

RISING TO THE CHALLENGE

Impacts of Climate Change in the South East
in the 21st Century

November 1999
SUMMARY REPORT



“The South East is currently under pressure from many quarters and climate change is going to make things worse. A new planning agenda is urgently required to prepare the region for the challenges it faces from a changing climate. These challenges are set out for the first time in this report.”

Merylyn Mackenzie Hedger, Programme Coordinator, The UK Climate Impacts Programme.

The Changing Climate

The climate of the South East is already changing. Over the past century average temperature has risen by 0.5°C and summer rainfall has decreased. Around the region's coastline the sea level is rising, threatening important coastal habitats and increasing the risks of coastal flooding. There are other more subtle signs of change; for example, higher temperatures have led to earlier leaf emergence in Oak trees and the earlier arrival of swallows on the South coast.

Greater climate changes are predicted for the 21st century. It will be warmer all year round, winters will be much wetter and summers much drier. Weather extremes - such as the storms that caused the great floods on the eastern coastline in 1953, the severe storm that devastated the South East in 1987 and the swelteringly hot summer of 1995 - may occur more frequently than in the past century.

Impacts on the South East

The South East has potentially more to gain, and certainly more to lose, from climate change than any other region in the UK. It has one of the fastest growing and most economically active populations in the UK. The economy of the South East is critical to the performance of the UK as a whole. With an economic output approaching £58 billion, it is the second biggest regional



An aerial view of the damage to trees in parkland caused by the storm in October 1987.

Courtesy National Trust Photographic Library/ Mike Howarth

economy behind London. In the past, the region was self-sufficient in terms of its natural resources such as water for domestic and industrial uses. More recently, water shortages have had many effects including the introduction of long-term hosepipe bans and the drying out of valued wetlands.

The Study Area



Front cover photographs:

Main Photograph

Courtesy The Met. Office

Flooded street

Courtesy The Env. Agency

Countryside

Courtesy Surrey Hills AONB Office

Isle of Wight coastline

Courtesy National Trust Photographic Library

Lightning

Courtesy The Met. Office

Cracked earth

Courtesy The Met. Office



Dover Port from Langdon Cliffs at dusk

Courtesy National Trust

Photographic Library / Joe Cornish

Rising to the Challenge

The changes we have seen to date are just the start of things to come. Climate change will create many new challenges for the region. How will we defend the coastline from rises in sea level and changes in storminess and the power of the waves? How will we improve flood warning as floodplains become more hazardous places to live? Will businesses adapt and take on the challenges created by changes in recreational patterns, tourist preferences and domestic lifestyles?

For the first time in the South East, local and national government, private companies and non-governmental organisations have risen to the challenge by funding a scoping study to identify the impacts of climate change. We don't have all the answers, but over the last 6 months we have consulted over 80 organisations that could be affected by climate change. Our report takes the first steps in developing climate change adaptation strategies by identifying the main impacts in a number of sectors, such as coastal management, water supply and the countryside.

A New Planning Agenda

It is clear from our consultation that a new way of thinking is urgently required to prepare for the challenges ahead. The approach must:

- be integrated, to make sure that adaptation in one area does not have a negative impact upon another
- include risk analysis for areas such as flood defence
- encourage improved monitoring to assess whether anticipated climate changes are taking place
- be flexible, so that strategies can be revised in response to changing conditions
- widen the traditional approach to land use planning to take account of changing circumstances
- identify the main pressure points in the region that warrant more detailed impact assessment

“Rise in sea level is probably our greatest future threat from an operational viewpoint. An increasing incidence of storm surge tides during the period August to April, especially if accompanied by strong winds and wave activity also pose serious problems, with disruptions of ferry services to the continent and quayside flooding.”

Robert Mackenzie,
Dover Harbour
Board.

The Earth has warmed by around 0.6 °C since 1900. The four warmest years globally have been (in decreasing order) 1998, 1997, 1995 and 1990. Temperature records for England show that four of the five warmest years since 1659 have occurred since 1988.

Global Climate Change

The global mean temperature in 1998 was more than half a degree above the average temperature for the period between 1961 and 1990. The warming has been due to both human impacts and to natural variation, such as the occurrence of strong and prolonged El Niño conditions in the Pacific Ocean in the 1980s and 1990s. In the UK several recent summers (for example, 1995) have been unusually warm with some individual months close to the recorded maxima. There have also been changes in rainfall patterns. Recent dry summers in England are part of a longer-term decline in summer rainfall over Western Europe, while at the same time the winter rainfall over some northern areas including Scotland has increased.

