Warming to the idea

Meeting the challenge of climate change in the South West

TECHNICAL REPORT

WARMING TO THE IDEA

Meeting the Challenge of Climate Change in the South West

A Stakeholder-led Scoping Study
into the
Impacts of Climate Change on the South West Region of England

Prepared for the

South West Climate Change Impacts Partnership

January 2003

The study has been supported by:

Countryside Agency; Environment Agency; South West Regional Development Agency; South West Water PLC; Wessex Water PLC; WSAtkins

The Steering Group for the study has included representatives from:

Association of Electricity Producers, Bristol City Council, Business in the Community, Confederation of British Industries, Devon Wildlife Trust, Environment Agency; Federation of Small Businesses, Government Office of the South West, National Farmers Union, National Trust, South West Regional Assembly, Royal Agricultural College, South West Regional Development Agency; South West Tourism; Sustainability South West, Wessex Water PLC; UK Climate Impacts Programme

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CHAPTER 0

EXECUTIVE SUMMARY

Introduction

This Scoping Study has been initiated and supported by the South West Climate Change Impacts Partnership (SWCCIP), a group of key stakeholders in the South West Region. It sets out to describe the climate change scenarios projected for the coming century in the south west region, to identify the likely impacts of such change, and to suggest appropriate action to respond to the challenges and opportunities presented by these impacts. The study recognises the importance of the mitigation of climate change (reducing the emissions of greenhouse gases) as part of a wider sustainability agenda. Nevertheless, the explicit focus of this study is on adapting to the potential impacts of climate change.

The principal conclusion from the study is that generally the region has little awareness of the issues associated with 'adaptation' to climate change. The central government funded organisation with responsibility for encouraging work on climate change impacts is the UK Climate Impacts Programme: (UKCIP). Despite the recent launch of a new set of sophisticated climate change scenarios (UKCIP02) only a small number of regional stakeholders are aware of these data, or have explored their implications for their sector.

Other UK Research

The study forms part of the series of regional Scoping Studies undertaken across the United Kingdom under the auspices of the UKCIP. Thematic studies on subjects such as Health & Biodiversity have also been carried out in the UK.

Global Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is acknowledged as the definitive, global authority on all aspects of climate change. Its work is endorsed by 99 national governments and many more independent, scientific and government reviewers. In its Third Assessment Report (known as TAR) the IPCC asserts that:

- climate change is occurring;
- the present climate is significantly warmer than at the beginning of the 20th Century;
- 'business-as-usual' will lead to continued major additions of greenhouse gases to atmosphere that will exacerbate so-called 'global warming'.

TAR suggests that global temperatures could rise by between 1.4 and 5.8 degrees C by the end of this century, and argues that most of the observed warming over the last 50 years is due to human activities.

The South West Region

The SW region is renowned for its outstandingly attractive environment. It is the largest geographic region in England, and is home to nearly 5 million people. The Regional Strategy prepared by the South West Regional Development Agency (SWRDA) identifies the three main characteristics of the region as:

- a growing region;
- a region of diversity;
- a region of environmental quality.

The region enjoys one of the lowest unemployment rates in the country. It attracts more tourist spending than any other UK region apart from London, although there is little recent growth in this sector. However, there are pockets of deprivation, for example in Cornwall and the Scillies, and in parts of urban areas such as Bristol. Environmental quality features include:

- high water quality (rivers and bathing water);
- large areas of landscape designations;
- extensive agricultural land;
- many wildlife designations;
- 25% of English listed buildings;
- 72% of English ancient monuments.

The economic development of the region will increasingly depend upon these regional assets many of which are vulnerable to climate change.

Climate Change in the SW Region

Season	***Anticipated Climate around 2050s***	***Anticipated Climate around 2080s***
Spring	Warmer by 1.0 to 2.0°C	Warmer by 1.5 to 3.5°C
	precipitation totals similar to present	precipitation totals similar to present
Summer	Warmer by 1.5 to 3.5°C	Warmer by 2.0 to 5.5°C
	Drier by 15 to 30%	Drier by 25 to 55%
Autumn	Warmer by 1.5 to 3.0°C	Warmer by 2.0 to 5.0°C
	Drier by 0 to 10%	Drier by 5 to 15%
Winter	Milder by 1.0 to 2.0°C	Milder by 1.5 to 3.5°C
	Wetter by 5 to 15%	Wetter by 10 to 30%
		Snowfall less by 70 to 90%

Table 0.1
Summary of Anticipated Climate Change for South West Region for around the 2050s and around the 2080s.

The table above shows the anticipated climate changes for each season for the South West region for the periods around the 2050s and around the 2080s. The latest climate scenarios released by UKCIP (UKCIP02) provide two related sets of data based on a 50km grid, each square with its own climate profile. The first dataset is a baseline of 1961-1990 against which future scenarios can be compared. The second dataset reports on a series of future scenarios for three different 30-year time periods: around the 2020s, around the 2050s and around the 2080s. A range of scenarios is based upon four different levels of future greenhouse gas emissions.

Likely Impacts and Responses

The studies that have been carried out by the research team explore a wide range of Impact Domains. The most significant outcomes of these studies show that, although individuals seem to be aware of climate change and the influence of global warming, this awareness does not appear to feature in the agendas of businesses and other organisations in the region. Where climate change does influence an organisation's policy it is mitigation (avoiding further climate change through reduction in greenhouse gas emissions), rather than adaptation (responding to climate impacts), that is the main consideration.

In the natural environment opportunities exist for new crops (maize, sunflowers, soya) and livestock in agriculture, and for new types of habitat. In coastal waters new warmer water species are already present and more are anticipated. Challenges exist from changes in rainfall and storm patterns (eg coastal erosion, river flooding, and reduced water availability in summer). There is a potential loss of species from coastal waters and decisions to be made about seeking to retain rare habitats and historic landscapes in the face of a shifting climate.

