



“There is new and stronger evidence that most of the warming observed over the

Living with climate change in the **East of England**
Summary Report

last 50 years is attributable to human activities”



Foreword



Whether we like it or not, climate change is now accepted to be an over-arching issue which will have an impact on the whole of the East of England.

It will touch the lives of everyone in some way, influencing the way we plan new housing developments and the communities of tomorrow, whilst also making us consider how we can minimise the effects on existing settlements and the natural environment in the East of England.

Climate change is also something which business must consider. Agri-food, forestry and tourism-related businesses are just some examples of companies which will be affected directly by climate change and all businesses will have to adapt in some way.

However, there is predicted to be considerable growth in the environmental goods and services sector, as businesses, organisations and householders demand more eco-efficient products and services.

Thinking ahead therefore and planning for eventualities is paramount if we are to face the challenges that climate change presents us with. Climate change is not something we can fight against, instead we must look to manage the impact it will have for the benefit of future generations.

In the summer of 2002, the East of England Sustainable Development Round Table (SDRT) commissioned a report to look at how we as a region can respond to the climate change scenarios, which have been developed by the UK Climate Impacts Programme (UKCIP). SDRT itself is a high-level, cross-sector group which actively encourages and promotes sustainable development in the region.

SDRT's aims when commissioning the study were wide ranging. They included the real need to provide hard evidence for decision makers on the expected regional effects of climate change over the next century and to identify appropriate policies and strategies to deal with the impact.

The study also looks at how local government services are likely to be affected, what can be done to counter those effects and how service delivery is likely to change as a result of the adaptation measures.

It will also have an authoritative input into the emerging Regional Planning Guidance for the East of England, which sets the framework for future development and planning in the region. There is now an opportunity for us all to look at the findings and to start planning together to instigate a process of adaptation across the region.

Richard Ellis, EEDA chair and former chair of the East of England Sustainable Development Round Table



Introduction

Our climate is changing and will continue to change over this century and beyond. In the East of England, summers will become hotter and drier, while winters will be milder and wetter. As well as seasonal changes, there will be more extreme climate events – very hot days and intense downpours of rain, leading to an increased risk of flooding in some areas. Sea levels will rise, increasing the risk of coastal flooding and erosion, and current extremes of high water levels will occur more frequently.

The impacts of climate change are likely to become increasingly evident in the coming decades. If we can incorporate resilience to climate change in the decisions we take today we will be better prepared for the future. It is essential that those who have a leading role to play in these decisions fully understand the implications of climate change and the need to start responding to the challenges it poses. This study is an important first step towards understanding those impacts and working out options for adaptation.

This summary document is accompanied by a technical report commissioned by a partnership of key regional stakeholders. Stage 1 of this technical report examines regional-level spatial adaptation responses, while Stage 2 looks at guidance and adaptation measures for responding to climate change at the local level. You can find out how to access the full study on the back page.



Key messages

- By planning ahead we can avoid the worst impacts and take advantage of any opportunities. Investing now to adapt to climate change can lead to cost savings in the future.
- Key stakeholders in the East of England favour adopting an approach to climate change which allows the region to live with the impacts of climate change in the long term, rather than fight against them in the short term.
- Climate change will create opportunities as well as threats. Tourism is one of the most obvious beneficiaries, but other sectors may also benefit, e.g. environmental technologies to deal with the impacts of climate change.
- Though very few business sectors consider climate change adaptation to be important, business activity will be significantly affected by changes in climate. This report includes resources for the business sector, providing guidance on potential changes in customer demand, sector vulnerabilities, physical impacts, insurance coverage, environmental legislation and working conditions.
- This study analyses the region according to five climate change sub-regions which provide useful geographical units for structuring decisions on climate change. Each sub-region has similar environmental, economic and social characteristics and is likely to face a similar set of climate change impacts, and hence could employ similar adaptation responses. The sub-regions are:
 - The Coast
 - The Fens
 - East of England Northern Heartland
 - East of England Southern Heartland
 - The Thames Gateway and Fringes
- The Thames Gateway and Fringes, and parts of The Coast, are the most vulnerable to the impacts of climate change. Both are vulnerable to sea level rise and increased flood risk, and water resources issues.
- For the Southern Heartland flood risk and water resource issues will be significant.
- The least vulnerable area in climate change terms is the Northern Heartland, as it will be less prone to water supply deficiencies and subsidence than the Southern Heartland, and less at risk of flooding than the Thames Gateway, Coast and Fens. This sub-region offers considerable opportunities, in climate change terms, for housing, economic growth and also for agriculture.
- Development will undoubtedly continue in areas more vulnerable to the impacts of climate change, often for good reasons; the guiding principles prepared as part of the study can help to optimise their location and reduce the vulnerability of settlements to climate change.

The changing climate

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities".

Intergovernmental Panel on Climate Change (IPCC), Third Assessment Report 2001.

Past and present

The earth's climate has been changing throughout its history and, until now, this has been mostly due to natural causes. Recent change, however, has been dramatic. According to the Intergovernmental Panel on Climate Change (IPCC), the increase in surface temperature over the 20th century for the Northern Hemisphere is likely to have been greater than that for any other century in the last thousand years.

Global temperatures have increased by about 0.6°C since the beginning of the twentieth century, with about 0.4°C of this change occurring since the 1970s. Nine of the 10 warmest years on record have occurred since 1990, including 1999, 2000, 2001, 2002 and 2003.

Where long term rainfall records are available a trend is also observable towards more seasonality in UK precipitation. The proportion of precipitation falling in winter relative to summer has increased over time – winters have been getting wetter and summers have been getting drier.



Future

While it is certain that some climate change is inevitable due to the legacy of historical greenhouse gas emissions, future rates of global warming can't be predicted because they depend on future emissions. As a framework for dealing with this uncertainty the UK Climate Impacts Programme (UKCIP) provides a set of future climate scenarios that describe the rates of warming in response to different levels of emissions, namely low emissions, medium-low emissions, medium-high emissions and high emissions. The following tables and maps provide a summary of future change in a variety of climatic variables under the low and high emissions scenarios.

