into account species likely to fare better and species likely to fare worse.
- Adaptation will also be required in many farming activities, such as the timing of planting and harvesting, the level and timing of fertiliser applications, ploughing techniques, etc.
- Adaptation to water supply constraints will also be very important – farmers will need to consider measures such as growing crops with lower water requirements, and innovative ways to manage water, such as winter storage reservoirs and rainwater harvesting.
- Woodland planting may be limited in some circumstances due to water demand and favourable woodland species may change.
- Inland fisheries may be affected if land is allowed to flood; the impacts on coastal fisheries are uncertain. At this stage no clear adaptation measures can be recommended, except to monitor the situation and plan accordingly.

5.48. The potential impact of climate change on arable farming is a key topic covered by the REGIS study[28]. The ACCELERATES programme[29], which has not yet produced any written outputs, should further inform the opportunities for agriculture. MAFF has also undertaken research into the implications of climate change for the agricultural industry[30], which was the culmination of seven years of research. The Forestry Commission has undertaken research into the climate change implications for trees and woodland in the East of England (Forestry Research, 2002)[31], and also for

[28] Holman I P, Loveland P J, Nicholls R J, Shackley S, Berry P M, Rounsvell M D A, Audsley E, Harrison P A and Wood R (2002), *REGIS – Regional Climate Change Impact and Response Studies in East Anglia and North West England*, Defra.

[29] ACCELERATES www.geo.ucl.ac.be/accelerates

[30] MAFF (no date) *Climate change and agriculture in the United Kingdom*. MAFF.

[31] See also website: www.woodlandforlife.net

forestry in Britain as a whole (Forestry Commission, 2000). Defra has also considered the implications of climate change for their activities[32], which includes findings and recommendations in relation to agriculture, woodland and forestry, as well as recommendations for further research and actions on the part of Defra.

Case study: Favourable conditions for some crop types

Conditions in the southern UK may become more suitable for crops common in continental Europe, such as grain maize and sunflower.

Climate Change and Agriculture in the United Kingdom, prepared for MAFF. 2000.

Case study: Crop development rates

Increased development rates caused by warming associated with climate change may be detrimental for some crops. Crops such as wheat and barley that depend on accumulated heat to trigger each developmental stage will have shorter development phases. The periods of grain filling and ripening may be too short to produce satisfactory yields. Early maturity induces woodiness in horticultural crops. To overcome this, selection of new cultivars or management practices may be required, for example by cutting herbage to keep crops in a vegetative condition.

In contrast, crops such as Sugar Beet, continue to produce leaves and other organs for as long as the temperature remains suitable. Yields increase with temperature rises.

Climate Change and Agriculture in the United Kingdom, prepared for MAFF. 2000.

Baseline conditions

5.49. Agriculture is an important activity in the East of England in terms of land use and economic activity. Primary agriculture contributes 2.1% to GDP in the East of England compared to England's average of 1.8%. The East of England has 26% of England's cereal hectarage, over a third of its pig population and 21% of the total poultry population[33]. Grade 1 and 2 agricultural land in the region is concentrated in the western side of the region, with the largest areas of Grade 1 land in the Fens. There are also pockets of Grade 1 and 2 agricultural land along the north Norfolk coast.

Case study: Soil erosion on agricultural land

In recent years some 24 billion tons of topsoil has been eroded from farmland per year globally, leading to the projection that 30% of the world's arable land could be depleted within 20 years. In the UK, 450,000m^3 of soil is eroded from farmland every year and water erosion of arable land has increased considerably over the last 20 years. For example, at the National Trust property in Arlington, a lake that was de-silted 10

[32] Defra (January 2003) *The impacts of climate change: Implications for Defra.* A report by the In House Policy Consultancy.

[33] ACCELERATES East Anglia case study from www.geo.ucl.ac.be/accelerates

years ago has since accumulated 18,000m^3 of silt. Climate change may worsen the erosion of farmland with wind blown erosion during drier summers and erosion from run-off during wetter winters.

The National Trust: Soil Policy. 2000.

5.50. The East of England has 7.3% woodland cover[34], compared to the highest cover of 14.1% in the South East, and the lowest cover (outside of London) of 5.1% in the East Midlands. Woodland is scattered throughout the region, bar the Fens, which have little or no wooded areas. There are concentrations of woodland in, for example, Thetford on the Norfolk-Suffolk border, and in the southwestern corner of the region in Hertfordshire.

Responsibilities for adapting services to climate change

5.51. A number of key partners are involved in delivering adaptation to climate change in terms of agriculture, fisheries, woodland and forestry.

5.52. Key partners in terms of agriculture include:

- Farmers and land managers
- Farmer producer groups and co-operatives
- Advisory bodies e.g. the Farming and Wildlife Advisory Group (FWAG)
- Industry bodies, including:
    - National Farmers Union (NFU)
    - Country Land Owners Association (CLA)
    - Tenant Farmers Association (TFA)
- Relevant industry associations e.g. National Beef Association
- EEDA
- Defra for national policy and guidance and the local Defra team in GO-East
- Research interests e.g. the Central Science Laboratory and Defra
- The Soil Association in relation to organic farming
- The Environment Agency in relation to flood risk, through providing flood risk management and playing an advisory role
- The Internal Drainage Boards (IDB's).

34 National inventory of woodland and trees. Forestry Commission. 2001.

5.53. The key partners in relation to woodland and forestry are the land managers who manage woodlands and forests and the Forestry Commission, a major land owner and land manager and also a provider of guidance and advice on a range of forestry issues. In terms of fisheries, key partners include industry bodies and Defra.

Key impacts and adaptation responses

5.54. The Stage 1 report sets out potential impacts on agriculture, woodland and forestry and fisheries. Key impacts include:

- Agriculture is likely to see an increased growing season; but decreasing soil moisture and availability of water supply for irrigation may constrain opportunities to capitalise on warmer temperatures.

Case study: Commercial benefits for some vegetable varieties

The successful production of field vegetables is related to the timing of maturity, crop uniformity and product quality. Changes in temperature will affect all of these aspects. Where higher temperatures create problems for certain vegetables, they can be avoided by selecting a different variety. Those species that are most likely to benefit commercially from increased temperature are Phaseolus Bean, Onion and Sweetcorn. High temperatures will also aid Carrot production. Carrot growth rates increase with temperature, and growth occurs best at soil temperatures of 20-30oC.

Climate Change and Agriculture in the United Kingdom, prepared for MAFF. 2000.

- Reduced summer soil moisture will be a key constraint, especially in the south of the region.
- The pressures which agriculture puts on water supplies is already felt in the Anglian region, which is the driest in the UK. Similarly the Thames region is facing great pressures.

Case study: Water conservation measures

Agricultural water demand and availability will be affected by climate change. The largest increase in water demand could potentially come from an increase in the area of land being irrigated. Methods to combat this include water efficiency and changing farming practices, for example, earlier planting and harvest dates would avoid periods of peak moisture demand. Or on-farm water conservation methods could be employed, for example, water harvesting from roofs and paved areas or construction of winter storage reservoirs.

Summarised from Climate Change and Agriculture in the United Kingdom, prepared for MAFF. 2000.

- Irrigation demand for key irrigated crops could increase by between 12 and 27% in the next 25 years according to Environment Agency research.

- Arable crop yields could initially benefit from temperature changes but this has the potential to decline over the long term.
- Some crops will become increasingly commercially attractive e.g. sugar beet and potato.
- Livestock production systems, could be affected by higher temperatures, leading to increased requirements for drinking water, water wallowing sites for pigs and water to cool livestock units.
- Access to land in winter may be constrained by increased precipitation, and possible increased storminess, causing waterlogging and flooding.
- Some agricultural land is likely to be lost due to fluvial and coastal flooding, the extent of which would depend on the climate change scenario and extent of flood risk. Increased flood risk may lead to changes in land use as farmers abandon arable cropping on such land.
- Woodland planting may be limited in some circumstances due to its higher water usage compared to some other land uses.
- Favourable woodland species may change (e.g. yields of Corsican Pine are predicted to increase, whilst Scots Pine is likely to decrease).

Case study: Choice of tree species

A review of climate change implications for trees and woodland by the Forestry Commission recommends that where a species is already close to the limit of its range (on the basis of moisture availability), further trees of that species should not be planted. Changes to the Woodland Grant Scheme (WGS) should be considered to accommodate this. Species and planting choice will become increasingly limited as a result of rising summer soil moisture deficiencies.

Summarised from Broadmeadow MSJ (2002). A review of climate change implications for trees and woodland in the East of England. Forest Research, Farnham.

- Increased risk of forest fires.
- Certain short rotation coppice tree species (Poplar and Willow) have higher water demand than other tree species which may limit opportunities; however, varieties are being developed to withstand drier conditions. There are also likely to be opportunities for new bioenergy crops e.g. Switch Grass as cultivated in the USA, Prairie Grass and Giant Reed. Miscanthus will continue to be suitable, as it is reasonably drought tolerant.
- Inshore fisheries and inland fresh water fisheries could be affected if low lying land is allowed to permanently flood as in the Fens.

- Impacts on coastal fisheries are uncertain, but external pressures of declining fish stocks are likely to exert far greater pressures on the industry.

5.55. **Tables 5.11 – 5.13** identify possible adaptation measures in relation to agriculture, woodland and forestry and fisheries in the East of England and set out time frames within which measures should be implemented, and the key partners who should be involved in bringing forward each measure.

Case study: Adapting planting regimes in the UK wine industry

There may be an increase in the commercial viability of the UK wine industry due to a longer, thermal growing season. Traditional agricultural practice for developing vineyards is to plant the vines and leave them unwatered so the roots burrow down into the earth and tap natural sources of water. This practice makes vines more robust during times of drought. However, vineyards managed in this way do not yield commercial returns for 5-10 years. Recently the wine industry, to meet demand, has been watering vines from the outset in order to become commercially viable within 2-3 years, this encourages continued intensive watering, as the vines' roots are shallow and unable to reach natural groundwater resources. In times of drought shallow vines die easily due to cracking of the earth, drier conditions and exposure of roots. With careful planning and guidance unnecessary water use and reliance can be avoided.