In society and infrastructure domains opportunities exist for reduced heating costs in winter, increasing the output of renewable energy sources, improved health as a result of more outdoor leisure activity, and exploiting the benefits of cycling and walking as modes of transport. Challenges exist for cooling buildings in summer, conserving and protecting historical and natural heritage, damage to buildings from floods, subsidence and storms, and maintaining strategic rail and road networks.

In the business sectors opportunities exist from new markets particularly arising from changing lifestyles. Examples include tourism and leisure, outdoor activities, food and drink, renewable energy, and environmental monitoring equipment. Challenges exist from extreme climate events eg disruption to transport, communication lines and utilities (creating delays and downtime), damage to coastal infrastructure and facilities, increased insurance claims, and increased demand for the summer cooling of buildings.

Recommendations

The SWCCIP is committed to taking forward the issues identified in its Scoping Study. The Partnership will work to ensure that consideration of climate change is built into strategic plans for the region. It has endorsed the following recommendations and proposed actions:

- Review the role of the South West Climate Change Impacts Partnership to take forward regional work on climate change.
- Ensure that the main findings and recommendations of the Scoping Study are incorporated into current and future strategies and frameworks within the region.
- Ensure that the South West Climate Change Impacts Partnership continues to have an overall understanding of South West regional work on climate change impacts and adaptation, and to be a focal point for information.
- Encourage all organisations to identify appropriate policy frameworks within which to incorporate adaptation strategies.
- Increase awareness of the need for climate change adaptation across all sectors. Most stakeholders are ill-informed about, and ill-prepared for, dealing with the potential impacts of climate change.
- Ensure that simple messages are conveyed to the media because conflicting messages can create confusion on the direction and magnitude of climate change.
- Identify and take forward specific projects for action:
  - Review regional and sub-regional arrangements for emergency planning in anticipation of extreme weather events.
  - Co-ordinate the development of climate change strategies within local authorities.
  - Co-ordinate the development of climate change strategies within sectors in the region.
  - Identify those issues at a regional level where central government action is required.
  - Undertake further research within selected sectors to better understand the significance of local impacts.

Further Activity in the SW Region

The involvement of key stakeholders in the study, from private, public and voluntary sectors, has been crucial to the findings of the study and its recommendations. The continuing engagement of these and other stakeholders will ensure that both the challenges and opportunities presented by climate change are the subject of appropriate concern across the region. The Scoping Study provides only the beginning of an ongoing process of regional activity to ensure that the South West is at the forefront of progress towards adapting to climate change.

CHAPTER 1

INTRODUCTION

"All organisations should anticipate climate change – those that are most well-informed and innovative will be best placed to respond to the risks and opportunities."

The Rt. Hon Margaret Beckett MP; Secretary of State for Environment, Food and Rural Affairs, April 2002

Background

The phenomenon of climate change is as old as planet Earth. Its significance for the United Kingdom in the 21st Century is the rate at which that climate is now changing, the underlying reasons for such rapid change, and the effects this will have on our lifestyle. This study is based upon the assumption that:

- The UK climate will continue to change.
- The scenarios offered by the UK Climate Impacts Programme (UKCIP) are increasingly reliable as indications of the UK climate over the 21st Century.
- It is worthwhile exploring the potential impacts of such scenarios, and to suggest appropriate responses.

The evidence for a rapid increase in the rate of climate change in the United Kingdom is compelling. Continuing research and monitoring at international and UK scales confirm the prospect of increased global temperatures and consequent changes in the UK climate over the 21st Century. Over 180 nations have ratified the United Nations Framework Convention on Climate Change and almost 100 parties have ratified or acceded to the Kyoto Protocol, which sets legally binding constraints on greenhouse gas emissions. Despite this, it is still predicted that significant climate change will occur over the coming century due to greenhouse gases which are already in the climatic system.

These changes in climate will create significant impacts that will present both problems and opportunities, for which well-informed adaptation strategies must be developed. Despite the improvement in the prediction techniques used by climate scientists, there are continuing realms of uncertainty. These uncertainties are particularly associated with the reliability of theoretical models, the control of greenhouse gas emissions, and the underlying contribution of natural processes to climate change.

Nevertheless, such uncertainties are not excuses for not taking appropriate or precautionary action. Uncertainty and risk form part of all strategic and commercial decision making. The lack of absolute certainty in climate scenarios should not be seen as a reason for inactivity.

Definitions

Before introducing the aims and objectives and scope of the study, it is worth stating some definitions of some of the principal concepts associated with climate change. For example, there is even some confusion over what is meant by the term *'climate change'* itself, and also some important distinctions to be made between *"mitigation*" and "*adaptation*" *(see also Glossary of Terms in Annex 1)*

"Climate" refers to the average weather experienced in a region over a long period, (30 years is the normal period taken by climate scientists). This includes not just temperature, but also wind and rainfall patterns, and other climate variables., such as humidity.

The climate of the Earth is not static, so *"climate change"* refers simply to the continuous pattern of changes occurring in the past, in response to a variety of natural causes. Unfortunately, the term *"climate change"* is now more casually used with reference to the recent changes in climate that have been observed since the early 1900's. The implication here is that 'climate change' arises (only) as a result of human activity. This study is based on the wider understanding that 'climate change' is a longstanding and continuous phenomenon, which is now subject to the influences of human activity, and is therefore changing more rapidly.

The "*greenhouse effect"* is also naturally occurring and makes life on earth possible. Certain gases in the atmosphere (so-called greenhouse gases) absorb energy that is radiated from the Earth's surface, and so warm the atmosphere. Without the greenhouse effect, life on Earth as we know it would not be possible, as the Earth would be cooler by about 30 degrees Centigrade.

However, the relatively recent increase in the burning of fossil fuels has resulted in the release of large amounts of greenhouse gases into the atmosphere, thereby enhancing the greenhouse effect.