The regional picture

The following maps show changes in the region's annual temperature and seasonal precipitation for the 2020s, the 2050s and the 2080s relative to the baseline period of 1961-90. They were modelled using UKCIP02 scenarios for high and low emissions of greenhouse gases.



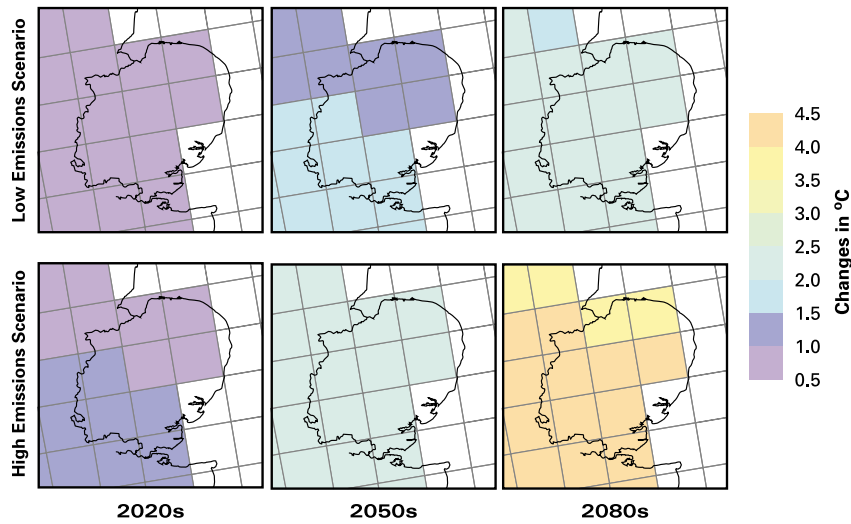


Fig 1 Change in annual temperature

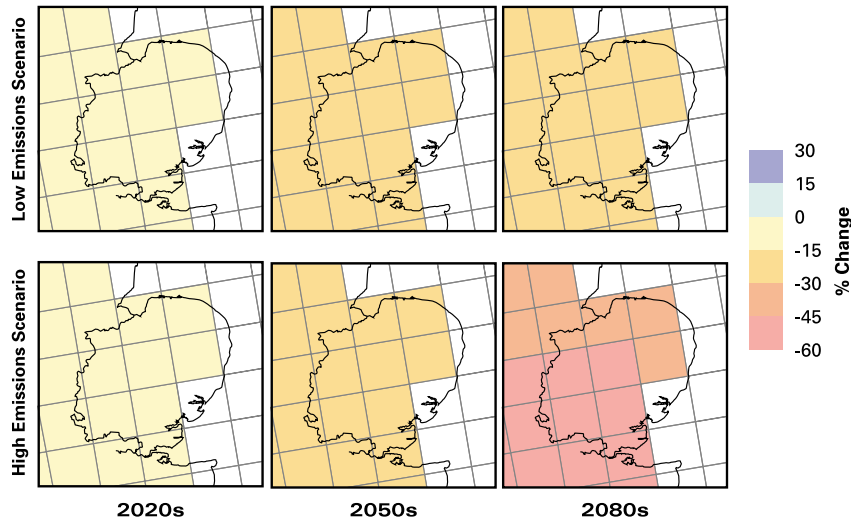


Fig 2 Change in summer precipitation

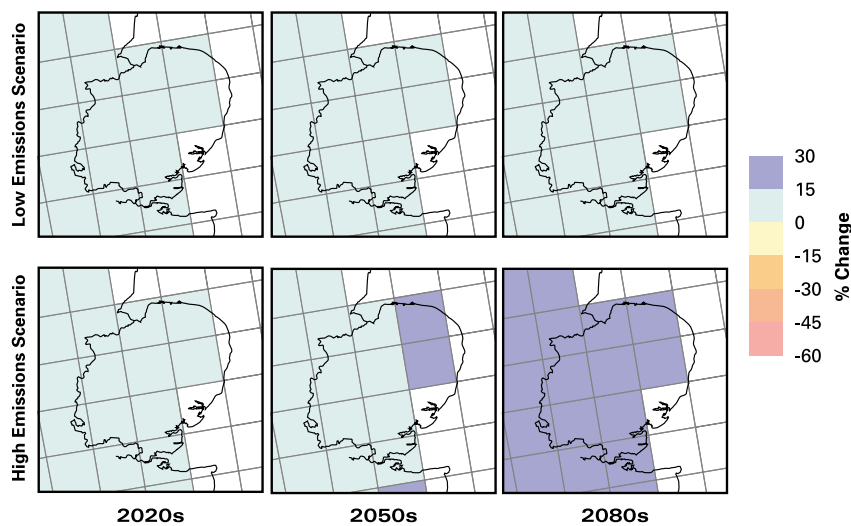


Fig 3 Change in winter precipitation





The following two charts show:

- Anticipated changes in annual and seasonal temperature in the East of England
- Anticipated changes in seasonal precipitation in the region

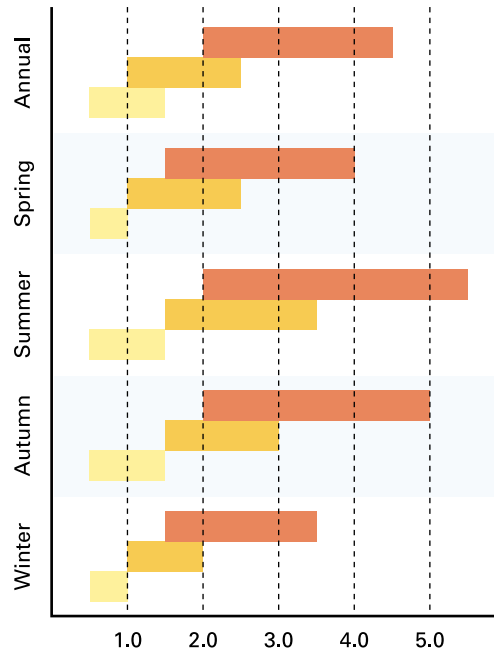


Fig 4 Changes in East of England annual and seasonal average temperature for the 2020s, 2050s and 2080s, as compared to the 1961-90 average (Ranges of figures indicates low and high emissions scenario results)