Case study: Farm level planning for drought management

Silver Birches Plc, a farm near Ely, is the site of a research project looking at how agribusinesses can adapt to the possibility of droughts. The farm has some 94,000 trees; an interruption of the mains water supply during a drought would irreparably damage the entire stock within 15 days. Two methods of drought management were reviewed: an "infrastructural strategy" and an "informational strategy", to determine which is the most effective.
The farm has recently received a licence to abstract water from a nearby field drain during the winter months from the Environment Agency. Thereafter the winter storage reservoir can be pumped for irrigation purposes at any time the farmer desires.
The "infrastructural strategy" involves filling the reservoir in winter and using only half the reserve in the summer to irrigate, therefore retaining enough water to cope during drought conditions (during which time water supplies would be cut off). However, once half the reserve has been used the remaining water needed for the summer would require costly purchases from the supply company.
The "informational strategy", in contrast, allows the use of water as needed, alongside monitoring of rainfall levels to regularly update a 'drought-warning chart'. This is used to determine if the farm needs to prepare for a drought event. Based on this a decision is taken as to whether to carry on extracting from the reservoir or to prepare for a drought event (during which time mains supplies would be cut off). If the latter decision is made, then the farm must immediately purchase sufficient water to add to the existing stock to withstand a potential drought.
The research showed that an information-based drought warning system is more flexible and far less costly. Such farm level planning is likely to become increasingly important as climate change brings with it more extreme events and more frequent low dry-season flows. Drought management at farm level should draw not only on civil engineering initiatives but also on an informed understanding of the often complex linkages between regional hydrology and the farm's hydro-social supply systems. Informational strategies, combined with infrastructural investment, can be cost-effective and can reduce or even eliminate the impact of drought on farm output if intelligent use is made of adaptive management based on trigger routines.

Summarised from Farm-level Drought Management: An Irrigation Case study from the UK, 2003, Dr Stephen Merrett. Unpublished

Case study: Increasing use of winter storage reservoirs

"Irrigation is hugely important in the East of England, and demand seems to be increasing. Historically, in some areas, this has been met from boreholes but, where catchments have been assessed as fully committed, farmers are having to look at alternatives. The most common is to go for winter storage and we are finding that reservoirs are now being considered (and constructed) in areas in which they had previously been considered to be uneconomical as well as in the more traditional 'clay' areas such as Essex."

Steve Dines, Senior Technical Specialist (Abstraction Licensing), Environment Agency Anglian Region

In 2003 the Agency issued a licence for a large irrigation reservoir (910,000 cubic metres capacity) to be used mainly to supply a large estate but may supply water to other farms as well. Although the developer may not have designed the reservoir with climate change specifically in mind, mitigating against uncertainty was definitely the driving force of the application for a licence.

David Hendrikz, Team Leader Regulation (Water Resources) Environment Agency.

Case study: Farm Waste Plans

The National Trust is developing a new agricultural policy which factors in climate change, for example, through Farm Waste Plans. These plans address factors such as rainfall run off, volume of dirty water storage, land available for spreading, high-risk areas, nitrogen loadings etc. They will need to take into account climate changes such as increases in rainfall and seasonality, temperatures and groundwater responses etc.

The National Trust: Climate Change: An update on recent work by the Trust and key issues. 2000.

Table 5.11: Agriculture

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Some crops will become increasingly commercially attractive e.g. Sugar Beet and Potato, but potential for new crops likely to be very limited as yields would remain too low at least until the 2050s.	• Adopt better adapted crop varieties.	Plan for the future/Keep a 'watching brief'	• Farmers and land managers • Farmer producer groups and co-operatives • Advisory bodies e.g. Farming and Wildlife Advisory Group (FWAG) • Industry bodies • Relevant industry associations • EEDA • The Defra team in Go-East • Research interests
		• Undertake close crop monitoring.	Keep a 'watching brief'	• Farmers and land managers • Farmer producer groups and co-operatives • Advisory bodies e.g. FWAG • Industry bodies • Relevant industry associations • The Defra team in Go-East • Research interests
	Increased temperatures and enhanced growing season likely to affect planting and harvesting dates.	• Take a flexible approach to planting and harvesting.	Keep a 'watching brief'	• Farmers and land managers • Farmer producer groups and co-operatives • Advisory bodies e.g. FWAG • Research interests
	Changes in rainfall patterns and temperature could affect the interaction between fertiliser use and water quality.	• Consider whether guidance on fertiliser application is appropriate or will need to be reviewed, for example as winters get wetter, and there is increased risk of leaching into watercourses.	Plan for the future/Keep a 'watching brief'	• Advisory bodies e.g. FWAG • Defra • Research interests • The Environment Agency

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	Livestock production systems, could be affected by higher temperatures, leading to increased requirements for drinking water, water wallowing sites for pigs and water to cool livestock units.	• Adopt, better adapted animal breeds.	Plan for the future/Keep a 'watching brief'	• Farmers and land managers • Farmer producer groups and co-operatives • Advisory bodies e.g. FWAG • Industry bodies • Relevant industry associations e.g. National Beef Association • The Defra team in Go-East • Research interests
		• Adopt and develop appropriate low-cost water conservation methods e.g. rainwater harvesting.	Act now/Plan for the future	• Farmers and land managers • And work with Environment Agency and water companies
		• Increase tree cover to provide shade.	Act now/Plan for the future	• Farmers and land managers • Forestry Commission
		• Undertake cooling of indoor livestock units where necessary (but aim to limit due to the associated water demands).	Plan for the future	• Farmers and land managers
	Possible increases in soil erosion in drier conditions and from flash flooding. Slope failure from excessive rainfall.	• Adopt techniques to control soil erosion e.g. contour ploughing.	Act now/Plan for the future	• Farmers and land managers • Advisory bodies e.g. FWAG – consider how good practice guidance can be incorporated into current guidance material
		• Reduce grazing pressures.	Act now/Plan for the future	• Farmers and land managers • Advisory bodies e.g. FWAG
		• Increase woodland and hedgerows to create shelter belts.	Act now/Plan for the future	• Farmers and land managers • Forestry Commission

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	Access to land in winter may be constrained by increased precipitation, and possible increased storminess, causing waterlogging and flooding.	• Improve drainage systems to prevent saturation of the soil.	Plan for the future	• Farmers and land managers • Environment Agency
		• Add organic material to soil, to allow better working of clay soils in wetter conditions.	Act now/Plan for the future	• Farmers and land managers • Advisory bodies e.g. FWAG • The Soil Association
		• Where possible site buildings outside areas liable to winter flooding.	Plan for the future	• Farmers and land managers • Work with Environment Agency and Local Authority Planning and Environment teams
	Possible changes in consumer demand for products e.g. for red meat in hot summers.	• Adapt agricultural systems to meet changing consumer demands.	Plan for the future	• Farmers and land managers • Farmer producer groups and co-operatives • Industry bodies • Relevant industry associations • EEDA • The Defra team in Go-East
All climate change sub-regions, in particular: **Fens** **Northern Heartland**	Possible threats from pests and diseases affecting crops and animals.	• Defra to ensure practical plans are in place to anticipate and respond to potential threats.	Plan for the future	• Defra
		• Develop weed, pest and disease control strategies.	Plan for the future	• Farmers and land managers • Advisory bodies e.g. FWAG
		• Organic farming will particularly need to consider threats and measures to cope with added threats.	Plan for the future/Keep a 'watching brief'	• Soil Association

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
		• Adopt; better adapted, crop varieties and animal breeds.	Plan for the future/Keep a 'watching brief'	• Farmers and land managers • Farmer producer groups and co-operatives • Advisory bodies e.g. FWAG • Industry bodies • Relevant industry associations • EEDA • The Defra team in Go-East • Research interests
		• Undertake close crop monitoring.	Keep a 'watching brief'	• Farmers and land managers • Farmer producer groups and co-operatives • Advisory bodies e.g. FWAG • Industry bodies • Relevant industry associations • The Defra team in Go-East • Research interests
All climate change sub-regions, in particular: Southern Heartland	Decreasing soil moisture and availability of water supply for irrigation, which may constrain opportunities to capitalise on warmer temperatures.	• Defra to ensure that grant-aid for agri-environment schemes, is directed to schemes which can withstand the expected impacts of climate change.	Plan for the future	• Defra
		• Adopt, appropriate low-cost water conservation methods e.g. small scale water reservoirs, water harvesting measures.	Act now/Plan for the future	• Farmers and land managers • And work with Environment Agency and water companies
		• Adopt water-efficient irrigation methods.	Act now	• Farmers and land managers • And work with Environment Agency and water companies
		• Adopt, better adapted, crop varieties.	Act now/Plan for the future	• Farmers and land managers • Farmer producer groups and co-operatives

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
				• Advisory bodies e.g. FWAG • Industry bodies • Relevant industry associations • EEDA • The Defra team in Go-East • Research interests
		• Undertake close crop monitoring.	Keep a 'watching brief'	• Farmers and land managers • Farmer producer groups and co-operatives • Advisory bodies e.g. FWAG • Industry bodies • Relevant industry associations • The Defra team in Go-East • Research interests
		• Implement water demand management measures.	Act now/Plan for the future	• Environment Agency
All climate change sub-regions, in particular: Fens Coast	Flood risk to agricultural land.	• Consider suitability of alternative less intensive agricultural systems e.g. wet grazing marsh.	Plan for the future	• Defra • Work with conservation organisations

Table 5.12: Fisheries

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
Coast	Impacts on coastal fisheries are uncertain, but external pressures of declining fish stocks are likely to exert far greater pressures on the industry.	• Monitor possible impacts as knowledge improves, and plan for accordingly.	Keep a 'watching brief'	• Industry bodies • Defra • Environment Agency

Table 5.13: Woodland and forestry

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	Woodland planting may be limited by water availability.	• Ensure new planting utilises species with appropriate water requirements.	Act now/Plan for the future	• Forestry Commission • Farmers and land managers
		• Bioenergy crops with lesser water demand/more tolerant of drier conditions should be considered.	Plan for the future	• Forestry Commission • Farmers and land managers
		• Avoid sites for woodland that are likely to be affected by increased wind and storm risks or reduced soil moisture/drought, possible use of new species should be taken into account.	Plan for the future/Keep a 'watching brief'	• Forestry Commission • Farmers and land managers
	Suitability of woodland species to climatic conditions may change.	• New planting should seek to utilise species, which are best able to cope with predicted climatic conditions.	Act now/Plan for the future	• Forestry Commission • Farmers and land managers
		• Undertake close monitoring of species.	Keep a 'watching brief'	• Forestry Commission
	Increased risk of forest fires.	• Ensure emergency preparedness is in place.	Plan for the future	• Forestry Commission • Co-ordination with emergency services.
	Increased recreational demand on woodlands.	• Put in place appropriate management plans.	Plan for the future	• Forestry Commission • Other land owners managing woods for recreational use
		• Provide appropriate facilities.	Plan for the future	• Forestry Commission • Other land owners managed for

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
				recreational use
	Possible threats from pests and diseases affecting woods and forests.	• Forestry Commission to ensure practical plans are in place to anticipate and respond to potential threats.	Plan for the future/Keep a 'watching brief'	• Forestry Commission
		• Develop weed, pest and disease control strategies.	Plan for the future	• Forestry Commission
		• Adopt, better-adapted species.	Plan for the future	• Forestry Commission
		• Undertake close monitoring of species.	Keep a 'watching brief'	• Forestry Commission

Sources of information

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Holman I P, Loveland P J, Nicholls R J, Shackley S, Berry P M, Rounsvell M D A, Audsley E, Harrison P A and Wood R (2002), *REGIS – Regional Climate Change Impact and Response Studies in East Anglia and North West England*, Defra.
MAFF (2000) *Climate change and agriculture in the United Kingdom*. MAFF.