It should be recognised that these ideas are not universally shared. The proposition that human activities are altering climate significantly is not accepted by some industrialists and some scientists. That there are dissenting voices indicates that what is being discussed are opinions, estimates and projections, backed by theory and deriving from hypotheses, and so are not necessarily "facts", however defined.

Nevertheless, the dominant view, and certainly that which is articulated by the Intergovernmental Panel on Climate Change (IPCC), is that the increase in greenhouse gases, caused by human activity, is the principal reason for increases in global temperatures, and consequent climate change. This is known as the *"anthropogenic*

component" of climate change. There is a variety of alternative views some of which seek to play down the human impact and provide explanations based upon "*natural variability*" in cycles of climate.

Most work on climate change both in terms of academic research and practical activity, seeks to reduce the human effects on global warming by reducing the quantity of greenhouse gases released to the atmosphere. This is known as *"mitigation"*, and forms a key part of the '*sustainability'* agendas adopted by central and local government, businesses and Non-Governmental Organisations (NGOs).

However, for the purposes of this study on the impacts of climate change, the causes of climate change are not so critical. The focus is on what actions society might take in responding to those changes in climate that are now 'in the system' and appear to be most likely. Such responses are known as *"adaptation"* and lie at the heart of this study.

Aims and Objectives

This Scoping Study sets out to understand the potential impacts of climate change upon the South West region of the United Kingdom, to explore the current understanding of adaptation to climate change across the region, and to consider possible responses. The principal aims of the Scoping Study are to:

- Provide an overview of the best current information on the predicted climate scenarios at global and UK scales.
- Provide a summary of historic and contemporary climate change data for the South West Region, revealing observed trends.
- Provide an overview of the latest UKCIP climate scenarios for the South West region for thirty year periods centred around the 2020's, the 2050's, and the 2080's.
- Identify the key stakeholders in the South West Region who will be most affected by climate and assess stakeholders' views on the likely impact on their interests.
- Report on how stakeholders expect to respond to 'opportunities' and 'problems' associated with adaptation to climate change.
- Assess the key climate change issues for the South West Region to provide integrated, cross-sector information on which to base future strategy for climate change adaptation.
- Identify priorities for further research and information collection in developing a better understanding of the type and extent of potential impacts and appropriate adaptation responses.
- Overall, to provide a single authoritative document on climate change impacts in the South West, for the use of stakeholders in the region, as well as for decision makers at national level.

Context

In the South West Region, work on the impacts of climate change is being co-ordinated through a partnership between key stakeholders, known as the South West Climate Change Impacts Partnership (SWCCIP). Its mission is: *"to investigate, inform and advise on the impacts of climate change in South West England".*

In 1996 the Climate Change Impacts Review Group (CCIRG) reported on the potential effects of climate change in the United Kingdom. The national response to this review is now led by the DEFRA funded UK Climate Impacts Programme (UKCIP), which seeks to facilitate stakeholder-led, integrated regional studies to assess the impacts of climate change on the UK and to encourage appropriate adaptation responses. UKCIP provides a national framework within which regional initiatives can be undertaken.

At a national level, this Scoping Study provides UKCIP with a study similar to those that have already been produced for other UK regions. So far eight regional Scoping Studies have been completed as well as a series of thematic studies. *(See Chapter 2 for further details)*

At a regional level this study will inform the ongoing regional partnership in addressing its approach to climate change adaptation in the region. The role of regional stakeholders has been of crucial importance in developing this work. A Steering Group was created for this study, co-ordinated by the SW Regional Office of the Environment Agency, and including representatives of all levels of government, the business community and NGOs. This provided a route to funding (from the South West Regional Development Agency [SWRDA] and other regional organisations) which has made the study possible.

In this way the Scoping Study responds to the Regional Sustainable Development Framework for the South West of England which states that *'The basis for addressing climate change and promoting sustainable development has to be a good understanding and a sound information base'*.

Scope of Study

The geographic boundaries are limited to the South West Region, as operated by the South West Regional Development Agency (SWRDA) and the Government Office for the South west (GOSW). The study area therefore contains the counties and unitary authority areas of: Cornwall and the Isles of Scilly, Devon, Plymouth and Torbay, Bournemouth, Dorset and Poole, Somerset, Swindon and Wiltshire, South Gloucestershire, Bristol, Bath and North East Somerset, North Somerset and Gloucestershire. *(see Figure 1.1)*