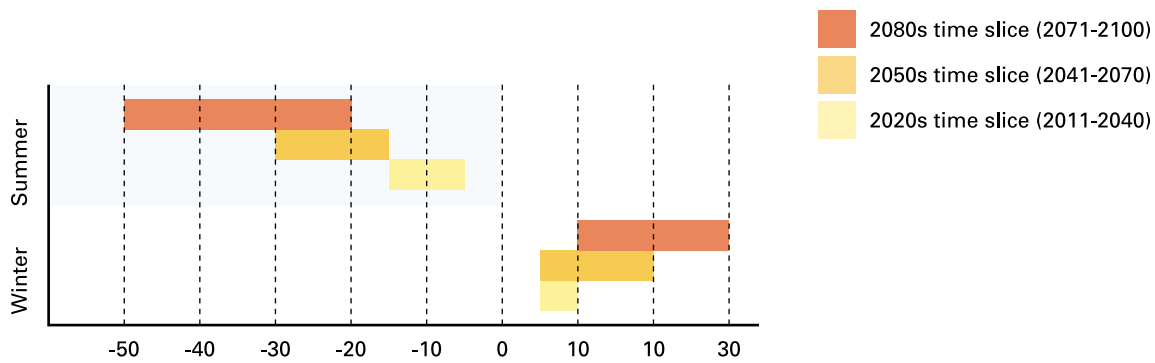


Fig 5 Changes in East of England annual and seasonal precipitation for the 2020s, 2050s and 2080s, as compared to the 1961-90 average (Ranges of figures indicates low and high emissions scenario results)

Responding to climate change

Our response to climate change should involve mitigation against the causes of climate change and adaptation to the impacts of climate change.

It is now widely accepted in scientific and political circles that human activity is contributing to climate change through emissions of greenhouse gases. Both government policy and individual action can help to cut back these greenhouse gas emissions in an effort to mitigate future climate change.

As the climate system is very complex and slow to respond some degree of climate change is inevitable despite our best efforts to reduce greenhouse gas emissions. Therefore we must respond to the impacts quickly and effectively by developing adaptation strategies, and action in key areas is needed now if future solutions are to take account of climate change. This study outlines the key climate change impacts faced by the East of England and presents a basis for developing adaptation strategies..



East of England - a special place

The East of England region is comprised of Hertfordshire, Bedfordshire, Cambridgeshire, Essex, Suffolk and Norfolk. The area is mainly low-lying with diverse landscapes characterised by a strong network of historic cathedral cities, county, market and new towns, and surrounding villages. Since the 1950s it has grown rapidly, influenced by its proximity to London, with the commuter belt containing the highest population densities. The rural and coastal areas are more sparsely populated, and are home to some of its most attractive and sensitive environments.

The Eastern region is rich in history, its wealth founded on agriculture and fishing, and its trading links with continental Europe. There are hundreds of ancient monuments, and many fine historic buildings and churches. Whilst many of the Eastern region's settlements retain a timeless quality, late 20th century growth has led to pressure on town centres and urban fringes and eroded the distinctive character of the region's cities, towns and villages.

The generally flat and low-lying countryside is mainly in agricultural use, and its characteristic scenery is a product of centuries of management by farmers. It has many landscapes rich in history and wildlife supporting important populations of arable farmland species, but in recent decades these have suffered from the impact of intensive farming methods. Other important habitats include ancient woodlands, wetlands, wet grasslands, chalk grasslands and lowland heaths, saltmarshes and mudflats. The Broads, Breckland, the Chilterns and the coast are outstanding in terms of their natural beauty and biodiversity. The quality of the countryside plays a significant role in attracting inward investment and sustainable tourism.

Food production is still the dominant land use in the East of England but is no longer dominant in economic terms. Growth industries include electronics, telecommunications, pharmaceuticals, transport, and tourism. Cambridge is a particular focus for growth. The region benefits economically from its proximity to London and continental Europe, and includes major ports at Felixstowe, Harwich and Tilbury and airports at Stansted and Luton.

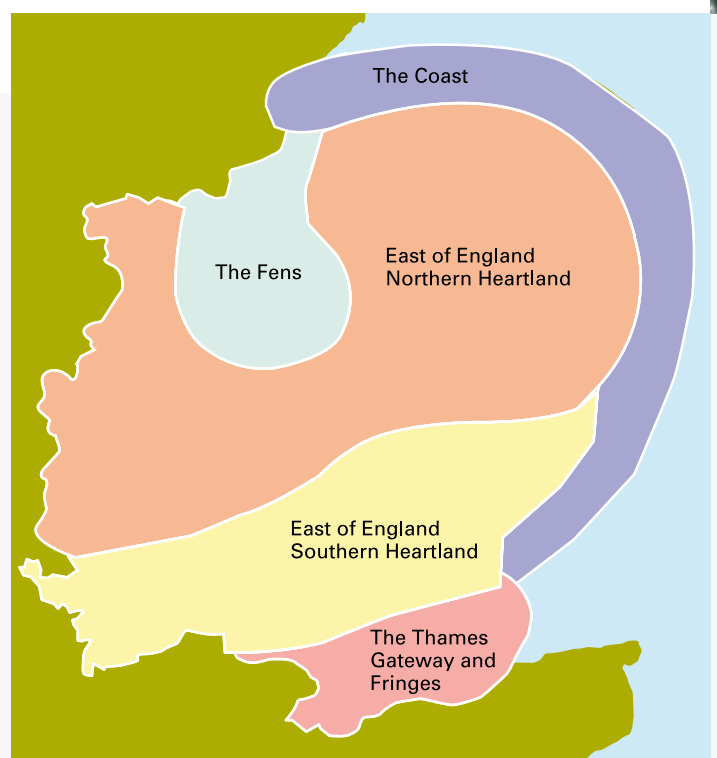
Probably the most valuable natural resource the East of England has to offer is its high grade agricultural land, although soil erosion in the Fens is a cause for concern. Apart from clay, sand and gravel, the region lacks mineral resources. Where extraction has taken place, the pits have subsequently been used for the disposal of waste, much of which has come from outside the region, especially London. The region is the driest in the UK, making it vulnerable to water shortages.