HEALTH SERVICES

Key issues for adaptation

- Impacts on health, without appropriate adaptation strategies, could be wide ranging, for example from heat related deaths and illness, increased food poisoning, increased injuries during storm events and increased incidence of skin cancer to note but a few.
- Climate change could place a burden on the National Health Service as these impacts arise, however, there may also be some lessening of pressures, for example from illness and death caused by cold winter temperatures.
- The Primary Care Trusts will have a key role to play in adapting services to the pressures created by climate change.
- Preventative care will be very important, for example ensuring people use UV sunscreens and ensuring vulnerable people are able to avoid high temperatures in summer e.g. in old people's homes.
- A wide range of other partners will also need to be involved in responding to health impacts. For example, local authorities, to ensure water quality used for recreational purposes does not deteriorate hence causing health problems and similarly local authority environmental health departments, will play a role in minimising food safety risks.

5.56. It is becoming clear that climate change will affect health. The Department of Health has recognised the fact that there is a need to understand the likely effects in the UK in order to develop strategies to mitigate such effects and to understand the extent of adaptation required. In addition, the increased burden likely to be imposed on the National Health Service must be understood. For example, the need for medical facilities to cope with the increased demands produced by more patients suffering from familiar disorders such as heat stroke or skin cancer and from comparatively rare disorders.

Case study: Hot weather linked to above average death rates

During a week in August 2003 when temperatures reached 38.1ºC, there were 907 more deaths than the five-year average (10,132). In France, up to 10,000 deaths were linked to the heat.

Summarised from Metro newspaper, Wednesday September 3rd, 2003.

5.57. In 2001, the Department of Health published a research report entitled, *Health Effects of Climate Change in the UK – An expert review for comment*. This provides a study of the likely incidence of different diseases and other health impacts, such as injuries, which might be expected to occur as a result of climate change.

Responsibilities for providing health services and adapting services to climate change

5.58. In terms of providing health services and ensuring health services are equipped to respond to climate change, the Primary Care Trusts, working within the structure set by the Strategic Health Authorities have a key role to play.

5.59. Strategic Health Authorities are responsible for developing strategies for the local health services and ensuring high-quality performance. They manage the NHS locally and are a key link between the Department of Health and the NHS. They also ensure that national priorities (such as programmes for improving cancer services) are integrated into local plans.

5.60. The Primary Care Trusts (PCTs) are the cornerstone of the NHS, responsible for the planning and securing of health services and improving the health of the local population. For example, PCTs must make sure there are enough GPs and hospitals to provide for the population and that they are accessible to patients. In addition, they are responsible for integrating health and social care, so the two systems work together for patients.

5.61. The partners identified above are responsible for provision of health services. However, a range of other partners will also need to be involved in responding to the potential implications of climate change on health. The range of partners involved, are identified below.

Key impacts and adaptation responses

5.62. **Table 5.14** summarises the potential impacts of climate change on health services. Much of the information is drawn from Department of Health research. It should be noted that this report refers to the 1998 UKCIP Climate Change Scenarios as a basis and not the most recent 2002 scenarios.

5.63. The UKCIP02 and UKCIP98 scenarios do differ slightly and may therefore have slightly different implications for health impacts. In summary the UKCIP02 scenarios show slightly greater warming rates, slightly smaller rates of sea-level rise, summers may become drier by a larger amount than under the 1998 scenarios, spring and summer are likely to become slightly drier (the UKCIP98 scenarios suggested they would become wetter). The UKCIP02 scenarios suggest different patterns of change in average wind speed compared to the 1998 scenarios, but little confidence can be attached to the simulated changes. Overall UKCIP02 includes a more comprehensive analysis in changes in some aspects of extreme weather and extreme sea levels, and hence UKCIP has more confidence in the UKCIP02 results.

5.64. As a very approximate guide, the East of England accounts for 9% of the UK population and so we have indicated the level of impacts on the East of

England on a simple pro rata basis taking 9% of the UK figures quoted in the Department of Health report.

Case study: Reducing heat related deaths

Heat-related deaths should be countered by advice on heat avoidance behaviour, improved ventilation and air conditioning.

Health Effects of Climate Change in the UK, 2002. Department of Health.

Case study: Health effects of floods

A detailed risk assessment of the likely health effects (morbidity, mortality, and mental health) of a major flood of low-lying areas is urgently needed.

Health Effects of Climate Change in the UK, 2002. Department of Health.

Case study: Reducing exposure to UV radiation

By 2050, some 5000 extra cases of skin cancer and some 2000 more cases of cataract than seen today may be expected each year. Measures to reduce personal exposure to UV radiation are proven to be effective. Campaigns to maintain public awareness of the need for such measures are required.

Health Effects of Climate Change in the UK, 2002. Department of Health.

Table 5.14: Health Services

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions	The UK has the highest **excess winter mortality** in Europe, with an estimated 60,000 – 80,000 cold related deaths per year. It is estimated that by the year 2050 excess winter deaths will have declined significantly, perhaps by 20,000 per year (medium high scenario) because of overall warmer temperatures and less frequent very cold days. For the East of England this could represent a decline in excess winter mortality of around 1,800 deaths per year. This would be matched by a similar order of decline in hospital admissions for **cold related illness**.	• Health services should monitor the excess winter death rate and the number of hospital admissions for cold related illnesses to establish actual trends.	Act now	• Primary Care Trusts
		• Consideration should be given to diverting health service resources to responding to areas of increasing risk such as heat stress - if the trends confirm a decline in excess winter deaths and cold related illness.	Keep a 'watching brief'	• Primary Care Trusts
	Taking a worst-case scenario, it is estimated that **heat related deaths** might rise from the current 800 deaths per year currently to 2800 per year for the whole of the UK in 2050. This translates into; approximately 250 deaths per year from heat stress in the East of England in 2050. The effects of heat may be concentrated into a small number of hot days each year, just 35	• Provide advice to vulnerable groups and particularly older people on how to stay cool including the use of portable fans.	Act now	• Primary Care Trusts • Social Services • Social Housing Providers
		• Improve the ventilation and cooling systems in care homes, public hospitals and other residential institutions catering for vulnerable groups (this has implications for energy use and greenhouse gas emissions).	Plan for the future	• Primary Care Trusts • Social Services • Social Housing Providers

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	days under the medium high scenario. This would indicate about 730 people at hospital in the East of England with **heat related illness** on each of these hot days in 2050.	• Change working practices and working hours to take advantage of the cooler times of the day during hot periods. • Improve the ventilation and cooling systems in workplaces.	Keep a 'watching brief' Plan for the future	• All employers • All employers
	Reported cases of **food poisoning** are steadily rising. There were 94,000 notified cases in England and Wales in 1998. There are almost certainly many more unreported cases. High incidence of food poisoning is strongly associated with hot summers. It is anticipated that there could be an increase of about 10,000 cases each year by 2050. This would imply an increase of about 900 cases for the East of England by 2050.	• Promote better food storage / preparation and improved hygiene to the public and food/catering industry • Increase level of inspection of food processors, retailers, restaurants and food outlets	Act now Plan for the future	• Co-ordination with emergency services • Local authority services: Environmental health
	Algal growths and algal blooms may increase and closer monitoring of water used for recreational purposes may be necessary	• Take measures to reduce nitrate run-off from agricultural land into waterways • Put in place systems to warn the public of the dangers of algal blooms in waters used for recreational purposes	Act now Act now	• DEFRA • Environment Agency • Environment Agency • Norfolk Broads National Park Authority • British Waterways • Water Companies • Local authorities • Port Authorities

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	Deaths and severe injuries are common consequences of **gales.** These result from people being blown over, debris falling off buildings, falling branches and trees and in the worst case buildings collapsing. The loss of electricity supplies during storms adds to the problems. Increasing frequency of gales is anticipated with climate change but it should be noted that the UKCIP02 scenarios show that winter depressions will become more frequent leading to possible increased storminess, but modelling inconsistencies mean that only a low level of confidence can be attached to these results.	• Improve maintenance regimes and building standards • Introduce better warning to the public	Plan for the future Plan for the future	• Building owners • Local authorities • Emergency planners • Local authorities • Emergency planners
	Coastal and river flooding present some the most serious natural hazards that the UK faces. The effects of climate change are likely to make the return time of an event such as the 1953 East Coast flood shorter and its impact more destructive. Such an event is likely to result in many deaths and injuries	• Work with other partners to ensure preparedness for a severe flooding event and the long-term follow up (see below)	Act now	• Environment Agency, • Local authorities • Emergency services