Mitigation v Adaptation

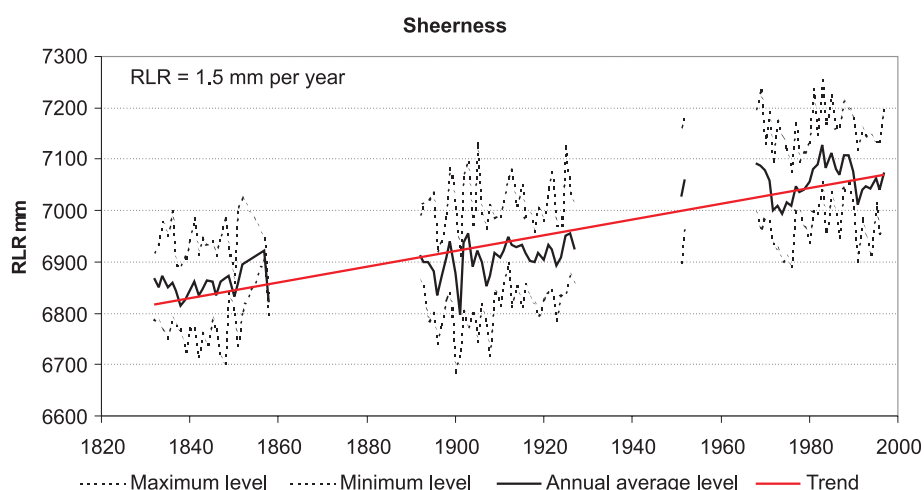
It is now widely accepted that human activity, such as the burning of fossil fuels, is causing global climate change. Both government policy and individual action can help to cut back these greenhouse gas emissions, for example through the introduction of a carbon tax or individual decisions on efficient transport and home energy use. Such **mitigation measures** are part of a long-

term strategy that will help reduce the level of global warming, but the global climate is slow to respond. In the meantime climate change will continue with implications for everyone. We need to respond to these inevitable impacts quickly and effectively by developing **adaptation strategies**. This report is about identifying the key impacts and making the first steps towards developing adaptation strategies within the South East.

Climate Change Models

Much of the information about the possible future effects of greenhouse gases on global warming has been produced by using climate change models. The UK Climate Impacts Programme (UKCIP), established by the Department of Environment, Transport and the Regions, has published a set of scenarios of possible future climate change for the 2020s, 2050s and 2080s based on work undertaken at the UK Met. Office Hadley Centre and the Climatic Research Unit at the University of East Anglia. This report uses these scenarios to project possible future climates in the South East.

Historic rates of sea level rise



Notes: The graph is based on the annual average, maximum and minimum of daily or sub-daily level gauges. Rates of rise anticipated due to climate change are approximately 5 times greater than the historical trend. The data are from the Permanent Service for Mean Sea Level (PSMSL) and are reproduced with permission from the Proudman Oceanographic Laboratory (POL), Bidston Observatory which is a component of the UK Natural Environment Research Council (NERC).

The reported sea level is units of mm relative to a 'Revised Local Reference' (RLR).

Data available on <http://www.nbi.ac.uk/psmsl/psmsl.info.html>

The Climate of the South East in the 21st Century

Tomorrow's climate will be different from today's. By the 2080s a number of changes will be evident:

- It will be warmer all year round with most of the warming in summer and autumn
- Winters will be wetter and summers will be drier
- It will be sunnier in summer, because of a reduction in average cloud cover and this, together with higher temperatures, will cause a large increase in summer evaporation
- It will be windier with an increased risk of severe storms

By the 2080s sea level in the English Channel will stand 54 cm higher than present due to the thermal expansion of sea water, melting of ice caps and sinking of the land into the sea. Locally there will be even higher rises in sea level relative to land level, in areas of pronounced land subsidence.

There is some uncertainty about the sensitivity of the earth's climate to increases in greenhouse gases. This is reflected in the four UKCIP scenarios, which cover a range of possible future climates. The main changes projected for the 2080s as compared to the (standard) 1961-90 period are given below. The values reflect the range across the four scenarios (named low, medium-low, medium-high and high):

• Mean annual temperature	+ 1.2 to + 3.4 °C
• Mean annual rainfall	+ 1 to + 4 %
• Winter rainfall	+ 6 to + 22 %
• Summer rainfall	- 8 to - 23 %
• Summer cloud cover	-3 to - 4 %
• Mean annual wind speed	0 to + 0.09 m/s
• Summer evaporation	+ 0.45 to + 0.91 mm/d
• Relative humidity remains fairly constant	
• Overall increase in temperature and rainfall variability	