Climate change may well have a greater impact in the East of England than in other regions. As well as having large low-lying areas, the region is also sinking very slowly due to geological processes, making it vulnerable to coastal inundation as sea levels rise. Greater intensity and frequency of winter rainfall may increase the risk of flooding from rivers, while drier summers may put additional pressure on water resources.

The climate change sub-regions

The impacts of climate change are likely to vary across the region, depending on the natural characteristics of the area and the vulnerability of human assets affected. The adaptation measures which local authorities and other service providers will need to plan for are also likely to differ across the region. This study has sought to map this variation with reference to 'climate change sub-regions'.



The Coast

The Coast broadly comprises the south east part of the Wash, 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 and it is home to some of the region's most important wildlife habitats. The Coast is also characterised by relatively remote rural and coastal communities, interspersed by larger towns such as Great Yarmouth and Lowestoft. Some pockets of the region are relatively wealthy such as North Norfolk, whereas much of the sub-region is in need of regeneration. Tourism is an important industry, as are agriculture, forestry, offshore oil and gas, transport and some manufacturing. The Coast is most vulnerable to rises in sea level, storm surges, and saline intrusion as well as 'coastal squeeze' as coastal habitats are squeezed against hard sea defences. This sub-region is also vulnerable to flooding of coastal habitats and erosion. The sustainability and feasibility of defending the Coast is the focus of coastal management, and assessment of appropriate levels of investment in coastal flood risk management needs to consider communities, coastal habitat protection and key infrastructure. In particular coastal archaeology is vulnerable to erosion – as demonstrated by the timber circle at Holme. In-depth assessment of these potential impacts will continue to take place as part of coastal strategy development.

Case study: Loss of natural coastal defences

Essex saltmarshes account for a tenth of the national resource, and between 1973 and 1998 around 950Ha (26% of Essex's total was lost). Overall Essex and Suffolk have lost an area equivalent to 750 football pitches in 25 years.

Coastlines: Issue 2, November 2003 an Environment Agency Anglian Region Publication.

The Fens

The Fens are neatly defined by a single Natural Area of the same name. The area 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. The Ouse and Nene Washes provide very significant wildlife areas in fens that are used to attenuate flooding.

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.

A large part of the Fens is already below sea level and water must be pumped off this land to provide adequate drainage. Climate change 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, and longer growing seasons. These impacts will have specific implications for the services provided by local authorities and other organisations in the sub-region.

Case study: Cash strapped councils seek money for drought hit roads

Subsidence due to the dessication and shrinkage of organic sub strata (eg. peaty deposits) will be significant if dry periods continue - road damage has already occurred in the Peterborough area of The Fens during the 2003 dry period.

Summarised from Repairs swamp cash-strapped council: Peterborough's engineers have been thrust in to the spotlight as their roads come under attack from dry weather induced subsidence in New Civil Engineer, 20th November 2003, p.10.

East of England Northern Heartland

The broad East of England Heartland region has been divided into two for this study. The two parts of the Heartland are distinguished by issues of water resource availability. The Northern Heartland comprises the Natural Areas of Breckland, West Anglian Plain, East Anglian Chalk, Bedfordshire Greens and Ridge, and the northern part of the East Anglian Plain. This part of the Heartland does not experience as much pressure on water resources as the Southern Heartland, mainly due to the lesser extent of short to medium-term housing demand in the region. The character of this sub-region is very varied ranging from the extensive areas of dry lowland heath and pine forest of Breckland to the lowland oaks and mixed deciduous woodlands of the West Anglian Plain.

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.

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



East of England Southern Heartland

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, 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.

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 will now be the subject of considerable growth in the future. There are pockets in need of regeneration, such as Luton and Harlow.

The sub-region is relatively less vulnerable to the impacts of climate change than the Coast, Fens and Thames Gateway. However, it does face agricultural impacts including reduced soil moisture in summer and autumn, higher annual and seasonal temperatures and potential deficiencies in water resources. Due to the water supply issues facing the sub-region, agricultural systems are likely to need to adapt. Landscapes and habitats are also likely to be affected by reduced water availability and temperature rises. 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.

Water resource issues and the risk of subsidence are likely to place specific requirements on service providers in this sub-region. Subsidence will have maintenance implications for local authorities and others involved in maintaining the road and rail networks, as well as service implications for property managers.



Thames Gateway and Fringes

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 and a rich archaeological record. 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. The sub-region is heavily influenced by London (into which the Thames Gateway policy area extends).

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

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 in turn affect our ability to adapt appropriately, if at all. There will, therefore, be particular pressures in relation to the vulnerability of property and infrastructure, to which local authorities and other service providers must respond. 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. A Strategy for Flood Risk Management for the Thames Estuary to 2100 is currently underway and taking the above issues under consideration.





Planning for adaptation

The impacts of climate change in the East of England are likely to have significant economic and operational implications for local authority services and on infrastructure provision in the region. Local decision-makers will undoubtedly wish to consider the cost implications of dealing with climate change, especially when there are still uncertainties about some of the impacts. It is difficult to plan for climate change impacts when the benefits of investment 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.