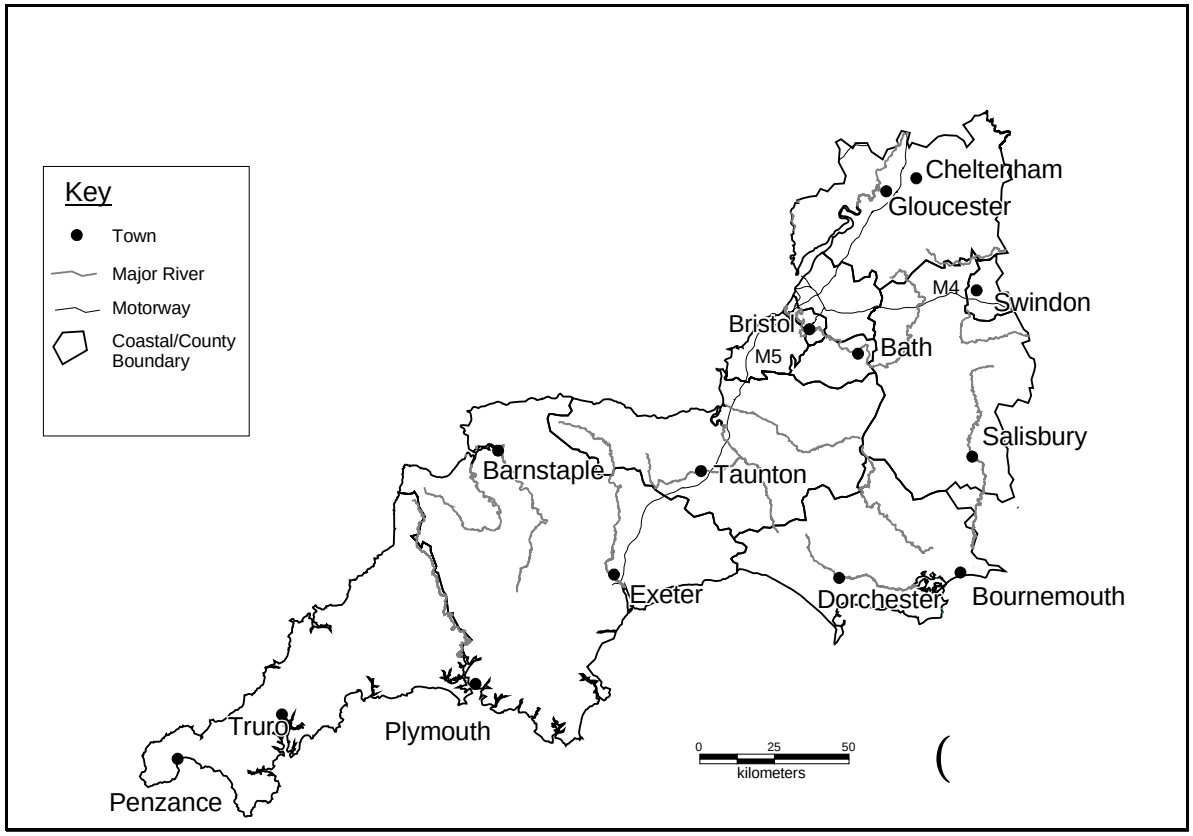


Figure 1.1
Map of South West Region which defines the area of study

Despite the tight regional focus, the study recognises a wider geographic context.

Firstly, the potential impacts of climate change are even more serious in other parts of the world. Sea level rises in places such as Bangladesh could increase global migration to levels that have not yet been contemplated. Increases in temperatures in Mediterranean tourist centres (such as Greece) could make such places less attractive as resorts. These and similar impacts may have significant consequences for the South West itself.

Secondly, the optimal level at which adaptation responses should be made will also vary spatially. For example, responses identified as necessary for the South West Region and requiring changes in Building Regulations will need addressing at a national level. Other responses may be best managed at regional or sub-regional levels.

It is acknowledged that issues of adaptation to climate change form part of a much wider 'sustainability' agenda, especially with regard to the mitigation of potential climate change effects through strategies for (eg.) reducing greenhouse gas emissions. Nevertheless, it is not possible within the scope of this study to give explicit consideration to aspects of mitigation. The focus is on impacts and adaptation. This being said, mitigation issues will be taken into account when considering adaptation strategies, so that any emerging proposals for responding to predicted changes in climate do not themselves make climate conditions worse by ignoring mitigation implications. In addition it is most likely that adaptation responses (for example by Local Authorities) will form part of a wider climate change or sustainability strategy.

Structure of Report

The study has been divided into main sections as indicated below:

- Other studies on Climate Change Impacts
- Global Climate Change Context.
- South West Regional Context.
- South West Regional Climate Change
- Impact Domain Reports
- Conclusions and Recommendations

Other studies that have been undertaken in the UK are briefly reported in a section on UK research activity. (Chapter 2)

Global Climate Change Context: This part of the study is based upon existing data recently published on climate change at a global scale. It highlights the observable trends in climate change, particularly over the last century; reports on the natural cycles in climate, the calculated

anthropogenic contributions to climate change, and predictions for changes in the climate over the coming century. It reviews the potential impacts of climate change at a global scale, and distinguishes between adaptation and mitigation responses to these impacts. UK initiatives on climate change are tracked mainly through the work of UKCIP. (Chapter 3)

South West Regional Context: This part of the study briefly describes the region in terms of its overall physical attributes, and its social, economic and cultural activity. Further information on specific sectors is provided at the beginning of each domain report. (Chapter 4)

South West Regional Climate Change: This chapter provides an analysis of climate change in the region, including an account of historic trends, a picture of current climatic conditions and future climate scenarios for the region. The historic and contemporary data is drawn from Met Office and similar records held within the region. The scenarios make use of the data recently published by UKCIP for the thirty year periods around the 2020's, the 2050's, and the 2080's. (Chapter 5)

Impact Domain Reports: This section reports on the perspectives of a wide range of stakeholders within the region. Various 'impact domains' have been selected based upon an analysis of other similar studies. These have been classified into three main groups:

- Natural Environment Domains (Chap 6)
- Society and Infrastructure Domains (Chap 7)
- Business Domains (Chap 8)

Each domain has been the subject of a focussed study providing information on context, key issues, opportunities and challenges presented by different climate variables, and suggestions for the way forward. Some domain reports are able to include information on: data availability, perceived significance of stakeholders, and potential adaptation responses. (*Further detail on the methodology, sources of information etc for these sections is available in Annex 2 and Annex 3)*

In addition, the implications for cross-sectoral issues are explored by considering a variety of spatial zones including: coastal environments; urban environments; and rural environments. These are assessed through case studies of single areas chosen as representative of each of the three environments. (Chapter 9)

Local authorities have been identified as important agencies in responding to climate change. A further chapter briefly identifies the range of issues that fall within the responsibility of local authorities and indicates a variety of responses. (Chapter 10)

A simple Summary of the findings of the study is to be found in Chapter 11.

The section on Recommendations is mainly a review of management issues, and again was reliant on contact with stakeholders; principally those public, private and voluntary agencies operating at a regional level, and with local government at county, unitary and district levels. The main purpose here is to draw together recommendations for action for those stakeholders with a regional remit, and others, especially local authorities, with a significant role to play, at sub-regional levels. (Chapter 12)

Priorities for research are identified in Chapter 13.

A brief set of conclusions is provided in Chapter 14.