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	The effects of **ground level ozone pollution** during the summer are likely to increase, perhaps by 20% by 2050. This is associated with the action of sunlight on polluting emissions. The frequency of hot sunny days is likely to increase with climate change. Ground level ozone pollution results in both deaths and hospitalisation.	• Put in place systems to warn the public when ground level ozone reaches dangerous levels • Plant trees to absorb ground level pollution	Act now Act now	• Primary Care Trusts • Local authorities • Local authorities
	Climate change is likely to lead to more people adopting an outdoor lifestyle**, increasing exposure to sunlight.** The gaseous emissions that damage the stratospheric ozone layer (that protects us from ultra violet radiation) is being controlled under the Montreal Convention and the subsequent Copenhagen Amendments. If these commitments are met then it is estimated that there will be 5000 extra cases of **skin cancer** each year by 2050 in the UK. This would indicate about 450 cases in the East of England each year by 2050.	• Promote the use of sun screening creams, wearing broad brimmed hats and limiting periods of exposure to sunlight • Increase tree planting to provide shade in public spaces	Act now Plan for the future	• Primary Care Trusts • Local authorities
Fens, Coast and Thames Gateway	By 2050 the climate of the UK may be such that indigenous **malaria** could become re-established. The indigenous malaria is likely to be *P.Vivax* as opposed to the more lethal	• Provide advice and preventative health care to those living in the proximity of salt marshes	Plan for the future	• Primary care trusts

Climate Change sub-regions affected	Most significant likely climate impacts on this service	Suggested Actions	Time Frame	Key Partners
	P.Falciparum variety. Those most at risk are people living in the proximity of salt marshes.			
Coast	The likelihood of future **severe flood events** is increasing with climate change.	Undertake a risk assessment to determine the resources needed to cope with such a large catastrophic flooding event, using the phases identified in the Department of Health research as a framework for risk assessment: • Impact phase: Death by drowning and exposure. • Immediate post impact phase: Death of injured or sick and aged individuals unable to obtain first aid, primary care or treatment in hospital. • Recovery phase: Subsequent increase in morbidity (hospital referrals and hospital admissions) and non-specific mortality in the flooded group in the months after. • Recovery phase and subsequent mental health sequelae: Mental health problems are likely to be significant in survivors of a major event. • Other causes of ill health: The risk of infections arising from floods in the UK appears to be quite low. Other hazards include the threat of toxic substances entering the floodwater and adding to the health impact.	Plan for the future	• Primary care trusts • Co-ordination with emergency services

Sources of information

Health Effects of Climate Change in the UK – An expert review for comment Department of Health in 2001

ECONOMIC SECTORS

Key issues for adaptation

- It is essential that economic sectors understand the implications of climate change on their economic activities and recognise the importance of adaptation.
- Taking steps to adapt to climate change now could avoid incurring costs at a later date.
- There are many overarching issues that all businesses must consider, such as how customer demand might change, whether the business is dependent on a sector that is vulnerable to changes in climate, whether climate change physically impacts on the business e.g. flooding, subsidence, supply chain disruption, etc.
- Different sectors will also face specific issues, which they will need to adapt to. For example, the insurance industry is likely to face increased risk/exposure from extreme weather events, which will require a continual review of risk assessment.
- Businesses may also benefit from climate change. For example, there may be an increase in demand for certain products, which the business could develop further.

Key EEDA sectors and the relative significance of climate change

5.65. In its RES, EEDA identified nine sectors, which it considered to be of strategic importance in terms of the performance of the regional economy:

- **Agriculture and food processing**: these are identified by EEDA as sectors in transition, which face rapidly changing market circumstances and increased competition. In policy terms, the Mid Term Review of CAP is likely to result in reduced price support and increased emphasis on sustainable rural development (which will be delivered through ERDP). Employment in the sectors is concentrated in the north of the region and the Fens has an important agri-food cluster
- **Automotive:** important and differentiated sector embracing major R&D (e.g. Ford Dunton), high end motorsport and the heritage of large scale manufacturing (e.g. Vauxhall at Luton)

Case Study: The Impacts of Climate Change on the Automotive Industry

A new study entitled **'Changing Drivers: The Impact of Climate Change on Competitiveness and Value Creation in the Automotive Industry'** produced by SAM (Sustainable Asset Management) Research and World Resources Institute.

The purpose of the report is to help investors make better informed decisions regarding automotive company stocks in light of emerging "carbon constraints" - policy measures designed to mitigate climate change by limiting emissions of carbon dioxide (CO^2) and other greenhouse gases. The report explores how carbon constraints in global automotive markets may affect value creation in 10 leading automotive companies between now and 2015, a timeframe in which major technological and policy changes are possible. The Original Equipment Manufacturers (OEMs) assessed are BMW, Daimler Chrysler (DC), Ford, GM, Honda, Nissan, PSA, Renault, Toyota and VW - the world's largest independent automotive companies. The geographical scope of the assessment is the United States, European Union and Japanese markets, which together account for nearly 70 per cent of current global sales.
The full report is available for download at either www.sam-group.com/changingdrivers or http://capitalmarkets.wri.org

- **Financial and business services**: very big sector in terms of employment. It has grown partly through decentralization from London and partly through specialist service providers growing at key nodes in the East of England

- **High tech manufacture and advanced engineering**: this is a big and diverse sector, one that provides an important input into many activities across the region

- **Information communications technology (ICT):** ICT has been badly hit by the recent downturn, but most commentators still consider this to be a "blip". The region has very significant resources in this sector: BT Exact at Adastral Park (near Ipswich) is, for example, a major focus for telecommunications research and it is also a sizeable employer

- **Life sciences: again**, this is a very important R&D-based activity, with major concentrations around Norwich (e.g. John Innes, Norwich Research Park) and Cambridge (e.g. activity linked to Addenbrooke's hospital and the high concentration of medical research). The south of the region (Hertfordshire and West Essex) has a high incidence of big pharmaceutical companies.

- **Media and cultural industries**: there are some key nodes around the region, notably Leavesden in Hertfordshire and the concentration of TV-related activity in Norwich. However related activities are increasingly important across a wide range of local economies

- **Tourism, leisure and heritage:** the region has some globally significant tourism attractions of which Cambridge is probably the most important single destination. The region's tourism offer is quite mixed, and some elements need to be refreshed – e.g. some seaside towns. Increasingly, tourism is playing a key role in terms of rural diversification and – in aggregate – it is a major employer.

- **Transport gateways**: the region has some very major transport gateways. Stansted and Luton Airports are key entry points and – over the medium term – new investment is likely. In addition, there are some very significant ports, particularly the Haven Ports. Again, major investment is proposed

5.66. For EEDA and its regional partners, it is important to try and anticipate the impacts of climate change – both positive and negative – on these sectors. However over a time period of 20 years plus, this exercise is inevitably fraught:

- Even without climate change, it is unlikely that the key strategic sectors of, say, 2033 would be the same as those of 2003; put another way, if we were writing in 1973, would we have foreseen the ascendancy of ICT, biotechnology and key business services?

- Over a medium-long term time horizon and from a sectoral perspective, there are many factors that are likely to have far greater impacts than climate change. Of these, changes in the global geopolitical map are absolutely key, as are technological developments and changes in the macroeconomy. Even in agriculture – one of the sectors that certainly will be affected by climate change – the impact of the Mid Term Review of the CAP is, for example, likely to bite harder and deeper.

5.67. In considering the possible impacts of climate change on key sectors, we clearly have to make some major assumptions with regard to both domains highlighted above.

> "Businesses need to make room on their agendas now to address the long-term opportunities and threats presented by climate change. Leaving climate change preparations to chance could prove a costly decision".
>
> **Rachel Jackson, Association of Chartered Certified Accountants' Head of Social and Environmental Issues quoted in ACCA press release: 'Plan for the future to weather climate change' 30 September 2002** http://www.acca.co.uk/news/releases/667056. **Downloaded 27/06/03.**

Nature of climate change impacts on economic activities

5.68. In addition, it is important to be clear about the varying nature of climate change impacts in the context of particular sectors. Our suggestion is that climate change could impact on economic activity in a number of different ways:

- In some situations, "climate" is a direct input into economic activity and changes in it will materially affect the manner in which the activity is undertaken. Agriculture is the clearest example, but the scale and characteristics of leisure and tourism, in the region, may also be directly affected by climate change.

- More common, however, will be the situation in which climate provides the backdrop to a sector and although climate changes will have some implications, the impacts will tend to incremental. In the life sciences, for example, changes in climate may affect the nature of R&D and focus of production (e.g. there may be changes in demand for pharmaceuticals and climate change may affect the focus of plant research in the region).

- It is possible to envisage a third situation in which the impact of climate change may be something of a secondary effect. Thus climate change could – in principle – cause changes to capital markets (as the buildings on which loans are secured become uninsurable) or changes to the road and rail infrastructure (because of flooding). In both cases, a wide variety of businesses and sectors would be affected, whether or not their principal activity had any direct relationship to climatic conditions.

Implications for the East of England

5.69. Against this backdrop, we review each of EEDA's key sectors in turn (see **Tables 5.15 – 5.23**). The discussion itself is very speculative. However it is hoped that the assessment will at least prompt debate. For each sector, we seek to provide some thoughts on the nature of the likely impacts and – where possible – we indicate those sub-regions that are most likely to be affected within the East of England. We also suggest some potential strategies for adaptation.

5.70. The following sources have been drawn on and may be useful reference sources for business, in planning for climate change:

- Advisory Committee on Business and the Environment (ACBE) (January 2003) Realising the value, enhancing business success – available at www.defra.gov.uk/environment/acbe/pubs/. This document explains how management of issues such as climate change will become increasingly important and sets out a straightforward process of risk management that will guide managers on factoring emerging issues into existing procedures.

- ACBE Sector specific risk and opportunities from predicted changes to UK climate – available as above

- ACCA Fact sheet: A business guide to climate change – available at www.acca.co.uk.

5.71. Other guidance tables in this document are cross-referred to where relevant, e.g. the transport gateways sector guidance should be read in conjunction with the guidance set out earlier in Section 5 aimed at road and rail transport service providers.