This report incorporates some of the guidance presented in *Climate adaptation: Risk, uncertainty and decision-making* (UKCIP Technical Report, 2003, available from www.ukcip.org.uk), which offers a framework for making adaptation decisions in the face of climate-related risks. Some of the key recommendations that we have incorporated include:

- keeping options open and flexible so that extra measures can be added in future
- avoiding making decisions that make it more difficult to cope with climate change in future, and
- trying to find no-regrets options that deliver benefits whatever the extent of climate change

The study also provides guidance on short, medium and long-term timeframes for adapting to climate change. Where there is a short to medium term need for change **'Act now'** indicates that these issues should be made a priority for action planning. For medium to long-term action **'Plan for the future'** is advised to ensure that a robust level of service or infrastructure will be in place to cope with the expected impacts. If actions are related to major investment in infrastructure or the construction of significant capital works with long timespans, budgets may have to be considered now to plan for added costs. The last category **'Keep a watching brief'**, encompasses the uncertain element of adaptation planning where the best advice is to monitor an issue to ensure that the most prudent action is taken at the optimal time.

Local service provision

Transport infrastructure

The adverse effects of more extremely hot days in summer (resulting in melting of tarred road surfaces and 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). Storm events and wetter weather could lead to flooding of transportation infrastructure, and where the possible impacts might result in blocked roads or severe damage there will also be traffic management issues. In the south of the region, investment may be needed to strengthen infrastructure at risk from subsidence in clay soil areas. Local authorities should also ensure that the maintenance programme for roadside verges takes into account the lengthening of the growing season and the need to cut vegetation over a long time period while ensuring that biodiversity is not unduly affected.

Planning, buildings and estates

Buildings and estates are designed to be operational over a long period, so it is important to incorporate information about future climatic conditions when making long-term planning decisions or investments. Planning policies should influence the location and design of new buildings to minimise vulnerability to climate change. Extreme climatic 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. Local authority properties and housing stock will benefit from measures to increase flood resilience, ventilation and water efficiency. Building in this resilience now will mean that properties can more easily adapt to climate change in the future. Historic buildings are particularly vulnerable, but also pose special problems of modification. Management of parks and estates will need to take account of the impacts of drier, hotter summers and wetter, warmer winters on trees and other vegetation. Maintaining the character of historic parks, which provide the landscape setting to many great houses, will be problematic. Warmer temperatures are also likely to lead to a more outdoor lifestyle, putting greater demands on our green open spaces.



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.

Emergency planning

We have already experienced growing numbers of extreme weather events which have required continued investment in warning systems. Under climate change, greater frequency and intensity of winter rainfall is likely to increase the risk of fluvial flooding, while higher and more frequent storm surges are likely to contribute to coastal floods and inundation. Both events require a co-ordinated emergency response. Periods of prolonged or extreme summer heat may also warrant an emergency response. The changing climate poses the risk of property damage with associated costs, as well as risks to human safety and health. In order to be effective, it is vital that emergency planning takes climate change into account.



Waste and pollution

Climate change is likely to make some chemical processes more active through warmer temperatures and some pollutants more mobile because of more frequent intense rainfall. This suggests that greater care will be required in dealing with waste (particularly organic wastes), including prompt and more frequent collections and better design of waste management facilities. Pests and vermin are likely to become more active in warmer weather, posing an increased public health risk. Warmer temperatures are also likely to exacerbate air pollution resulting from traffic and congestion. There are considerable problems associated with the spread of pollution via flooding, the frequency of which is likely to increase under climate change. In addition, currently acceptable levels of pollutants released as effluent to rivers may well become unacceptable if drier, hotter summers cause lower seasonal river flows.

Ipswich Borough Council Drainage and Flood Defence Policy – a proactive approach to flood risk

A number of features in the urban environment can exacerbate the damage caused by flash flooding. Increasingly dense house building, shared surface roads with very low kerbs, and disabled access requirements for very low thresholds all mean that intense rainfall events are more likely to lead to urban flooding. Extreme events, resulting from increasing amounts and intensity of rainfall, are likely to become more common with climate change, indicating 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 unless adequate measures are taken, many properties are likely to suffer flooding, which could place costly post-flood burdens on the Council. Ipswich Borough Council is therefore taking a proactive approach through, for example, the promotion of Sustainable Urban Drainage Systems (SUDS) to help alleviate urban flood risk.

Ipswich Drainage and Flood Defence Policy, 2002. Ipswich Borough Council.

The wider environment

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 long-term strategies and when managing sites. Historic buildings are particularly susceptible to the impacts of climate change from subsidence, penetration by heavy rain and damage from flooding and extreme weather events. Local authorities should work with others to identify threats and to develop and implement strategies for protection. Adaptation strategies for preservation of biodiversity include providing space for species to adapt, creating wildlife corridors to facilitate migration, and realising the opportunities for the creation of new habitats as others are lost.

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.*

*many of which are situated in the East of England
Potential UK Adaptation Strategies for Climate Change: Technical report, 2000, ERM.

Other agencies' service provision

Water services

Climate change is likely to cause demand for water to increase. During hotter, drier summers it may be increasingly difficult for supplies to keep up with demand, with implications for water service providers. Increased climatic variability and more intense winter rainfall could put pressure on drainage systems, particularly in urban areas. 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. Low summer river flows may affect water quality, and actions to counter this range from specific measures to modify water treatment plants and sewage systems, to wider measures to improve river basin management. The development of the second generation of Shoreline Management Plans will help assess the risks to coastal communities over the next 100 years, while Catchment Flood Management Plans will look at fluvial issues over the next 50 years.



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.

Energy services

Energy providers may need to adapt to changing patterns of seasonal energy demand under climate change. For example, there may be increased summer demand for power for cooling, with decreased demand in winter for heating. Climate change mitigation policy will also create new opportunities for renewable energies like wind, solar or tidal power. The use of on-site renewable energy will increase an individual business or organisation's resilience to disruption of supply. Key adaptation responses relate to the impacts of climate change on energy infrastructure such as power stations and pylons.

Transport services

A wide range of adaptation measures may be needed to adapt road and rail infrastructure (including road surfaces and rail tracks, earth structures, bridges and gantries) to make it more resilient to the impacts of climate change. As an example, changes to rail track specifications may be necessary to prevent buckling in warmer summer temperatures. Other measures could include the use of more durable materials, 'climate proofed' designs, and improved drainage. Climate change could lead to increased risk of road accidents from both wetter winter and warmer summer conditions. Clearer signage around accident 'hotspots' could decrease this risk to some extent. With respect to sea transport there are likely to be critical impacts on the UK as an island and especially the East of England region as a host of many ports, particularly with respect to the potential for increased storm surges. Climate change may offer some benefits for transport services, like the reduced need for salting and gritting during milder winters.