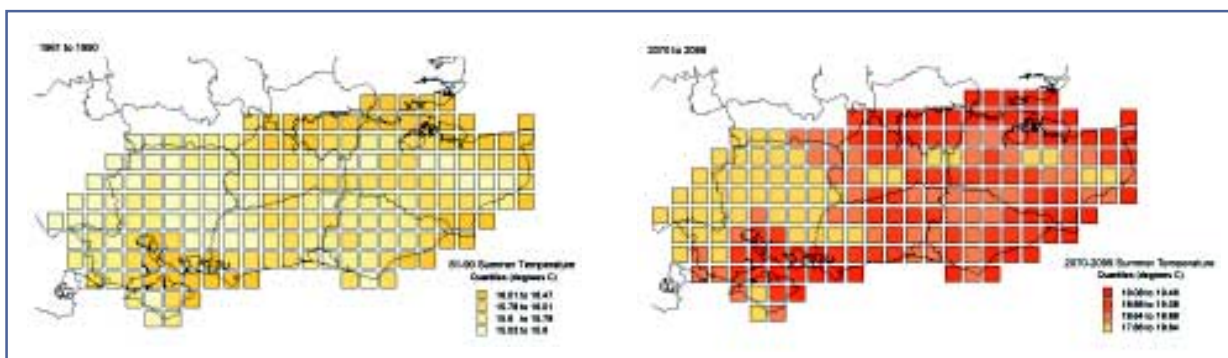
This report mainly uses the climate projections from the medium high scenario. This predicts the following changes; from the present to the 2080's.

- Mean sea level in the English Channel + 54 cm.
- A "1995" summer temperature – almost every year.
- A wet winter (160% of normal winter rainfall) – likelihood of occurrence of 11% as compared to 1.7 % with present climate.
- A dry summer (50% of normal summer rainfall) – likelihood of occurrence of 10% compared to 1% with present climate.

There will be an increasing risk of extreme weather events. Coastal features such as Hurst Castle Spit in the Solent and East Head at the mouth of Chichester Harbour may be lost in the more frequent coastal storms. Without adaptation there could be water shortages every

summer and more damage from flooding almost every winter. Floodplains such as those of the Upper Medway in Kent and River Arun in West Sussex may become more hazardous places to live. We will need to adapt to prevent new extremes becoming catastrophes.

Average summer temperatures for 1961-90 and for the 2080s under the medium-high scenario. (UKCIP, 1998)



“There is no doubt that many of the climate change scenarios are extremely challenging to our flood defence role. Southern Region is dominated by its coastline. Climate change will make it extremely difficult to maintain standards of defence against both flooding and erosion”

Gary Lane, Regional Water Manager, Environment Agency, Southern Region.

Holding the Line?

The coastline of the South East is under threat. Rising sea level combined with increased storminess and changes in wave direction and energy will lead to more frequent overtopping and breaches of coastal defences, and changes in the patterns of coastal erosion and deposition.

Since the 1953 floods that devastated the East Coast of England, coastal defences in the South East have been strengthened, raised and extended in order to protect agricultural land and coastal settlements. The Ministry of Agriculture, Fisheries and Food and maritime local authorities (who are responsible for coastal defences) and the Environment Agency (with their responsibility for flood protection) face a difficult task under a changing climate. There are almost 1200 km of sea defences across the region and difficult decisions must be made on whether to maintain, improve or even abandon defences. Some environmental groups have questioned whether current approaches are sustainable because of the high cost of sea defences and the potential loss of important coastal habitats as they are “squeezed” between fixed defences and a rising sea level.

By the 2050s, sea level will rise by 34 cm in the English Channel but coastal engineers are

already anticipating rise of up to 50 cm in some areas such as the Solent. Some of our natural coastal features may be lost, such as Hurst Castle Spit, East Head, Selsey Bill and the Denge Peninsula. Areas of developed coastline are also threatened. Dover Harbour, Southampton, Folkestone and other ports will be affected by more frequent storms and strong winds. Coastal towns such as Hastings, Littlehampton and Worthing may be flooded placing some vulnerable groups, such as the elderly, at risk.

As well as inundation, the coastline is also at risk from erosion. The spectacular cliff-fall at Beachy Head in 1999 is a reminder that parts of the coast are eroding rapidly. In fact the South East has some of the fastest erosion rates in Europe. Cliff-falls are dramatic and capture the imagination, but areas of mudflats and salt marshes are also being lost. In areas with shingle beaches, erosion is held at bay through the continual dredging, deposition and engineering of shingle banks. The supply of shingle is limited and already there are signs that shingle banks off the Isle of Wight are being depleted. Small changes in wave patterns and sediment movement could result in the loss of this resource. Some areas of coastline could then be left undefended. There is an urgent need for more research in this area to monitor and predict change and to plan adaptation responses.