Table 5.15: Possible impacts on the agriculture and food processing sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions with food production and processing will be affected. Impacts especially acute in: **Fens** and the Brecks (**Northern Heartland/Coast**) where there are already major concerns about water shortages.	Changing range of threats from pests and diseases. Decreasing soil moisture and availability of water for irrigation which may constrain opportunities to capitalise on higher temperatures. Increased growing season will affect favourable crop types and planting / harvesting cycles and combined with higher average temperatures, could increase crop yield (provided water shortages can be overcome). Changing relationship between fertiliser use and water quality. Increasing risk of soil erosion as a result of more extreme climate Increased problems of vehicular access in winter to poorly drained sites and compaction of heavy soils.	• Consider the establishment of an East of England climate change foresight group for food and drink, to discuss the implications of climate change for the industry and to disseminate information.	Act now	DEFRA, EEDA Environment Agency
		• Make necessary changes to agricultural practices, particularly in response to increasing temperatures, changes in rainfall patterns and decreasing availability of water for irrigation and cooling of farm installations. Changes are likely to be needed in terms of the types of crops and livestock species farmed, the timing of agricultural activities and in the use of water, for example, by making use of, more water efficient irrigation systems. (For more detailed actions for the agricultural sector, please refer to **Table 5.12**).	Plan for the future	DEFRA
		• Seek and exploit opportunities in the domain of plant breeding, etc. for which the East of England ought to be well positioned.	Plan for the future	DEFRA and key research establishments e.g. Rothampstead
		• Exploit advantages in anticipating demand for agrochemicals and pesticides to protect against insects/diseases and aim to develop in this area of expertise.	Plan for the future	EEDA, Pharmaceuticals companies, Environment Agency
		• Seek and exploit opportunities that may arise as major importing and exporting countries, which already have more extreme climates, face climatic changes (e.g. Spain may be able to grow less and therefore may import more): The East of England should be able to learn from these places and to capture emerging opportunities	Watching brief	Trade Partners - United Kingdom (TP-UK), EEDA

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
	Changing patterns of consumer demands for primary produce – e.g. more lettuces, fewer turnips, less demand for red meat etc.	• Seek and exploit opportunities to grow new crops such as Mediterranean vegetables and fruit.	Watching brief	DEFRA
	Changing patterns of consumer demand for manufactured products e.g. cold drinks and ice creams and demand for regional produce (which reduces transportation distances) e.g. locally/organically produced ice cream.	• Predict and plan for changes in consumer demand. • Capitalise on opportunities to expand the regional market for food and drink in line with increased visitor numbers and local demand, in particular for local specialities.	Watching brief Act now	IGD Regional Tourist Authorities, DEFRA, EEDA, Tastes of Anglia
	Major issues around the availability of water for food preparation processes, many of which are "water hungry". This is also a major issue facing the drinks industry.	• Investigate ways to address the issues surrounding "water hungry" processes, particularly in drink manufacturing.	Act now	Research institutes, trade associations, Environment Agency
	For food processors and distributors, costs associated with maintaining the chill chain will tend to rise in a warmer climate.	• Plan for the increased costs of maintaining the chill chain.	Plan for the future	
	Logistics across the industry might be interrupted as a result of increased storminess, etc., and thus the whole food chain might be vulnerable, particularly given its dependence on Just In Time (JIT) delivery systems.	• Plan for possible increased costs, due to disruption of logistics and seek ways to minimise risks. For example, utilising local suppliers where possible to reduce the need for transportation of goods from primary producers to factories and factories to the point of sale.	Watching brief	Trade associations
	Likelihood that the incidence of food poisoning, etc. will rise in a warmer climate.	• Enhance cooling methods to avoid damage to produce and reduce bacterial build up and hence limit increases in food poisoning.	Plan for the future	FSA

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
	There may be health impacts on workers resulting from warmer temperatures	• Consider whether regulations governing working conditions will need to be reviewed in the face of climate change, for example, as the likelihood of 'extremely' warm days increases. • Ensure opportunities for natural ventilation are incorporated where possible, or otherwise air conditioning, to ensure comfortable working conditions.	Watching brief	DEFRA, FSA,

Table 5.16: Possible impacts on the automotive sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
Areas in which the automotive industry currently has a presence: Luton, Dunton, etc. (i.e. **Southern Heartland** in particular).	Ford's R&D plant at Dunton in Essex is a key asset in terms of the region's automotive industry, but could be at risk of flooding.	• Assess the likely risk, and consider implications for insurance: some form of adaptation may be necessary	Watching brief	Private sector
	Changes in motoring conditions may affect consumer demand for certain features e.g. more intense rainfall events in winter may have implications for motor vehicle safety, whilst warmer summers would be likely to affect comfort in vehicles.	• Consider the implications of climate change for the design of motor vehicles and start to design new features into vehicles. E.g. improved ventilation, air conditioning (through passive rather than active cooling where possible), and alternative fuelling systems to help mitigate against climate change, innovations to improve the performance of vehicles in extreme weather conditions.	Plan for the future	Key universities, e.g. Cranfield
	Increases in outdoor leisure pursuits may affect demand for certain types of vehicles (e.g. soft-tops, four-wheel drives, camper vans, etc).	• Respond to changes in vehicle demand (whilst recognising the importance of clean fuels, reduced fuel consumption etc. in mitigating against climate change).	Watching brief	Key universities, e.g. Cranfield
	Climate changes might benefit the motorsports industry although with increased storminess, etc. there may be an issue around "clean environments" (i.e. clean air and water, etc.).	• Assess the possible implications, and design features into motor vehicles as appropriate.	Watching brief	Motorsports Industry Assocation
	For volume car manufacture, increased temperatures may raise issues about working conditions, etc. and there may be increased costs as a result, although less heating in winter could offset more air conditioning in summer.	• Consider whether regulations governing working conditions will need to be reviewed in the face of climate change, for example, as the likelihood of 'extremely' warm days increases. • Ensure opportunities for natural ventilation are incorporated where possible, or otherwise air conditioning, to ensure comfortable working conditions.	Watching brief	SMMT
	In the volume car industry, there may also be issues around the distribution of valuable cargos in stormy conditions and possible implications in terms of insurance	• Evaluate risks to manufacturers of stormier winter weather conditions and the associated insurance implications.	Watching brief	SMMT

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
	for the transportation of vehicles during stormy conditions.	• Consider whether certain modes/routes for transportation could decrease the risks.		

Table 5.17: Possible impacts of climate change on the financial and business services sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
Areas in which the financial and business services sector is currently strong: Chelmsford, Norwich, Ipswich, Cambridge, etc. (i.e. particularly the **Northern and Southern Heartlands**) Arguably these – and other – locations could see further decentralisation from London as a result of climate change.	Insurance industry will be affected significantly by climate changes: flooding, severe weather events and subsidence are all likely to lead to increased claims against the industry and increased demand for insurance. In the case of commercial insurance, claims can extend beyond direct damage and loss to include lost income and business. Lifestyle changes which may result from climate change (e.g. more outdoor leisure) may also have an impact.	• The insurance industry must continue to assess the implications of climate change, and may need to change the manner in which risk is assessed.	Act now	Major Insurance companies with a presence in the region
		• In particular policies in relation to losses from natural hazards, particularly in relation to commercial activities may need to change (for example, through a reduction in services offered or premiums paid).	Watching brief	
		• Insurance companies should consider opportunities for new geographical markets in which climate change impacts are less volatile.	Watching brief	Major companies, with TP-UK
	Prices of property in floodplains may fall and this in turn will impact upon lending (as loans are typically secured against property) with the result that there might be severe localised "credit crunches".			

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
	Climate change introduces uncertainty into a market place which already has uncertainties attached. Banks and building societies may lose income as customers incur losses through climate impacts, such as disruption to supply chains. The full range of climate change impacts on all sectors will be felt by the banks, in particular, short term impacts of extreme events. Increased investment opportunities exist in climate change mitigation activities, including emissions trading activities, Renewable Obligations Certificates and low carbon technologies.	• Financial/investment sectors should seek new products/investment opportunities in emerging and established markets e.g. low carbon technologies and renewable energies.	Watching brief	EEEGR
	Developing opportunities in "carbon trading", etc.	• Exploit opportunities to develop climate change consultancy, as a business service, as companies seek to adapt their operations: the East of England region ought to be relatively well placed to respond.	Watching brief	Private sector
		• The sector should seek and develop opportunities for carbon accounting and emissions trading.	Watching brief	
	There may be health impacts on workers resulting from warmer temperatures, and also impacts for insurance from those insured under health insurance schemes (e.g. from strokes, heat stress, etc.).	• Consider whether regulations governing working conditions will need to be reviewed in the face of climate change, for example, as the likelihood of 'extremely' warm days increases. • Ensure opportunities for natural ventilation are incorporated where possible, or otherwise air conditioning, to ensure comfortable working conditions.	Watching brief	Government - at all scales

Table 5.18: Possible impacts of climate change on the high tech manufacture and advanced engineering sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions: many scattered locations around the region - Hatfield, Cambridge, Cranfield, etc.	South Essex has a concentration of high end manufacturing activities and this area may be prone to flooding.	• Assess the likely risk, and consider implications for insurance. There may also be opportunities to develop 'flood proof' infrastructure and flood risk management technologies.	Plan for the future	Developers
	Increased temperatures may require changes in manufacturing processes to accommodate increased internal and external heat.	• Assess the need for and adapt/develop new processes.	Watching brief	Private sector
	Restricted water supplies and possible changes to energy costs (for example, through disruption to facilities through storms) could have implications for manufacturing processes.	• Aim to develop water and energy efficient technologies, to reduce reliance on these inputs.	Watching brief	Key universities, e.g. Cranfield
	Climate change may lead to more high tech manufacturing opportunities - e.g. wind farms and more demand for turbines, engineering support services, etc. and also there may be increased demand for solar technologies.	• Exploit opportunities for more high tech manufacturing opportunities, e.g. renewable energy technologies.	Watching brief	EEEGR
	Demand for new materials that perform well in changed climatic conditions (for example, in relation to materials used in road and rail infrastructure which will need to withstand greater heat stress - see **Tables 5.8 and 5.9**).	• Exploit opportunities for developing new materials.	Watching brief	Key Universities, e.g. Cranfield and Cambridge
	Issues may arise around the need for "clean" environments.	• Exploit opportunities for developing environmental 'clean-up' technologies e.g. carbon dioxide fixing and disposal technologies and low carbon technologies.	Watching brief	

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
	May be opportunities for new medical technologies.	• Exploit opportunities for developing new medical technologies to address the health implications of climate change.	Watching brief	Medilink
	There may be health impacts on workers resulting from warmer temperatures.	• Consider whether regulations governing working conditions will need to be reviewed in the face of climate change, for example, as the likelihood of 'extremely' warm days increases. • Ensure opportunities for natural ventilation are incorporated where possible, or otherwise air conditioning, to ensure comfortable working conditions.	Watching brief	