Nature conservation

Under climate change, species may be affected by direct habitat loss as a result of rising sea levels, for example, or by physical environmental changes associated with availability of water and higher temperatures. Climate 'spaces' will shift, and some species will see an increase in climate space while others will see a decrease. The response to changes in habitats and species will largely depend on attitudes – what should we try to save? What should we allow to migrate, evolve and change? Climate change will also provide opportunities for the creation of new habitats. Policy and management of natural spaces must build on the natural dynamics of ecosystems.

Case study: Accommodating climate change within the Biodiversity Action Plan (BAP) process

Nature conservation policy and management must build on the natural dynamics of ecosystems, and encourage the creation of ecological networks and buffer zones which will allow species to colonise new areas. There must be a consistent approach to habitat creation, restoration and management of loss, taking a steer from panels of expertise and the priorities identified through the BAP process. Overall a precautionary approach must be adopted whereby decisions taken now should not constrain or reduce the region's ability to adapt effectively to the impacts of climate change in the future.

Quote from Paul Wilkinson, Chairman, East of England Biodiversity Forum, 10th December 2003.

The historic and archaeological environment

There is a wealth of historic sites on the coast, and these sites will be subject to increased coastal flood risk, while inland properties may also be at increased risk of fluvial flooding. Where sites cannot be protected, further strategies are needed to allow recording. English Heritage is currently considering the impacts of climate change on the historic and archaeological environment, which encompasses both the built heritage and parks and gardens and other 'outdoor' sites. Due to the sensitive nature of this type of 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, while storms may cause costly structural damage.

Agriculture, fisheries, woodland and forestry

Agriculture is an important economic activity in the East of England. It is likely to face considerable impacts due to climate change. Key implications revolve around increased temperatures, an increased thermal growing season, and reduced summer precipitation and soil moisture. Flood risk will also have a significant bearing on agriculture and forestry, for instance floodplains may be more frequently flooded. Adaptation in the types of crop varieties grown will probably 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, and ploughing techniques. Adaptation to water resource pressures will also be very important. Farmers will need to consider growing crops with lower water requirements. Many farmers are already adopting innovative ways of managing 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.

Health services

Without appropriate adaptation strategies impacts on health could be wide ranging, including heat-related deaths and illness, increased incidence of food poisoning, increased injuries during storm events, and increased incidence of skin cancer. Climate change could place an additional burden on the National Health Service as climate change impacts arise. There may also be some lessening of pressures in other areas, however, as illness and death caused by cold winter temperatures decreases. 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. Some impacts can be avoided by ensuring people use UV sunscreens, and by making sure that vulnerable people are able to avoid high temperatures in summer.



Economic sectors

"Climate change is a crucial issue for UK investors and business. Climate change represents major opportunities – to invest in new cleaner technologies, and to trade in greenhouse gas emissions, but it also poses risks for those in business who do not address it properly."

The Rt Hon Margaret Beckett MP, Secretary of State for Environment, Food and Rural Affairs, addressing the Institutional Investors' Group on Climate Change (IIGCC) conference, 26 November 2003.

Business activity will be significantly affected by climate change, and it is essential that economic sectors prepare for these impacts and recognise the importance of adaptation. By planning ahead businesses can minimise the negative impacts of climate change and take advantage of the potential benefits.

There are several key issues for all businesses to consider. Here are some examples:

- How might customer demand change as a result of climate change?
- Is the business dependent upon a sector or activity that is vulnerable to changes in climate?
- How might competitors be relatively disadvantaged or advantaged?
- Will climate change have a physical impact upon the business (e.g. increased risk of flooding or subsidence, supply chain disruption, etc.)?
- How might climate change affect insurance cover for the business?
- How might environmental legislation in relation to climate change affect the business?
- How might climate change affect employee working conditions?

Different sectors will also face specific impacts to which they will need to adapt. This study explored impacts and adaptation responses for the nine economic sectors, considered by the East of England Development Agency (EEDA) to be of strategic importance in terms of the performance of the regional economy.

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 20-30°C.

Climate Change and Agriculture in the United Kingdom, prepared for MAFF, 2000.

Agriculture and food processing

The agricultural industry, concentrated in the north of the region and the Fens, is likely to be affected by a combination of impacts, from reduced soil moisture levels and increased soil erosion to a lengthening of the thermal growing season. Non-climate related impacts such as reduced direct price support and changes in the way farmers are marketing their produce is changing the face of the industry as it becomes increasingly diversified, specialised and connected to new opportunities in the tourism sector. Farmers will need to deal with new pests and diseases while exploring new heat or drought-resistant crop varieties. During the heat wave of summer 2003 sales of salads and drinks increased noticeably, demonstrating the effect of changing patterns of consumer demand for more 'warmer climate foods'. Refrigeration of foods over long distances will present a challenge under a warmer climate, as will an increased likelihood of food poisoning cases. Partners working on the 'Sustainable Food and Farming Strategy' for the region are currently taking a range of climate change impacts, including water resource and supply issues, into consideration. Continued partnership working by key parties will allow this sector to reduce negative climate change impacts in the future and help the region to reap the benefits of the new opportunities climate change might present.



Automotive

The automotive sector will be challenged by consumer demand for vehicles that perform better on wetter roads in winter and in drier conditions during the summer months. Due to an increase in the likelihood of flooding, manufacturing plants may have to consider adaptation or relocation if their plant is based in a low-lying area. In the volume car industry there may also be impacts around the distribution of valuable cargos in stormy conditions and possible implications in terms of insurance for the transportation of vehicles during extreme weather events. There may also be an increase in the demand for vehicles suited to outdoor leisure pursuits, like soft-tops, four wheel drives and camper vans.