Annexes: Annexes include bibliographies, lists of those contributing to the report through the completion of questionnaires, participation in interviews and workshops, a glossary of terms, and an explanation of the methodology used for the impact domain reports.

Outputs of the Study

The outcomes of the Scoping Study are available in both paper and electronic format. The full Technical Report (this document) is available as a paper copy and can be accessed on the web at the following address: www.ourSouthWest. A shorter version (24 pages) is also available as a Summary Report.

CHAPTER 2

OTHER RESEARCH (ETC.) ON CLIMATE CHANGE IMPACTS

This section is largely based upon material published on the UKCIP website at www.ukcip.org.uk.

Global Studies

The Intergovernmental Panel on Climate Change (IPCC) is acknowledged as the definitive, global authority on all aspects of climate change. It was set up by the World Meteorological Organisation and the United Nations Environment Programme in 1988 to assess scientific and socio-economic information on climate change and its impacts and to advise the United Nations Framework Convention on Climate Change. The IPCC represents over 1000 top scientists from the field of climate change research. Its work is endorsed by 99 governments and many more independent, scientific and government reviewers.

There is a long list of IPCC publications (many of which are available on the Internet) which provide authoritative scenarios for global climate change, a summary of potential impacts across the planet, and a range of adaptation responses. In its Third Assessment Report (known as TAR) the IPCC asserts that:

(a) climate change is occurring;

(b) the present climate is significantly warmer than at the beginning of the 20th Century;

(c) 'business-as-usual' will lead to continued major additions of greenhouse gases to atmosphere that will exacerbate so-called 'global warming'.

The TAR suggests that global temperatures could rise by between 1.4 and 5.8 degrees C by the end of this century, and argues that most of the observed warming over the last 50 years is due to human activities.

(See Chapter 3 for more detailed consideration of global climate change)

UK Initiatives

The UK government makes a clear distinction between "mitigation" and "adaptation" in dealing with these two aspects of climate change.

UKCIP was established in 1997 to establish a research framework for integrating assessments of climate change impacts in the UK and to provide support to organisations to undertake their own assessments of the impacts of climate change so that they can prepare appropriate responses. It is supported by DEFRA to provide services, data and scenarios to partner organisations. Responsibility for dealing with the mitigation of climate change rests within DEFRA.

Summary of Other UK Studies

UKCIP supports a number of studies that attempt to identify in more detail how climate change will impact on the UK. Through its co-ordinating and advisory role, and the use of common research tools and data, UKCIP aims to bring studies together to achieve an integrated assessment of climate change impacts in the UK. A summary of the work carried out in UKCIP's first three years of operation can be found in the report: "Climate Change: Assessing the impacts - identifying responses", UKCIP, 2000.

UK Regional Studies

Amongst the main research outputs that have been orchestrated by UKCIP is the series of regional scoping studies, of which this South West study forms a part. The publication dates are indicated below.

Region	Progress
North West	November 1998
Scotland	December 1999
Northern Ireland	March 2002
North East	Pending
Yorkshire & Humberside	Summer 2002
East Midlands	August 2000
East of England	Ongoing
West Midlands	Ongoing
Wales	February 2000
London	October 2002
South East	November 1999

Figure 2.1
Publication Dates of Regional Scoping Studies

UK Sectoral Studies

A number of sectoral studies has been undertaken and are ongoing under the UKCIP umbrella. Biodiversity, or nature, features strongly in these studies at present, as national organisations have realised the vulnerability of the natural environment and the need for further research. The main studies either completed or ongoing include the following.

DEFRA Biodiversity Review

This project, funded by DEFRA (DETR and MAFF at the time), provides a review of the impacts of climate change on biodiversity habitats and species in the UK and offers advice on the implications for UK nature conservation policy.

Climate Change and Nature Conservation in Britain and Ireland MONARCH

The MONARCH study was commissioned to provide quantitative evidence to complement the biodiversity assessments already carried out under UKCIP. This has been achieved through the development of complex computerised models, which are able to estimate changes in species distribution under climate change conditions.

Gardens

A Scoping Study provides an overview of the best current information on the potential impacts that climate change may have on UK gardens and garden plants. It also identifies and prioritises key information gaps and defines a future research agenda. Publication was in November 2002.

Health

The Department of Health funded a study into the impacts of climate change on health in the UK, the final version of which was published in the summer of 2002. The report concluded that climate change would have some significant effects on health, but that early action could mitigate many of the possible negative effects.

Water Demand

DEFRA has commissioned a study to evaluate the impact of climate change on the demand for water in England and Wales. The research will cover all aspects of water demand with a special focus on sectors that are most sensitive to climate change, namely agriculture, garden watering, and leisure.

Marine Environment
Marine Biodiversity and Climate Change (MarClim) is a four-year study, investigating how inter-tidal species across Britain and Ireland have responded to climate changes over the last 50 years, and will use the UKCIP scenarios to explore future models.

Built Environment
The Engineering & Physical Sciences Research Council (EPSRC) is sponsoring multidisciplinary research consortia to undertake studies of the potential impacts of climate change on the built environment in the UK in the 21st Century. Studies addressing climate change impacts on urban areas, drainage, historic buildings and energy infrastructure, and studies addressing risk and further work on the UKCIP climate scenarios, are due to start in April 2003.

RegIS

The RegIS study forms the first integrated assessment to investigate the impacts of climate and socio-economic change, using computer modelling and stakeholder discussion. The study focused upon two regions in the UK, East Anglia and the North West of England.

South West Region Initiatives

In October 1999, the Climatic Challenge Conference was held in Cornwall to address the impacts and opportunities of climate change for the economy of the South West region. The conference was aimed at key representatives of the public and private sectors. The Centre for Climate Change Impact Forecasting (C-CLIF), a partnership of three academic institutions, was established as a direct result of the conference. Conference outcomes were disseminated to Small- and Medium-sized Enterprises (SMEs) in Cornwall, Devon, Somerset and the Isles of Scilly through a series of workshops held throughout 2000.