The result of the massive cliff fall at Beachy Head, January 1999

Courtesy National Trust
Photographic Library/
David Sellman



The Changing Countryside

Distinctive parts of the South East countryside, such as the Surrey Hills, Kent's "Garden of England" and the Hampshire Downs are going to change. As temperatures rise and the amount of water in the soil changes, so the balance of the flora will shift; some plant species will flourish while others will be less suited to the new conditions and alien plant species may replace native flora. Aggressive, weedy plant species may spread, but the speed of climate change, and the fragmented nature of the countryside will restrict the ability of other more valuable species to migrate.

Surrey is the most heavily wooded county in England but this could change as familiar trees, such as the shallow-rooted Beech will suffer under the drier summer conditions. This may make them more susceptible to insect pests, disease and windthrow in the more stormy conditions. The South East's ancient and semi-natural woodlands will also suffer from drought, particularly on the Chalk Downs, and the milder winters will favour alien broad-leafed species like the Sweet Chestnut and coniferous species, such as Corsican and Scots Pine.



Six spot burnet moth

Courtesy Country Life

For the lowland grasslands of the North and South Downs and the Isle of Wight there will be some benefits as well as losses. Some orchid species and butterflies such as the Adonis Blue may flourish and become more widely distributed than at present. The New Forest and Wealden heathlands will also change. Rare reptiles, such as the sand lizard and smooth snake, will prefer the warmer conditions. Other animals and plants, such as the mole cricket and marsh gentian, which are suited to wetter heaths may suffer as their habitat dries out in summer. Drier summers will also increase the risk of fire on heaths.

Adaptation at the farm level will be at the centre of the changing countryside. Farmers have always adapted rapidly to changing conditions such as changes in European agricultural policy and the development of new crop varieties. Their response to climate change may already be seen in the growth in the number of successful vineyards in the South East in recent years. But more significant and large scale adaptation will be needed to meet the challenge of climate change in the 21st century.

Farmers are concerned about climate change and many have already noticed signs of change. The greatest concern is the availability of adequate water supplies and the increased risk of drought. There will need to be more on-farm water storage reservoirs but these are expensive to install and will not be enough in isolation. Further investment will be required into irrigation equipment but this may only be viable for the highest value crops. More information and advice is needed so that farmers can make the best use of their limited water abstraction licences.

Heron

Courtesy Surrey Hills

AONB Office

There will be opportunities for large scale production of new crops such as sunflowers

Courtesy Jo Hossell



There will be other environmental impacts from the agricultural response to climate change. Livestock housing for pig and poultry production will need to be adapted to cope with higher temperatures. There may be a switch to less intensive methods such as outdoor-reared pigs but this has important implications for soil erosion and water pollution. At the same time farmers will have to cope with changes in the timing and number of pest and disease outbreaks due to the reduction of cold snaps in the winter. Will farmers be allowed to respond by increasing the use of pesticides/fungicides? How will such changes affect organic producers? Will agri-environment policies keep pace with climate change?

However, not all of the impacts for agriculture will be detrimental - there will be opportunities to grow novel crops such as sunflowers and navy beans. Large-scale production of soya should be possible along the southern margins of Hampshire, West and East Sussex early in the next century. However, the visual impact of such changes in the landscape may be dramatic, for example if sunflowers replace areas of oilseed rape.

Managing our Heritage

Our heritage is often seen as the preservation of the past - for example through the maintenance of important historical houses and gardens, the protection of archaeological sites and the designation of important inland and coastal landscapes to prevent development. But preservation will no longer be enough. A changing climate requires proactive and more forward looking management approaches that take account of changes in the water requirements of historic gardens, vulnerability of woodlands and the risks and costs of maintaining historic buildings under a changed climate. The character of parks and gardens will change due to more frequent droughts, the scarcity of water supplies and a changing mixture of plant species. Similarly, sports and recreational fishing could suffer in dry summers and, in some years, there may be insufficient water to maintain inland canal navigations.

Parks such as Sheffield Park in Sussex are still repairing the damage of the 1987 storms that destroyed large areas of woodland. Extreme winds will occur more frequently in future and planting strategies must adapt accordingly. As well as higher wind speeds, buildings will be vulnerable to subsidence and increased internal temperatures. Investment will be required in improved ventilation and shading to protect historical artefacts.