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' has been 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 (CO₂) 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 www.sam-group.com/changingdrivers and <http://capitalmarkets.wri.org>

Financial and business services

This is a very big sector in terms of employment in the region. It has grown partly through decentralisation from London and partly through specialist service providers growing at key nodes in the East of England. Climate change is likely to present major implications for the insurance industry as flooding, severe weather events and subsidence are all likely to lead to increased claims against the industry. It is possible that 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 localised 'credit crunches'. There will, however, be new opportunities for climate change mitigation activities, including low carbon and renewable technologies and 'carbon trading'.

High-tech manufacture and advanced engineering

This is a large and diverse sector, and one that provides an important input into many activities across the region. Increased temperatures, increased pressure on water supplies, and possible changes to energy costs may all require changes to manufacturing processes. These should be assessed now to gauge the level of adaptation necessary, and to avoid high costs in the future. There is concern that South Essex, in particular, with its high concentration of automotive manufacturing activities may be increasingly prone to flooding in the future. Climate change is likely to present more opportunities for renewable technologies as demand for wind farms, turbines, solar technology, and engineering support services grows. There may also be demand for new materials that perform well in changed climatic conditions.

Information and communications technologies (ICT)

The ICT sector is a sizeable employer in the East of England, as well as being a focus for regional investment. Extreme climate events may increase the incidence of ICT 'down time' as a result of loss of infrastructure or change. In buildings with major hardware installations it will become increasingly difficult to maintain a maximum internal temperature. Opportunities for natural ventilation should be incorporated wherever possible when other building refurbishments are planned.

Case study: Example

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.

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.'

Extract from "Visiting Professor Honoured", Horizon: News of the University Hertfordshire, Issue 41, October 2003.

Life sciences

The life sciences sector is an industry that features a high-level of R&D based activity, with major concentrations around Norwich and Cambridge and the south of the region, while Hertfordshire and west Essex have a high incidence of big pharmaceutical companies. The impacts on this sector are most likely to be secondary effects of climate change. For example, challenges facing agriculture such as increased risk of drought and flooding could create opportunities for plant genetics. The industry would also be affected by any changes in the capital markets (which might come about because of changes in the value of property). Finally climate change is likely to result in an increased need for air conditioning, particularly in buildings with laboratory equipment.

Media and cultural industries

There are some key nodes for these sectors around the region, notably Leavesden in Hertfordshire and a concentration of TV-related activity in Norwich. Drier summers may make the East of England more attractive, and the region could benefit from decentralisation of an overheated Soho cluster. Some areas with a relatively strong presence in the cultural industries, however, are within climate change sub-regions that are at risk of flooding (e.g. Southend).

Tourism, leisure and heritage

The East of England has some globally significant tourist 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 is a major employer. Longer summers with less rain could make the East of England a much more attractive destination for main break holidays, and the warmer weather may see domestic holidays substituted for overseas trips. The region can act to ensure that efforts to promote tourism seek to do so in a sustainable way that respects the value of the natural environment. Efforts to increase coastal tourism must also be compatible with flood defence decisions undertaken by the Environment Agency and other partners. Some schemes designed to adapt to climate change (such as realignment of coastal flood defences, creation of wetlands for flood risk management) may offer significant tourism attractions. Watercourses with significant tourism or leisure value may be increasingly prone to winter flooding (e.g. the Broads) or low summer flows (e.g. the Cam). Heritage sites are particularly vulnerable to the impacts of climate change, and adaptation responses are generally more complicated than those for the conventional built environment.

Transport gateways

The East of England region contains 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, where, again, major investment is proposed. The impacts of climate change on these transportation gateways include inundation and siltation in port channels, increased susceptibility of landslip on railway embankments, fewer ice/snow-related delays to rail and air travel, and increased likelihood of enforced speed reductions due to buckling rails in extreme heat. Detailed guidance for road and rail transport service providers is given in other sections of this document. In response to these climate change impacts it is important for the region to invest in public transport systems that will be appropriate for hotter and more extreme conditions.

Working together

As this summary document 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.

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 recommendations should be considered:

Integration into Community Strategy and LSP – The Community Strategy and Local Strategic Partnership 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 the Partnership and through the Community Strategy.

A number of local authorities, such as Leicester City Council have already integrated energy and climate change concerns into their LSP and Broxtowe Borough Council (Nottingham) have included it in 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.

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 sustainable development, 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.

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 the CSERGE at the University of East Anglia. There is thus potential for partnership working between local authorities and academic bodies in the adaptation response.

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, the Sustainable Development Round Table and the East of England Regional Assembly.

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 the 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.