Table 5.19: Possible impacts of climate change on the ICT sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
Ipswich, Cambridge and parts of Hertfordshire (**Northern and Southern Heartlands**).	Market changes as a result of climate change	• Exploit market opportunities e.g. for technologies associated with mitigating and adapting to climate change, such as monitoring equipment for building temperatures and flood risks. • Exploit opportunities to develop software and computer technologies for global climate modelling and risk modelling.	Watching brief	Private sector
	Possible that changed weather conditions may impact upon satellite and other communications technologies e.g. communications masts and overhead cables. Increased levels of down time as a result of loss of energy supplies and telecommunications during periods of extreme climate impacts.	• Assess and plan for the risks.	Watching brief	Telecommunication companies
	Increased uncertainty may limit the willingness of businesses and governments to invest in new ICT infrastructures and this will affect providers based in the East of England.		Watching brief	
	Climate change likely to result in increased need for ventilation in buildings with major hardware installations. There may be health impacts on workers resulting from warmer temperatures.	• Consider whether regulations governing working conditions will need to be reviewed in the face of climate change, for example, as the likelihood of 'extremely' warm days increases. • Ensure opportunities for natural ventilation are incorporated where possible, or otherwise air conditioning, to ensure comfortable working conditions.	Watching brief	Developers

Table 5.20: Possible impacts of climate change on the life sciences sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
Major centres of life science activity: Norwich, Cambridge and parts of Hertfordshire and Essex (**Northern and Southern Heartlands**).	Direct effects are likely to be quite limited.			
	Changes brought about by climate change in other sectors may create opportunities for the life sciences sector. For example, challenges facing agriculture such as droughts and flood risk could create opportunities for plant genetics.	• Seek and exploit new opportunities in terms of plant genetics e.g. for climate resistant crops. • Seek and exploit opportunities for new health products relating to a change in the incidence of illnesses e.g. relating to increased solar radiation, heat effects and dehydration. • Seek and exploit opportunities to provide advice and consultancy services to other business sectors.	Watching brief	Private sector, research institutions
	The industry would be affected by any changes in the capital markets (which might come about because of changes in the value of property).			
	The industry is international and changes in the reliability of travel would have implications for the sector.			
	Climate change likely to result in increased need for air conditioning, particularly in buildings with laboratory equipment. There may be health impacts on workers resulting from warmer temperatures.	• Consider whether regulations governing working conditions will need to be reviewed in the face of climate change, for example, as the likelihood of 'extremely' warm days increases. • Ensure opportunities for natural ventilation are incorporated where possible, or otherwise air conditioning, to ensure comfortable working conditions.		Developers, regulators

Table 5.21: Possible impacts of climate change on the media and cultural industries sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
Media industry is concentrated in Hertfordshire and Norwich. Cultural industries are found across the region. (i.e. **All climate change sub-regions**, and **Northern and Southern Heartlands** in particular).	East of England may become a stronger location for film. Some areas with a relatively strong presence in the cultural industries are within the climate change sub-regions that are at risk of flooding (e.g. Southend).	• The industry is already concentrated in Hertfordshire and may benefit from decentralisation from an overheated Soho cluster: steps could be taken to encourage this.	Watching brief	EMMA

Table 5.22: Possible impacts of climate change on the tourism, leisure and heritage sector

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions and the **Coast** in particular: tourism destinations across the region will be affected in different ways: coastal areas are at some risk whereas inland areas could benefit.	Changes in climate may affect demand for holidays in the East of England in a number of ways: • Longer, hotter summers with less rain will make the East of England a much more attractive destination than now, for main break holidays. • Warmer weather may mean that domestic holidays will be substituted for overseas holidays. • More tourists may be attracted to the East of England from elsewhere in Europe and further afield, as current destinations become too hot, etc. • However, some tourists may prefer cooler areas, such as upland areas of Britain, hence reducing the potential increase in summer tourism. • Increased winter rainfall likely to reduce the attractiveness of the region for winter tourists.	• Implement a marketing strategy to market the East of England (or selected parts of the region) as a tourism destination and initiate a process of re-branding and re-educating consumers.	Plan for the future	Tourism authorities
		• Exploit increasing opportunities to attract foreign tourists.	Plan for the future	Tourism authorities
		• Adapt visitor facilities e.g. hotels, for warmer temperatures, through improved natural ventilation where possible, or otherwise through air conditioning.	Watching brief	Tourism authorities
		• Ensure efforts to increase coastal tourism are compatible with flood risk management decisions undertaken by the Environment Agency and other partners.	Watching brief	Tourism authorities
		• Ensure that efforts to promote tourism seek to do so in a sustainable way, which respects the value of the natural environments on which it is based. This includes the need to ensure facilities are water efficient.	Plan for the future	Tourism authorities
		• Seek opportunities to promote 'green' tourism.	Act now	Tourism authorities
		• Consider the establishment of an East of England climate change foresight group for the tourism, leisure and heritage sector, to discuss the implications of climate change for the industry and to disseminate information. This is important since many businesses involved are small scale and unlikely to fully understand and have the ability to consider climate change.	Plan for the future	Tourism authorities
	Likely increase in outdoor leisure activities and possible reduction in demand for indoor pursuits.	• Develop and promote outdoor leisure activities.	Act now	Tourism authorities

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
		• Where possible incorporate 'outdoor elements' into leisure facilities e.g. outdoor swimming pools at leisure centres.	Act now	Tourism authorities
	Changes in climate may also affect outdoor leisure activities, for example: • Some recreational activities (e.g. fishing) could be directly affected by climate change, for example, adversely where reduced summer rainfall affects water levels. • Reduced rainfall may reduce the effectiveness and attractiveness of inland waterways / rivers and this may have implications (e.g. the Cam is part of Cambridge's tourism offer). • Other watercourses with significant tourism value may be increasingly prone to flooding (e.g. the Broads). • Climate changes might have impacts for key historic buildings e.g. through increased weathering.	• Monitor the possible affects of climate change on other leisure activities e.g. fishing, boating and visits to historic sites and respond where possible to adapt to any negative impacts.	Plan for the future	Tourism authorities

Table 5.23: Possible impacts of climate change on transport gateways

Climate change sub-regions affected	Most significant likely impacts	Suggested Actions	Time Frame	Key Partners
All climate change sub-regions and the **Coast** and **Southern Heartland** in particular: the principal transport gateways are the East Coast ports and Stansted airport. These would be affected in different ways.	Flooding and other extreme weather events may disrupt transportation; this may be a particular issue at the East Coast ports, which may become prone to inundation and siltation in channels. Railway cuttings may be susceptible to landslips and high temperatures could cause railways to buckle. But there will be fewer 'frozen points' type problems. Risk that in responding to climate change, investments in public transport fall behind those in private vehicles, such that the former becomes unpopular, especially in warm weather. Roads may buckle in hot weather, but will be less affected by frost in winter – overall, maintenance costs may reduce. Reduction in frosts and cold days might increase the reliability of air travel (but uncertain impact of climate change on incidence of fog). Falling demand for international flights as domestic holidays are substituted for overseas ones; for the same reason, there may be more demand from in-coming passengers.	• Invest in public transport systems that will be appropriate for hotter and more extreme conditions, for example, improve ventilation on trains and buses. • Develop innovative transport solutions to decrease reliance on the private car. • Please refer to **Tables 5.8 and 5.9,** which suggest detailed actions for road and rail transport service providers.	Plan for the future Plan for the future	**Port authorities** **Transport authorities**

Climate change considerations for all business domains

5.72. The preceding section provides specific guidance for key business sectors in the East of England. However, it is important that all businesses are aware of the potential impacts that climate change could have on their activities and are able to evaluate their vulnerability.

5.73. The Advisory Committee on Business and the Environment (ACBE) has produced a framework for evaluating risk of emerging issues, such as climate change (see www.defra.gov.uk/environment/acbe/pubs/). This document provides a useful framework for helping business to address the following questions:

- Is this issue significant for our business?
- How do we know we are right?
- Does the issue present a risk or an opportunity?
- What mechanisms are in place to address this risk/opportunity?
- Does this impact our business objectives?

5.74. The box below, which draws on the climate change precautionary principles set out by the Association of Chartered Certified Accountants (ACCA)[35], sets out the types of specific issues that business should consider in relation to climate change.

Thinking about climate change: issues for businesses to consider

- How might customer demand change (will demand increase or will products/services become redundant) and what impacts will this have on the products/services provided by the business?
- Will the business need to diversify? Are there opportunities that can be capitalised on?
- How might competitors be relatively disadvantaged/advantaged, and what are the implications for the business?
- Could climate change increase risks to the business? Ensure risk assessment strategies are part of major investment decisions.
- To what extent does the business rely on various transportation networks and can the risks be reduced through the use of alternative suppliers, transportation networks, etc?
- How might raw materials be affected, and is there the need or scope to change the types of materials used (***see example of risk evaluation***

[35] http://www.acca.co.uk

below)?

- How will climate change affect business location in the future e.g. flood risk?
- Check existing insurance policies for validity or possibility of increased premiums if the business is based in a low-lying area.
- How might environmental legislation affect the business? E.g. the climate change levy and carbon trading regimes.

5.75. Evaluation of and responding to risk is essential in making decisions in relation to climate change. The box below contains an example of how a company, whose supply chain may be affected by climate change, could respond.

Example of climate change risk evaluation, from ACBE 'Realising the value, enhancing success'

Scenario: The effects of climate change on weather patterns has the potential to disrupt the supply of products by affecting availability of raw materials, as plant growth rates and plant based ingredients are impacted.

Possible means of addressing risk:

Transfer risk:	Include risks such as supply disruption into supplier contracts
Mitigate risks:	Minimise exposure through cutting down impacted products
Minimise risks:	Diversify product range
Accept risks:	Retain same product range and take no action with suppliers
Insure risks:	Diversify range of suppliers

5.76. UKCIP is also producing guidance, which will help businesses to assess their vulnerability to climate change and to develop appropriate adaptation strategies. The guidance will address how climate change might affect customer demand, supply chains, transportation networks, and regulatory mechanisms. It's now available, further details are available by contacting enquiries (enquiries@ukcip.org.uk).

6. IMPLEMENTATION AND COMMUNICATION

WORKING TOGETHER

6.1. As this report has outlined, adapting to climate change will present a major challenge to a wide range of local and regional government bodies, the private sector and the wider public.

6.2. Developing a coherent response requires that local authorities properly integrate climate change not just into departmental working but into their wider corporate approach, establishing links with outside agencies to tackle this agenda in the most effective fashion. A number of actions should be considered:

6.3. **Integration into Community Strategies and LSPs** – the Community Strategies and Local Strategic Partnerships will be the main mechanism for collaborative working between local authorities, other public sector agencies and the private sector. As such, it is important that climate change considerations are taken on board in the work of LSPs and through Community Strategies.