Meeting the Demand for Water

There is no doubt that one of the greatest challenges for the South East will be balancing the supply and demand for water. The area has the highest demand for water per head of any other area in the UK. During the summer of 1995 three of the water companies in the South East imposed restrictions on water use, including hosepipe bans. By the 2080s, the dry conditions experienced in 1995 will occur more frequently.

There will be a range of impacts upon the delicate balance of supply and demand. Water supply sources will benefit from greater rainfall in the winter, which will increase river flows and may also benefit groundwater recharge. However, river flows will be much reduced during the summer so some water companies may wish to increase the number or size of reservoirs to store winter rainfall. The demand for water increases considerably in hot summers. The management of these demands will become more important through water metering, the use of water saving devices, restrictions for some uses (such as golf courses and car washes) and increased awareness amongst the public to “use water wisely.”

Government expects that around 1.3 million new households will have to be accommodated in the South East by 2016. The region's capacity to

meet the consequent increases in demand for water resources will require careful examination. An increase in water transfers within the South East and from outside the region may be required to meet the increased demand while maintaining summer flows in our rivers and water levels in valued wetland sites.

Currently much of the region's water resource is abstracted from rivers or groundwater and only used once before being discharged back to rivers, estuaries or the English Channel. Can better use be made of sewage effluent through improved treatment technology?

There will be many impacts on water supply from other sectors. For example problems may arise due to the deterioration of river water quality from increased soil erosion, nutrient enrichment or elevated pesticide levels as a result of agricultural change and increased rainfall intensity. The reduction in summer flows in chalk streams, such as the Test in Hampshire will mean that there is less water to dilute sewage treatment work discharges. Internationally important aquatic habitats such as the River Itchen will be subject to lower flows and higher concentrations of pollution. Other sources of water, such as the Denge aquifer in Kent and the River Arun will suffer from saline intrusion due to rising sea levels.

“...climate change really forces us to consider issues that should be important today in any event. Demand management is an obvious example, but conjunctive resource management and, where appropriate, development of additional storage will also play important roles. The new water resources planning framework should establish where there are significant risks and any new requirements over time.”

***Dr. Brian Arkell,
Environment
Agency, Thames
Region***

No Fishing!
Low flows on the River
Teise, Kent, May 1997
Courtesy Country Life



The South East avoided the famous Easter Floods in 1998 but this is no reason for complacency. Climate change will mean more winter rainfall, wetter soils in winter and a greater risk of extreme flooding.

A country cottage with an attractive view of a pretty stream?

Courtesy Country Life



Protecting the Floodplain

There are almost 3000 km of “main” river with flood defences in the South East. Some rivers have extensive floodplain areas. Much wetter winters and the increase in extremely wet winters have serious implications for river flooding. The region avoided the Easter Floods 1998 but more extreme conditions are inevitable in the next century.

Flood risks cannot be eliminated. In the past we have managed the risks by providing flood warning, defence and emergency response. However, our flood defences are based on historical flood conditions and will not offer sufficient levels of protection in the future. Areas that were never considered at risk maybe liable to flood. The risk of flooding can be reduced by

preventing development in the floodplain but what area of land should be used to define the flood boundary? The current approach by the Environment Agency is to define the 1 in 100 year (1% probability) boundary and to oppose development within this area. How can climate change impacts be accounted for in protecting the floodplain?

There is a high demand for land for housing and industrial uses. Yet allowing further development in the floodplain may place many people at risk. Developers and the public need to be made aware of the risks. There must be improvements in flood contingency planning. Lessons have been learned from the 1998 Easter Floods but further improvements are required in flood forecasting and flood contingency planning.

Emergency response

Courtesy Country Life



Emerging Economic Issues

Few businesses in the South East have woken up to the pressing need for climate change adaptation. The most important sectors of the regional economy are the service sector, public administration, banking and insurance. Stakeholders in the service sector consider that their business performance is unaffected by climate variation but this sector employs 1.5 million people – all of whom will be affected as patterns of transport, health and the nature of the working environment shift in response to climate change. More work is urgently needed to quantify the impacts of climate change on the service industry.

However, there are some exceptions; a few industries have a heightened awareness of climate change impacts. The insurance sector, in particular, is concerned with the potential losses due to coastal flooding, subsidence and wind damage. The storms of October 1987 and January 1990 had severe impacts on the South East and the cost of insurance claims associated with these events was very high. A rise in the number and cost of subsidence related claims was evident in the hot dry summers of the past decade. Any increase in the frequency of hot dry summers is therefore of importance, particularly in the South East where there is a large

concentration of high value property, much of which is located on clay soils.