ECONOMY, LEISURE AND TOURISM		
Potential Impacts	Adaptation responses	Time frame for action
Changes in climate may increase in demand for some products and services (e.g. tourism and leisure services, climate change related technology, etc.)	Ensure that climate change risks and opportunities are taken into account in economic development plans/strategies	Plan for the future
Economic development may be constrained in areas vulnerable to flood risk	Work with other partners to put in place land use planning policies that address climate change impacts on economic development	Plan for the future
Warmer, drier summers could boost tourism and demand for outdoor leisure facilities	Review Tourism Strategies to ensure they take account of climate change impacts	Act now
EMERGENCY PLANNING		
Potential Impacts	Adaptation responses	Time frame for action
Likely significant increase in costs and demand for services as a result of extreme weather events, in particular flooding	Ensure appropriate allocation of resources for emergency planning	Act now
	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
	Ensure that emergency control rooms are not at risk from flooding	Plan for the future
PLANNING, BUILDINGS AND ESTATES		
Potential Impacts	Adaptation responses	Time frame for action
Damage costs to buildings from extreme weather events and flooding	Adapt properties to make them more resilient to flood damage and ensure siting does not exacerbate flood risk	Act now/plan for the future
Higher temperatures leading to increased demand for cooling and ventilation	Improve ventilation, cooling and shading in Council owned properties	Plan for the future
Possibility of water shortages during hot, dry summers	Include water conservation measures in new build and retrofit existing stock	Act now/plan for the future
Increased demand for parks and open spaces	Create well-shaded green spaces	Act now
TRANSPORT INFRASTRUCTURE		
Potential Impacts	Adaptation responses	Time frame for action
Traffic disruption from more frequent extreme weather, particularly flooding	Continue to maintain highways and update maintenance systems	Act now
	Identify infrastructure at risk from flooding	Plan for the future
	Plan to re-site infrastructure as necessary and plan routes to minimise disruption	Plan for the future
Any disruption of rail routes (from flooding, subsidence, landslips following heavy rainfall, disruption to overhead lines during storms, etc.) will impact on traffic management	Prepare emergency plans to manage road traffic in the event of a major disruption to rail services	Act now
WASTE SERVICES, POLLUTION CONTROL AND MONITORING AND ENVIRONMENTAL HEALTH SERVICES		
Potential Impacts	Adaptation responses	Time frame for action
Some impacts on handling and disposal of putrescible materials (e.g. odour and vermin control during warmer summers)	Ensure that waste contractors take into account warmer temperatures in the design and management of waste sites	Act now
	Consider the need for more frequent collections and street cleaning	Plan for the future
Increased summer temperatures and extremely hot days will exacerbate air pollution	Model potential increases in the main air pollutants to inform action in Air Quality Management Areas	Plan for the future
	Work to reduce air pollution from motorised transport through promotion of Travel to Work Plans	Act now
HEALTH SERVICE PROVISION		
Potential Impacts	Adaptation responses	Time frame for action
Potential increases in heat related deaths and incidence of heat related illness due to more frequent extremely hot days	Provide advice to vulnerable groups on how to stay cool	Act now
Potential increase in deaths and severe injuries during more frequent storms and flood events	Introduce better warning systems	Plan for the future
	Work with other partners to ensure preparedness for a severe flooding event and the long-term follow up	Act now

CONSERVATION AND MANAGEMENT OF THE HISTORIC AND ARCHAEOLOGICAL ENVIRONMENT		
Potential Impacts	Adaptation responses	Time frame for action
Implications of seasonal temperature changes for ventilation and heating of heritage buildings	Review ventilation requirements	Plan for the future
Increased damage to structures from more frequent extreme winter precipitation and storm events	Allocate adequate resources for monitoring and maintenance	Plan for the future
	Ensure disaster planning is undertaken	Plan for the future
Increased cost of conserving the historic environment due to subsidence, penetration by heavy rain, and potential damage from flooding	Plan for the increased need for shelterbelts	Plan for the future
	Work with stakeholders to survey elements of the historic environment at risk from climate change impacts and develop and implement a strategy to conserve them	Plan for the future

CONSERVATION OF THE NATURAL ENVIRONMENT		
Potential Impacts	Adaptation responses	Time frame for action
Changes in water availability and temperature increases will affect habitats and species	Consider the responses of species to climate change and community dynamics in Biodiversity Action Plans/ management plans	Plan for the future
	Ensure policy builds on the natural dynamics of ecosystems by, for example, incorporating buffer zones around designated areas	Plan for the future
Increased flood risk from rivers and streams could have detrimental effects on ecology and soils	Ensure that relevant plans consider the implications of climate change for flood risk and the associated impacts on ecology and soils	Act now
Woodlands may face increased frequency of drought conditions and storm damage	Implement appropriate strategies e.g. to plant new more drought tolerant species	Plan for the future

WATER SERVICE PROVISION		
Potential Impacts	Adaptation responses	Time frame for action
Temperature increases, lower summer precipitation and increased climatic variability will affect water resource availability and demand	Promote water conservation measures such as use of grey water and rain water harvesting	Act now
Higher summer temperatures and lower summer precipitation will increase the concentration of pollutants in water sources	Ensure that the abstraction of water is sustainable	Act now/plan for the future
	Improve river basin management by implementing the Water Framework Directive	Plan for the future



With thanks to English Nature for their generous contribution of selected images used in this publication.

In September 2002, the East of England Regional Assembly and Sustainable Development Round Table 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.

The 'Living with Climate Change in the East of England' study consisted of two stages which produced technical adaptation guidance. The Stage 1 report covers 'Guidance on Spatial Issues', looking at regional spatial adaptation responses. The Stage 2 report covers 'Guidance for Local Service Provision', providing guidance on adaptation responses for business, local authorities' and other agencies' service provision.

The steering group for the study included representatives of:

Sustainable Development Round Table for the East of England, UK Climate Impacts Programme (UKCIP), Environment Agency, English Heritage, English Nature, Government Office for the East of England, University of East Anglia (CSERG), The Royal Society for the Protection of Birds (RSPB), East of England Regional Assembly (Environmental Forum), Hertfordshire County Council, East of England Regional Development Agency, East of England Regional Planning Body, Anglian Water, Countryside Agency, Forestry Commission

The steering group would like to thank the following organisations for their contributions to the study:

Hertfordshire County Council, Hertfordshire Environmental Forum, English Regions Network, Government Office For the East of England, Essex County Council, Norfolk County Council, Suffolk County Council, English Heritage, East of England Development Agency, English Nature, Environment Agency, United Kingdom Climate Impacts Programme, Countryside Agency, Bedfordshire County Council, The Royal Institute Of Chartered Surveyors, The East Of England Regional Assembly

To download the full technical documents of the study findings visit <http://www.sustainability-east.com/>



For other further information on the study contact the Secretary of the East of England Sustainable Development Round Table, Clare Merritt, email: cmerritt.go-east@go-regions.gsi.gov.uk. For further information on climate change in other regions visit the UK Climate Impacts Programme website <http://www.ukcip.org.uk>

This is one of a number of studies conducted under the umbrella of the UK Climate Impacts Programme (UKCIP). Based at the University of Oxford, UKCIP was set up by the Government in 1997, to provide a framework for an integrated assessment of climate impacts and to help organisations assess how they might be affected by climate change, so they can prepare.