6.4. A number of local authorities, such as Leicester City Council and Broxtowe Borough Council, have already integrated energy and climate change concerns into their Community Strategy. Given the cross-cutting nature of energy and climate change, they can become a useful theme drawing together a range of issues.

6.5. **Development of a Climate Change or Sustainable Energy Strategy** – Local authorities should seek to draw together the various adaptation (and mitigation) responses that are required in a single corporate strategy covering climate change or wider sustainable energy issues. Alternatively, Councils should consider the means to properly integrate this agenda into existing strategies, such as those on economic development, emergency planning or Local Agenda 21.

Leicester City Council and Woking Borough Council (Surrey) have produced climate change strategies (which can be viewed online). Councils who have voluntarily signed up to the Nottingham Declaration on Climate Change (over 60 councils) have to develop a climate change strategy. Local examples include Cambridgeshire and South Cambridgeshire. Gateshead Metropolitan Borough Council incorporate climate change in their LA21 strategy, and others such as Hampshire County Council, have included climate change in a Sustainable Development Strategy.

6.6. **Work with Regional institutions** – local authorities should work with regional government structures in the East of England, such as the Government Office of the East of England (GO-East), EEDA, Sustainable Development Round Table and the East of England Regional Assembly

(EERA),in order to develop a region-wide response to the challenge of climate change.

6.7. **Work with Universities and Academic Institutions** – the East of England is blessed with some of the leading academic institutions involved in work on climate change, including the Tyndall Centre and Centre for Social and Economic Research on the Global Environment (CSERGE) at the University of East Anglia. There is thus potential for partnership working between local authorities and academic bodies on the adaptation response.

6.8. **Establishing a Regional Climate Change Partnership -** This could take the form of a partnership of organisations headed by a lead agency, which meets regularly to discuss climate change issues. The Partnership would be open to any interested parties, including business representatives. A similar partnership is successfully operating in several English regions, including the South East and East Midlands. Such a mechanism would also ensure that issues surrounding climate change are continually reviewed, which is essential given the rate at which our understanding of climate change, and in particular adaptation strategies, is developing[36].

COMMUNICATIONS AND AWARENESS

6.9. Delivery of a coherent response to climate change requires a high level of awareness of the issues among decision-makers and the wider public. Local authorities have a central role to play in this. Action could include:

- Raising awareness among council staff as to the likely impacts of climate change and how it could affect the work of the Council in relation to different areas of policy. This could be achieved through training of staff or the production of information materials.
- Engagement, through the Community Strategies and other mechanisms, with the business community and other institutions to discuss likely opportunities and threats posed by the changing climate and the means by which businesses can address these challenges. As this report has highlighted, climate change will impact on all sectors of society. The new community leadership role given to local authorities through the local government improvement agenda means that there are new opportunities to engage with and encourage the wider community to act.

[36] For European Projects see also the ESPACE (European Spatial Planning Adapting to Climate Events) partnership. http://www.hants.gov.uk/environment/climatechange/spatialplanning.html

- Engagement with the wider public through both formal school and adult education and wider information campaigns.

The communications strategy

6.10. The Living with Climate Change in the East of England study cannot provide a full Communications Strategy for the guidance produced through the study. The study has many important messages, which need to be carefully presented and communicated to appropriate audiences. A comprehensive Strategy is being developed by Hertfordshire County Council.

6.10. This report, however, includes important key messages and recommendations for wider co-ordination, which should be considered as part of the Communications Strategy.

6.11. A key element of a successful Communications Strategy, which will ensure that the messages are disseminated to a wide audience, is the establishment of a Climate Change Partnership. This could take the form of a partnership of organisations headed by a lead agency, which meets regularly to discuss climate change issues. The Partnership could be open to any interested parties, including business representatives. A similar partnership is successfully operating in the South East. Such a mechanism would also ensure that issues surrounding climate change are continually reviewed, which is essential given the rate at which our understanding of climate change and in particular, potential adaptation strategies, is developing.

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APPENDIX 1

BACKGROUND TO THE STUDY (STAGES 1, 2 & 3)

BACKGROUND TO THE STUDY (STAGES 1, 2 & 3)

Study aims and objectives

The specific objectives of the study are to:

- Provide decision-makers in the East of England with a synthesis of evidence on the expected regional effects of climate change over the next century, this to include regional agencies, local authorities, business support organisations and where appropriate key businesses within the East of England
- Identify appropriate measures to put in place in policies, strategies and programmes to address the effects of these changes - when considering measures thought should be given to any potential conflicts with existing regional strategy/policy and the likely costs involved in undertaking such measures
- Provide authoritative input to the process of producing draft Regional Planning Guidance for the East of England and for the production or revision of other regional strategies
- Identify local government services which would be affected by climate change, the degree to which adaptive measures could be taken and how these might necessitate changes to service delivery for (each of) county, district and unitary services and identify how this pattern might differ across the region
- Identify practical and sustainable actions that can be started now, or in the short to medium term (10-20 years)
- Provide advice on ways of communicating the likely impacts of climate change to regional stakeholders and the wider public so as to raise awareness of the need, and support for, adaptation measures
- Produce a reference work comprising a range of source materials capable of use by a wide range of audiences in the private, public and voluntary sectors, schools and by other learning groups and by the public at large on climate change in the Eastern Region
- Inform the development of the Sustainable Development Framework for the East of England through the identification of performance targets

Key stages of work

Together the stages of the study address regional and more local level adaptation measures.

Stage 1: Spatial Study, involved a scoping exercise and the production of guidance on the key spatial decisions and the strategies and actions required to address them.

Stage 2: Local Service Provision, considers which services are likely to be affected by climate change; whether the effect is likely to be similar across the region as a whole; what opportunities might be afforded (e.g. promotion of environmental technologies, tourism, agricultural diversification etc.); the key decisions that will need to be made with respect to these effects and opportunities; and when these decisions will need to be made by (e.g. short term, medium term, long term).

Stage 3: Final Report will bring together the findings of the work carried out in the first two stages of the study. It will provide guidance for regional bodies, local government, the private sector, agencies, support groups and other service providers, on the local policy decisions, strategies and actions required to adapt to the effects of climate change and the likely threats and opportunities presented.

Method of approach to Stage 2

Stage 2 comprised the following tasks:

Task 1: Identifying Key Decisions to be made at the Local Level

The first task involved identifying the impacts that climate change could have at the local level and how these may vary across the region.

In order to inform this process, a matrix for each of the five climate change sub-regions was constructed, listing the services provided and how they could be impacted on by climate change, the nature and significance of the impacts, what opportunities might be afforded (e.g. promotion of environmental technologies, tourism, agricultural diversification etc.), the key decisions that will need to be made with respect to these impacts and opportunities, when these decisions will need to be made by (e.g. short term, medium term, long term) and the level of uncertainty and risk attached.

These matrices were then refined through discussions with the Project Management Group, prior to sub-regional workshops with a wide range of regional stakeholders.

Task 2: Local Service Providers Workshops

Two workshops were held (in Great Yarmouth and Letchworth) to which local government and other service providers were invited.

The aim of the workshops was to identify the key decisions and measures that may need to be taken to adapt to make the most of opportunities that climate change presents and to minimise its adverse effects, and to consider how these might vary across the region. The specific objectives were to:

- Determine whether the key services provided by local authorities had been correctly identified.
- Discuss the extent to which local services are likely to be affected by the impacts of climate change and the nature and significance of any effects.

- Consider whether the impact of climate change and effects on local service provision are likely to be similar across the region as a whole, or whether they are likely to vary depending upon location.
- Explore what opportunities might be afforded by the impacts of climate change (e.g. promotion of environmental technologies, tourism, agricultural diversification etc.).
- Identify and prioritise the key decisions that will need to be made with respect to these impacts and opportunities, and when these decisions will need to be made by (e.g. short term, medium term, long term).
- Assess the level of uncertainty and risk attached.
- Identify service areas where a co-ordinated response between local authorities and statutory agencies/infrastructure providers will be required.

Task 3: Guidance on Local Service Provision

This guidance document takes the findings of our detailed research as discussed at the two workshops and provides guidance for local government, the private sector, agencies, support groups and other service providers. This guidance being on the local policy decisions, strategies and actions required, to adapt to the effects of climate change and the likely threats and opportunities presented.

The document identifies likely local variations in the impacts of Climate Change across the region and highlights mechanisms, such as the Community Plan and the Local Strategic Partnership, through which local authorities can work with other agencies and the private sector to develop a strategic approach.

APPENDIX 2

INTEGRATING CLIMATE CHANGE INTO KEY PLANS AND STRATEGIES

INTEGRATING CLIMATE CHANGE INTO KEY PLANS AND STRATEGIES

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
General				
Regional Planning Guidance	Regional	Regional Planning Body	The purpose of RPG is to agree a framework for the broad spatial distribution of development in the plan period in step with the investment proposals for housing, transport, health, education and other agencies. RPG sets, amongst other things, housing and employment land targets for Structure Plans.	Stage 1 of this project produced guidance on adapting to climate change in spatial terms at the regional level – it addresses how adaptation to climate change can be integrated into RPG.
Waste Local Plan	County/Unitary Authority	County Council/Unitary Authority	Waste local plans set out the detailed land-use planning policy framework for the management and disposal of waste in the plan area.	Should take into account the impact climate change on waste management facilities and how these may need to adapt, for example through flood risk management.
Transport Plan	County/Unitary Authority	County Council/Unitary Authority	Transport plans set out the County Council's proposals, programmes and strategy for integrated transport and expenditure on transport in the area.	Transport plans should consider the implications of climate change for new transport developments and in maintenance of existing infrastructure and aim to incorporate adaptation measures as appropriate.