On Jan 31st 2001 the Cheltenham Climate Change Forum was held to develop themes already introduced at the Climatic Challenge conference. The Forum was a high profile event, addressing an audience drawn from industry, commerce, regional and local policy makers, academics and representatives of environmental agencies. A major rationale for the meeting was to provide a springboard to establish regional studies to be supported by UKCIP. As a result of these initiatives the supportive partnership and funding were created in order to undertake this Scoping Study.

Available Data and Tools

As well as the recently published (UKCIP02) climate scenarios upon which this Scoping Study is based, UKCIP has also prepared a range of tools for climate impacts research. These include: socio-economic scenarios, costing methodology (forthcoming) and a risk assessment framework.

CHAPTER 3

CLIMATE CHANGE SCENARIOS AND IMPACTS FOR PLANET EARTH AS A CONTEXT FOR SW STUDIES

This chapter is based upon a variety of sources but largely upon material developed and published by the IPCC. The latest relevant publication is "IPCC Third Assessment Report – Climate Change, 2001" and is available at http://www.ipcc.ch/.

"Global Warming"

Interest in "global warming" is now prevalent amongst a wide range of scientists, politicians, economists and some industrialists. Most attention has focussed on the present and continuing effects upon climate of both domestic and industrial fuel use, and of other processes. These include agro-environmental processes (such as the burning of tropical forests and introduction of livestock grazing) and industrial processes (such as the use and escape of halocarbons). These lead to the release into the atmosphere of so-called "greenhouse" gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs). The 1997 Kyoto Protocol seeks to regulate these and three other trace gases, namely hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluorane (SF_6).

Historically, carbon dioxide has been the most important "greenhouse gas", but all are now seen as potentially contributing to global warming, such that other gases are projected to contribute, directly, about the same amount to potential global warming over the next 60 years as carbon dioxide.

In 1996 IPCC pronounced that "...the balance of evidence suggests that there is a discernible human influence on global climate". This was seen by many as confirmation of the already widespread acceptance amongst environmental campaigning organisations that not only is there a discernible human effect upon climate, but that the effect will both accelerate and continue into the next century until well after greenhouse gas emissions are stabilised. The IPCC Third Assessment Report in 2001 reinforced that message, and stated " there is new and stronger evidence that most of the observed warming over the last fifty years is attributable to human activity".

Climate Defined

'Climate' is defined as the total experience of weather at any place, over some period of time. The usual comparative period for climate statistics is thirty consecutive years of records, and these are advanced a decade at a time: for example, the World Meteorological Office has been using the years 1961-1990 as their baseline (rather than, say, 1967-1996). These are the statistics that meteorologists use when making daily comparisons from 'normal'. The period 1961-1990 is also the baseline against which future climate scenarios are compared.

IPCC Scenarios and Climate Change Predictions

Computer simulation models can demonstrate the magnitude and spatial variation of the changes that might be expected in future climate. The global models can produce scenarios for future global temperatures and precipitation (rainfall). It is also possible to calculate the sea-level rise anticipated as a result of the thermal expansion of the oceans and the melting of ice on land. Globally, the IPCC predicts a rise in sea level of perhaps half to three-quarters of a metre for the mid 21st century, while the UKCIP predict 9-69cm by the 2080's, and 7-36cm by the 2050's. When the models are applied at a national or regional level, other aspects of climate can be presented, such as the number of days of frost that might be expected in a year.

The figures below, (Figures 3.1 and 3.2) produced by one of the UK Met Office models, show first the change in mean annual surface air temperature that might be anticipated globally for the late 21st century, and secondly the equivalent change in precipitation.

The family of greenhouse gas emissions scenarios used to produce the UKCIP02 climate change scenarios covers the range of 35 scenarios outlined by the IPCC. The climate change predictions that arise from these scenarios include the change already in-built due to past and present emissions (the "*commitment to future warming"*) as well as the change due to future greenhouse gas production.

The following predictions are made by IPCC (TAR, 2001) and are generalised across a range of emissions scenarios.

In all of the IPCC reports, provisional terms (likely, unlikely, very likely etc.) are tightly defined in terms of probability. The table below (Table 3.1) indicates the statistical chances of a result being true, with reference to the linguistic descriptions that are used.

Provisional term	Probability
Virtually certain	> 99% chance
Very likely	90-99% chance
Likely	66-90% chance
Medium likelihood	33-66% chance
Unlikely	10-33% chance
Very unlikely	1-10% chance
Exceptionally unlikely	< 1% chance

Table 3.1
Degrees of statistical probability associated with provisional terms

Temperature

- The globally averaged surface temperature is projected to increase by 1.4 to 5.8^{o}C over the period 1990-2100.

- The projected warming is much larger than the observed changes during the 20th century and is *very likely* to be without precedent during the last 10,000 years, based on palaeoclimatic data.

- Based on recent global model simulations it is *very likely* that nearly all land areas will warm more rapidly than the global average, particularly those at northern latitudes in the cold season.

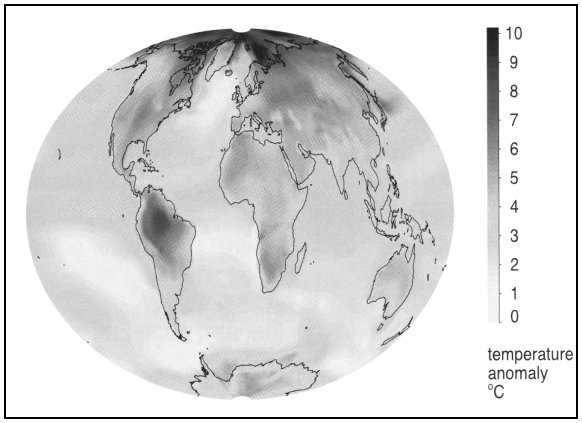


Figure 3.1
Change in annual average temperature for the 2080s period, relative to 1961-1990, for the HadCM3 ensemble-average under an A2 forcing scenario, (source: UKCIP02 Scientific Report, April 2002)

Precipitation

- Based on global model simulations and for a wide range of scenarios, global average water vapour concentrations and precipitation are projected to increase during the 21st century.