Industries such as paper manufacturing, pharmaceuticals and chemical manufacturing require large amounts of water. For the paper industry small changes in groundwater yield would have a major impact. Water quality has a direct impact on the paper making process. Groundwater provides the best source but this resource may be limited in future. If paper manufacturers are forced to use lower quality water they could become uncompetitive. There is a need for innovation in water use in manufacturing processes.

Tourism and recreation industries could benefit considerably from warmer conditions. It is the perception of the predictability of the weather that will influence visitor destinations and length of stay. The South East could have more visitors, an increase in second or holiday home ownership and return migration as expatriates move to the South East as Southern European summers become too hot. The success of the tourist industry depends on maintaining a high quality environment, efficient transport system and sufficient capacity to cope with a rise in tourist numbers.

“A change from groundwater to surface water abstraction imposes costs on paper production at our plant of 1-2% due to the salinity of our surface water source. This cost change would mean loss of business to companies in the North (UK and further N. Europe) who will have advantages if their resources are not scarce”

(Paper manufacturer)



The agricultural sector has responded to new opportunities. Will other sectors do the same? A view east over the Vineyard from Denbies Hill on a summer's day.

Courtesy National Trust
Photographic Library

Flooding in Surbiton, with hail the size of golfballs, following storms in September 1999

Courtesy Kevin Wheal, Mediaficient Ltd



Designs for the Future?

We will enter the next millennium living in towns and cities designed for past climates rather than the warmer, wetter and more extreme climate of the future. Additional consideration at the planning, design and construction phase will be required to ensure that our houses are not subject to subsidence, are adequately ventilated and constructed to withstand higher rainfalls and windspeeds. Gardens will be home to some novel plants and insects, and gardeners will have to adapt their plantings to cope with drought. Many offices will have inadequate ventilation and shading and may become uncomfortable and unproductive places to work. The infrastructure of towns including drainage, roads and rail and civic buildings will also be affected.

Gardens of the future could be designed with low water requirements. The use of gravels and pebbles to prevent evaporation from the soil, the use of dramatic grasses and hardy palms and the use of water butts to collect roof runoff could lead to the "zero water garden." This adaptation has already started with the publication of information and education campaigns.

Intense winter storms will lead to urban flooding due to "under-designed" drains, possibly bringing roads to a stand-still. Many of Surrey's roads were flooded during an intense storm on 5th September 1999. Surface water drains could not cope with the high volume of rainfall. Just like our flood defences, urban drainage is designed based on historical climate information. If the changing frequency of extreme rainfall events is not considered in future drainage plans we can expect more local flooding, more disruption to transport and more flooded homes.

The Way Ahead

In this report we have identified some of the main impacts of climate change in the South East. The next steps now need to be taken to develop sustainable approaches to manage the threats and make the most of the opportunities presented by a changing climate. A new way of thinking is required that cuts across individual economic sectors and areas of government responsibility to identify appropriate adaptation strategies. We propose that a single organisation or body working across the region takes the responsibility to develop strategic and cross-sectoral adaptation strategies for the South East. As well as specific impacts our scoping study identified four general themes that must be considered in the next stages of the climate change planning agenda.

Integrated regional planning

In several areas there is a need for more holistic planning. Climate change will result in a “cascade” of impacts that influence a wide range of planning issues. For example, traditional land use planning will need to give a greater weight to new factors, such as flood risk and the availability of adequate water resources for new housing or industrial development. For coastal planning the Environment Agency’s partnership approach to producing strategic coastal plans needs to be broadened to include wider planning issues such as the cultural heritage. Such a change would require significant support from Local Authorities and a broadening of government guidance.

Raising awareness

There are very different levels of awareness of climate change in different sectors of the economy. For example, the water industry has included climate change as part of its long term strategic planning for some time - with an obvious increase in awareness of the importance of the issue in recent years. Other key sectors for the South East have not yet considered the impact of a changing climate on their activities. Businesses need to be made aware of potential impacts in relation to profitability, marketing and potential new ventures through publications, seminars and conferences.

Raising public awareness of climate change and the likely future implications for our quality of

life is an important responsibility. Individual actions such as water conservation in the home are important adaptive responses. In addition, the dissemination of information with regard to climate hazards such as flooding must be improved. Many people living in the floodplain are currently unaware of the risks.

Monitoring Change

A comprehensive, rigorous and robust system of monitoring, measuring and evaluating climate change at the regional level is required. For example, satellite or airborne remote sensing of the coastal environment can be used to detect changes such as increased erosion or deposition. Various regional indicators of climate change should be maintained and new indicators developed that link human health and business performance to climate variations. Data management should improve and information should be made freely available to help planners consider changing conditions.