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
Development Plan (Structure, UDP, Local)	County/ Local	County Council/Unitary Authorities or District/Borough Councils	Development plans set out local authority policies and proposals for the development and use of land in the area. The plan guides and informs day-to-day decisions as to whether or not planning permission should be granted for applications.	Development control can have a decisive role to play in adaptation to climate change. For example, taking a sustainable approach to development and flood risk, and promoting and specifying sustainable construction techniques and materials. Supplementary Planning Guidance (SPG) could be used to facilitate good design, for example through the production of a Design Guide for sustainable design and construction.
Social				
Sustainable Communities Plan	National	Office of the Deputy Prime Minister	This document confirmed and described plans for growth and regeneration in England, including significant additional housing development in the South-east for the period up to 2031. It is the Government's strategic response to the need for a large-scale plan to ensure the sustainability of large-scale development and regeneration.	The Sustainable Communities Plan stresses the importance of delivering sustainable forms of development, including such measures as energy and water efficiency. The impacts of climate change and the need to adapt to climate change need to be taken into account in this process. It is also essential that developments take a sustainable approach to flood risk management.
Community Plan/Strategy	Local	Unitary Authority/District/Borough Council	Community Plans are developed by the local council, along with its partners in the public,	Ensure adaptation to climate change is considered during preparation of the plan, and is incorporated into the plan in line

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
			private, voluntary and community sectors. Through the development of key themes, visions and priorities are identified along with strategies identifying how these will be achieved.	with key partners views.
Health and Social Inclusion Strategy	Regional	Regional Assembly Health and Social Inclusion Panel	A strategic framework addressing health inequalities and social inclusion in the East of England.	Ensure adaptation to climate change is considered during preparation of the plan and is incorporated into the plan in line with key partners views.
Regional Cultural Strategy	Regional	Living East (the Regional Cultural Forum), the EEDA, regional assembly and local government	A strategy for cultural development in order to improve both the quality of life for the people of the East of England and the economic prospects of the region.	The Strategy should consider the impacts of climate change on culture in the region and consider how the various sectors can adapt accordingly. The Strategy should include or facilitate the dissemination of information on adaptation to climate change to all sectors involved.
Regional Housing Strategy	Regional	The Regional Housing Forum (consisting of members from local government, EEDA, GO-East, Countryside Agency, National Housing Federation, Housing Corporation, Chartered Institute of Housing and the House Builders Federation	A strategic plan to provide the homes needed in the East of England whilst achieving the Decent Homes standard and safeguarding the current housing stock as an asset for future generations.	The Regional Housing Strategy can play an important role in ensuring measures are taken to adapt housing to climate change. For example, ensuring a sustainable approach to development and flood risk, and promoting and specifying sustainable construction techniques and materials. It can also stress the importance of incorporating such measures as

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
				energy and water efficiency into buildings.
Economic				
EEDA's Regional Economic Strategy	Regional	East of England Development Agency	The East of England Development Agency (EEDA) is a business led organisation, which leads on producing the Regional Economic Strategy. EEDA has a budget of around £90 million a year to help implement the strategy. It works with many regional and local partners to deliver a wide range of economic development and regeneration initiatives for business, learning and skills, regeneration and sustainable development.	The Strategy should consider the impacts of climate change on the location of business development and how businesses can adapt accordingly. The Strategy should include or facilitate the dissemination of information on adaptation to climate change to key business sectors.
Economic Development Strategy	County/Local	County Council/Unitary Authority/District/Borough Council	Economic Development Plans/Strategies set out the issues and challenges for the continued economic development and regeneration of the area and outline the key economic aims and objectives of the Council and its partners. It also provides the framework for the Council's subsequent years' Economic Development Plans.	As with the RES, the Economic Development Strategy should consider the impacts of climate change on the location of business development and how businesses can adapt accordingly. The Strategy should include or facilitate the dissemination of information on adaptation to climate change to key business sectors.
Tourism Strategy	County/Local	County/Unitary/	A collaboration with key	The Strategy should consider the

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
		District/Borough Council	stakeholders to produce a strategy document which is intended to support and guide all local authority tourism work for a specified time scale.	impacts of climate change on the tourism industry and consider how the industry can adapt accordingly. The Strategy should include or facilitate the dissemination of information on adaptation to climate change to businesses and other parties.
Environmental				
Environment Strategy	Regional	East of England Environment Forum and East of England Regional Assembly	The strategy sets out how the natural, historic and built environment of the East of England can be celebrated, protected and enhanced. It highlights the importance of the environment to the broader improvement of quality of life for people in the region.	The strategy must take into account the predicted effects of climate change on the environment. It must also ensure adaptation measures are identified and the information disseminated to the relevant parties.
Coastal Zone Management Plans	Broad coastal zones	Partnership of Local Authorities (County Council/Unitary Authority/Borough District Council) working with a wide range of partners, under a recommendation by the EU	Integrated Coastal Zone Management (ICZM) is a process that brings together all those involved in the development, management and use of the coast within a framework that facilitates the integration of their interests and responsibilities. This results in the production of a Coastal Zone Management Plan. The objective is to establish sustainable levels of	These plans should consider the implications of climate change for coastal erosion and flood risk. The Plans could be used to identify areas of land for managed realignment schemes. The plans should also consider alternative approaches to flood risk management such as soft engineering methods.

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
			economic and social activity in coastal areas while protecting the coastal environment. An EU recommendation, outlining steps that the Member States should take to develop national strategies for ICZM , was released in May 2002. Not all areas in the UK have undertaken a CZMP as yet and a guidance document on the production of a CZMP has not yet been devised.	
Shoreline Management Plan	Broad coastal zones	Local Authorities (County Council/Unitary Authority/Borough District Council), the Environment Agency and a range of partners	The aim of a Shoreline Management Plan is to provide a strategic framework for the future management of sustainable coastal defence by reflecting natural processes, planning pressure, current and future land use, recreation, conservation, fisheries, etc.	These plans should consider the implications of climate change for coastal erosion and flood risk. The Plans could be used to identify areas of land for managed realignment schemes. The plans should also consider alternative approaches to flood risk management such as soft engineering methods.
Flood and Coastal Defence Strategies	Local	Local Authorities (County Council/Unitary Authority/Borough District Council)	A public statement of the Council's approach to flood and coastal defence in its area. It is based upon the government's policy aims and objectives produced by Defra (formally MAFF).	These plans should consider the implications of climate change for coastal erosion and flood risk. The Plans could be used to identify areas of land for managed realignment schemes. The plans should also consider alternative approaches to flood risk management such as soft

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
				engineering methods.
River Basin Management Plan	Regional	Environment Agency	The EC Water Framework Directive (2000/60/EC) places a duty on member states to ensure that a comprehensive river basin management plan (RBMP) is produced, and updated every six years, for each river basin district. The purpose of the plan is to set out the objectives for the water bodies within the river basin district and to explain in broad terms how those objectives are to be achieved – through the programme of measures. The RBMP must also include information on monitoring arrangements and the status of the water bodies within the river basin district.	The plans must take into account the predicted effects of climate change on the water environment. This includes water resources and supply, water quality and flood risk management and coastal defence. Consideration should be given to how adaptation measures are incorporated into the programme of measures included in the RBMP.
Integrated Catchment Management Plan	Regional	Environment Agency	Integrated Catchment Management Plans are based on geographical catchments, for identifying and assessing, prioritising and solving local issues directly related to protection of the aquatic environment, taking into account the views of the Agency's local customers.	The plans must take into account the predicted effects of climate change on the aquatic environment – for example through impacts on water resources and water quality. Consideration should be given to how adaptation measures are incorporated into Integrated Catchment Management Plans.
Catchment Abstraction	Catchment based	Environment Agency	In England and Wales, abstraction is controlled by a	The plans must take into account the predicted effects of climate

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
Management Strategy (CAMS)			licensing system that was introduced in 1965. This system is administered by the Environment Agency. In 1999, the UK Government renewed the licensing system and identified a number of changes that should be made. Foremost amongst these was the proposal for Catchment Abstraction Management Strategies. CAMS are strategies for management of water resources at a local level. They will make more information on water resources and licensing practices publicly available and allow the balance between the needs of abstractors, other water uses and the aquatic environment to be considered in consultation with the local community and interested parties.	change. These will include changes to water resources, and a potential increase in water demand.
Catchment Flood Management Plan	Catchment based	Environment Agency and Defra (formally MAFF)	The plan provides a comprehensive framework for addressing all Environment Agency functions, including flood defence, within the catchment of a main river.	The plans must take into account the predicted effects of climate change on flooding in catchment areas. Consideration should be given to how adaptation measures concerning flood risk are

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
				incorporated into Catchment Flood Management Plans.
England Biodiversity Strategy	National	Defra (formally DETR)	The 'Biodiversity Strategy for England: Working with the grain of nature' was launched in October 2002. It is the principle means through which the Government will integrate biodiversity into policies and programmes. The Strategy contains a section specifically aimed at encouraging businesses to contribute positively to the UKBAP.	These strategies should take into account and plan for the likely implications of climate change. For example, the migration of species (generally northwards or to higher altitudes) as local climates alter.
UKBAP	National	Statutory agencies e.g. English Nature and the Countryside Councils.	A national (UK) Biodiversity Action Plan (BAP) consisting of Habitat Action Plans (HAP) and Species Action Plans (SAP). It sets out priorities for nationally important and locally important habitats and wildlife and targets to attain.	These strategies should take into account and plan for the likely implications of climate change. For example, the migration of species, as local climates alter.
Local Biodiversity Action Plan	County/Local	Biodiversity Steering Group: central and local government, statutory nature conservation agencies, industry, the main collections, scientific and academic institutions, farming and land management, and the nature Conservation NGOs.	LBAPs are local versions of the UKBAP, they too contain HAPs and SAPs. Around 160 Local Biodiversity Action Plans are in preparation or being implemented across Great Britain. Each Action Plan works on the basis of partnership to identify local priorities and to determine	These strategies should take into account and plan for the likely implications of climate change. For example, the migration of species, as local climates alter.

Plan/Strategy	Level of Plan	Lead partner	Remit of Plan/Strategy	Integrating Action on Climate Change
			the contribution they can make to the delivery of the national Species and Habitat Action Plan targets.	
Air Quality Management Plan	County/Local	County Council/Unitary Authority/District/Borough Council	Following the publication of the National Air Quality Strategy in 1997, a new regime of managing local air quality was introduced across the UK. The focus of Local Air Quality Management (LAQM) is the identification of local pollution hot spots where members of the public might be exposed to future periods of pollution exceeding specific air quality objectives. Local authorities have been responsible for undertaking a scientific assessment process to identify where such hot spots exist within their locality. Where levels are predicted to exceed the national air quality objectives, local authorities must declare Air Quality Management Areas (AQMAs) and prepare an Air Quality Action Plan (AQMP) to reduce concentrations of air pollutants.	Evidently mitigation measures for climate change are very important for air quality. However, consideration should also be given to the implications of climate change for air quality.