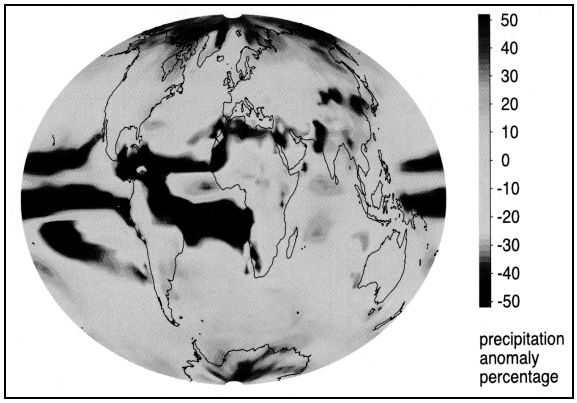


Figure 3.2
Change in annual average precipitation for the 2080s period, relative to 1961-1990, for the HadCM3 ensemble-average under an A2 forcing scenario, (source: UKCIP02 Scientific Report, April 2002)

Monsoons

- It is *likely* that warming associated with increasing greenhouse concentrations will cause an increase in the variability of Asian summer monsoon precipitation.

Thermohaline circulation (*the Gulf Stream*)

- Most models show weakening of the ocean thermohaline circulation, leading to a reduction of the heat transport into high latitudes of the Northern Hemisphere. This modelled ocean cooling does not counterbalance the regional warming over Europe caused by greenhouse gas emissions. Although thermohaline circulation could ultimately shut down, models do not predict this for the 21st century. Nevertheless it remains a long-term potential threat.

Snow and Ice

- Northern Hemisphere snow cover and sea-ice extent are projected to decrease further.

- Glaciers and ice caps are projected to continue their widespread retreat during the 21st Century. (However, it should be noted additionally that in some areas such as south-central Norway, increased precipitation may result in local glacier advance).

- The Antarctic ice sheet is *likely* to gain mass because of greater precipitation, while the Greenland ice sheet is likely to lose mass because the increase in melting will exceed the precipitation increase.

- It is thought *very unlikely* that the west Antarctic ice sheet will collapse in the 21st century, although such a scenario may occur especially for longer time-scale projections.

Sea level

- Global mean sea level is projected to rise by 0.09 to 0.88 metres between 1990 and 2100, primarily as a result of thermal expansion of the oceans, with a secondary but significant input from glacial melt water.

Confidence in observed changes (latter half of 20th century)	Changes in Phenomenon	Confidence in projected changes (during the 21st century)
Likely	**Higher maximum temperatures and more hot days over nearly all land areas**	Very Likely
Very Likely	**Higher minimum temperatures, fewer cold days and frost days over nearly all land areas**	Very Likely
Very Likely	**Reduced diurnal temperature range over most land areas**	Very Likely
Likely, over many areas	**Increase of heat index over land areas**	Very Likely, over most areas
Likely, over many Northern Hemisphere mid–high latitude areas	**More intense precipitation events**	Very Likely, over many areas
Likely, in a few areas	**Increased summer continental drying and associated risk of drought**	Likely, over most mid-latitude continental areas (lack of consistent projections in other areas).
Not observed in the few analyses available	**Increase in tropical cyclone peak wind intensities**	Likely, over some areas
Insufficient data for assessment	**Increase in tropical cyclone mean and peak precipitation intensities**	Likely, over some areas

Table 3.2
Confidence levels of observed and predicted data for different climatic phenomena

Global Climate Change Impacts

The sensitivity, adaptive capacity, and vulnerability of natural and human systems to climatic change, and the potential consequences of climate change, have been assessed in the Third Assessment Report (TAR) of Working Group II of the IPCC, Climate Change 2001: Impacts, Adaptation and Vulnerability (McCarthy et al., 2001).

Whilst the rapidity and magnitude of the projected changes may be *comparatively* limited, they may be occurring in a world more heavily populated, and living closer to its limits, than ever before. Heavily populated coastal regions of south-east Asia, for example, may be affected catastrophically from increased cyclonic activity superimposed on a rising sea-level. Thus, an emergent view from the IPCC report is that those in the 'developing' world are the most vulnerable to projected climate change. The vulnerability, however, is clearly not confined to developing regions, but is potentially closer to home. Western populations may be vulnerable in terms of their infrastructural and technological reliances. Climate changes of magnitudes tolerated by more mobile and flexible societies of the past may pose greater threats to societies of the 21st century.

The TAR report on impacts, adaptation and vulnerability takes both sectoral and regional approaches to investigating the impacts of climate change. In all instances it emphasises the need for adaptation and response to climate change, in addition to adopting mitigation strategies. As such, it mirrors the UKCIP approach and that of this Scoping Study. A detailed review of regional factors at a global scale is reported in the TAR. It is clear that one of the potential societal impacts of climate change is an acceleration of trans-boundary emigration currently driven largely by political, economic and humanitarian factors. Thus local consequences of climate change may arise from impacts far removed in other regions of the world.

Natural System Vulnerability

Natural systems can be especially vulnerable to climate changes due to their limited adaptive capacity, and some systems may undergo significant and irreversible change. Natural systems at risk include glaciers, coral reefs and atolls, mangroves, boreal and tropical forest, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands. Whilst some species may increase their range or population, climate change will increase existing risks of extinction and loss of biodiversity. Rates and magnitudes of biodiversity losses have a well-established link to rates of climate change.

Human System Vulnerability

Human systems that are sensitive to climate change include water resources; agriculture (especially food security) and forestry; coastal zones and marine systems (fisheries); human settlements; energy and industry; insurance and other financial services; and human health. The vulnerability of these systems varies with geographical location, time, and social, economic, and environmental conditions.