Managing Uncertainty

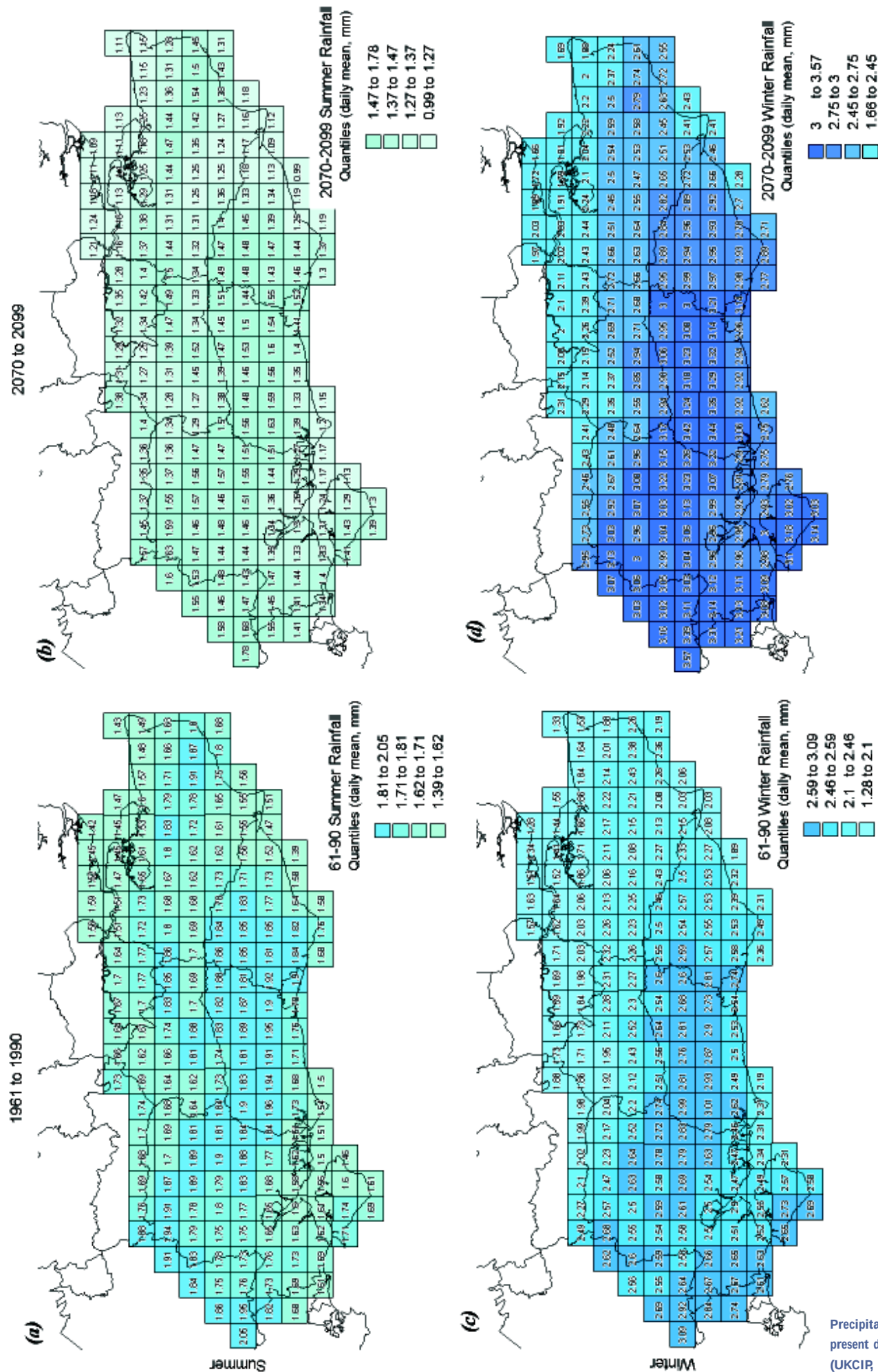
The science of climate change has uncertainties but is continually developing and improving. We need to develop methods of dealing with uncertainty rather than wait for improved climate change models. For example, risk assessment techniques for dealing with uncertainty should be used for managing vulnerable coastal and river floodplain areas. In the countryside, habitat corridors should be developed where possible to allow species migration and prevent fragmentation. At the same time some important gaps in our knowledge must be filled. For example, an improved understanding of how climate change will affect extreme events is urgently required.

“ Doing nothing is not an option. You may doubt some of the predictions and their likely impacts, but I suggest that a sensible analysis of the risks does not allow us to sit back and wait.”

Peter Ewins, Chief Executive, The Met. Office. From a lecture given to The Royal Academy of Engineering, January 1999

Summary of Impacts

Sector	Main Points
Floods and Coastal defence	- Increased frequency of overtopping of coastal defences and increased risk of breaches due to the combined effects of increased storminess, changes in wave direction and sea level rise. - River flooding will increase during the winter months due to wetter ground conditions and an increase in daily rainfall totals over 30 mm. - Flood defences will need to be improved along some lengths of coastline and selected reaches of main river. - A strong presumption against development in flood risk areas will be needed to avoid an increase in risks to lives and property. - Improved flood forecasting and warning systems are required.
Water supply	- The greatest challenge will be to meet peak demands during or following drought periods when resources are depleted. - Potential reduction of summer river flows leading to a reduction in dilution of effluent from sewage treatment works. - Sea level rise increases risk of saline intrusion at coastal boreholes. - Lower raw water quality from surface water sources likely, with implications for water treatment and drinking water quality.
Agriculture	- Increased temperatures across all seasons, leading to longer growing season. - Change in the level and timing of water availability due to a decline in summer rainfall but increase in autumn and winter totals. - Potential to grow new crop types such as grain maize and soya. - Increase risk of summer drought particularly on thin arable soils. - Change in the timing and incidence of crop and livestock pests.
Forestry	- Increased tree stress and loss through drought. - Greater yields resulting from increased temperatures and the CO₂ fertilisation effect. - Potential for increased incidence and damage from pests, diseases and pathogens.
Ecology	- The combined effects of sea level rise and coastal erosion will result in a loss of habitats and characteristic species. - Reduced summer rainfall and increased temperatures, in conjunction with increased demand for water resources, are likely to have detrimental effects on river and wetland ecology. - Potential benefits to species favoured by warmer climates, especially those at the northern edge of their range in the South East at present. - The absence or lack of opportunity for habitats/species to migrate in the face of climate change as a result of habitat fragmentation, obstacles to migration (for example, the widespread development in the South East) and the fast rate of change projected. - The increase in frequency of extreme events, such as severe storms and droughts, and associated events, such as fire, may increase the likelihood of local extinctions.
Cultural heritage, Leisure, Tourism	- Changes to the coastline, 'squeeze' of marginal ecosystems, change in vegetation types. - Effects on the character of parks and gardens, for example due to water requirements, changing plant species and design. - It is the perception of the predictability of the weather that will influence visitor destinations and length of stay. - Potential for increased visitor pressure is also dependent on the sustainability of a significant tourist industry which is based on the quality of the natural environment and features in the South East, for example in Kent the 'Garden of England.' - Increased opportunities for outdoor leisure activities, particularly water-based activities.
Insurance industry	- Subsidence is a key issue where soil conditions and high property prices mean potential costs to the insurance industry can be high. - The storms of October 1987 and January 1990 resulted in large insurance losses.
Economic Sectors	- A rise in sea level is a concern to economic activity based on coastal and estuarine areas. - Secondary or manufacturing industries e.g. paper manufacturing are vulnerable to the costs and availability of raw materials, particularly water. - Important sectors of the regional economy are currently unaware or not concerned about climate change impacts.



Precipitation change from
present day to 2080's
(UKCIP (R1) (UK) (899))



The Impacts of Climate Change in the South East Study

The background research for this report was completed by a team from WS Atkins, The Met. Office and ADAS on behalf of a consortium of local authorities, non-governmental organisations and private companies. The study is linked to the UK Climate Impacts Programme (UKCIP) programme which is supported by the Department of the Environment, Transport and the Regions (DETR) to facilitate organisations to undertake research to assess their vulnerability to climate change and its impacts, and to plan appropriate responses.

A Stakeholder Approach

The scoping study was initiated by Surrey County Council with support from Kent County Council, West Sussex County Council, Hampshire County Council, the Wildlife Trusts, the National Trust, the World Wildlife Fund, Country Life magazine, the Government Office of the South East, the Environment Agency and Thames Water. Over 80 organisations that will be affected by climate change were consulted over the last 6 months to gain further insight into the likely impacts.

Further Information

A full technical report for this study is available from:

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Information about the UK Climate Impacts Programme can be found on their web site <http://www.ukcip.org.uk>. Email: enquiries@ukcip.org.uk

Designed by WS Atkins Graphics, Epsom