Projected Impacts

In addition to highlighting the 'negative' impacts of climate change, the TAR also illustrates the potential local and regional benefits of such change. Projected adverse impacts based on models and other studies include:

- A general reduction in potential crop yields in most tropical and sub-tropical regions for most projected increases in temperature.
- A general reduction, with some variation, in potential crop yields in most regions in mid-latitudes for increases in annual average temperature of more than a few ºC.
- Decreased water availability for populations in many water-scarce regions, particularly in the sub-tropics.
- An increase in the number of people exposed to vector-borne disease (e.g. malaria) and water-borne diseases (e.g. cholera), and an increase in heat stress mortality.
- A widespread increase in the risk of flooding for many human settlements (tens of millions of inhabitants in settlements studies) from both increased heavy precipitation events and sea-level rise.
- Increased energy demand for space cooling, owing to higher summer temperatures.

Potential beneficial impacts based on models and other studies include:

- Increased potential crop yields in some regions of the mid-latitudes for increases in temperature of less than a few ºC.
- A potential increase in the global timber supply from appropriately managed forests.
- Increased water availability for populations in some water-scarce regions – for example, parts of Southeast Asia.
- Reduced winter mortality in mid- and high-latitudes.
- Reduced energy demand for space heating owing to higher winter temperatures.

Global Impacts on South West Region

The data and scenarios outlined above provide a global context for understanding the potential changes in the climate of the South West Region of the UK. As well as setting the climate context it is also a reminder that significant climate change consequences are being predicted for other parts of the world. Some of these consequences, may have global implications for the South West region of the UK, for example in terms of inmigration, and patterns of tourism and trade.

CHAPTER 4

THE SOUTH WEST REGION

This section is largely based upon material developed and published by the SWRDA in its the State of the Region section of the Regional Strategy for the South West of England 2000-2010 (SWRDA 2000) and later revisions.

The South West has a land area of 23,829 km^2 and is the largest of the English regions (accounting for 15% of England) More than two thirds (70%) of this land area is devoted to agriculture, as is the overall figure for the UK. The land-based industries play a major role in maintaining and preserving the region's distinctive and varied countryside and landscape. The population of 4.9 million people live at average densities of 206 persons/sq km (16% below the UK average but much higher than the EU average). The region is predominantly rural but has a number of significant urban centres. These urban and rural locations combine to provide a diverse economic base for the region, while creating distinct sub-regional disparities.

The coastline extends to 1000km and provides some of the most popular UK destinations for long- and short-break holidays. Other, non-coastal attractions, particularly the built and natural heritage, feature strongly in the region.

The environment of the South West is one of the most rich and diverse in the UK. Traditionally, industry and business have often seen the environment as a constraint upon economic development. There is increasing recognition that the high quality environment plays a significant role in attracting people to live in, work in and visit the region and provides an important driver for economic development and regeneration.

The environment already makes a significant contribution to employment and economic output. It has been estimated that economic activity related to the environment sustains around 100,000 jobs in the South West and £1.6 billion to GDP. This equates to over 4% of the region's employment and 3% of GDP.

The South West is a growing region. The region's economic performance over the last two decades has outstripped national averages, notably in terms of GDP and employment growth. In 1998, the South West accounted for 7.8% of the nation's GDP. Over the 1991-1998 period, the rate of growth in the South West's regional GDP has been the fourth greatest of all the UK regions; higher than that for Great Britain as a whole. GDP per head in the region consistently runs at around 91% of the national level. While GDP per head in the South West has remained relatively static, its performance relative to other UK regions has improved.

Avon makes the largest contribution to the region's GDP at 24% - Bristol accounts for 11.5%. Wiltshire, especially Swindon Unitary Authority (UA), former Avon, and Gloucestershire which have the highest levels of GDP per head, are the only counties within the region to achieve levels of GDP above the national average. Somerset, Dorset and Devon have levels of GDP varying between 80% and 90% of the national average. Cornwall has experienced little growth in GDP per head over the past two decades and has the lowest level of GDP at levels 25% below the regional average, 29% lower than the national average. It has the lowest contribution to regional GDP at 7.3%.

The principal urban centres of the region are Bristol, Cheltenham, Gloucester, Swindon, Exeter, Plymouth, Bournemouth and Poole, Christchurch, Torbay and Weymouth and Portland. Together these urban areas contain over 40% of all employment in the region and house 35% of the region's population. Taunton, though not an urban district in its own right, is also an important centre.

The urban centres are the locations of the region's airports (except Newquay) and major ports. As principal service and entertainment centres they serve a much wider area and may attract people from up to 100 miles away.

Accessible rural areas have particular concentrations of employment in the hi-tech and knowledge clusters. Remote rural parts of the South West have experienced slower growth than accessible areas. These areas also have the lowest wages and experience significant levels of seasonal unemployment, partly due to the importance of the agriculture and tourism sectors.

There is a total of 203,900 business establishments in the South West, the majority (85.4%) employing less than 10 people. Only 1.3% of workplaces employ more than 100 people in the South West, slightly less than nationally. Although medium and large workplaces (employing 25 or more people) are heavily outnumbered by small workplaces, the former provide the bulk of employment in the South West. Most jobs in the South West are provided by medium and large workplaces, but the region has few large businesses, host to only two of the top 100 companies in the UK.

The South West has been successful in attracting inward investors, particularly to centres in the east of the region. These firms are concentrated in hi-tech, research, automotive, plastics and food processing clusters. Regionally, tourism is a key sector in the South West economy, attracting some 21m visitors each year and contributing around 6.6% (£3.5bn) of the region's GDP.

CHAPTER 5

CLIMATE IN THE SOUTHWEST

Introduction

The climate for the South West is reported here in two sections:

1. Historical Climate in the Region;
2. Future Climate in the Region.

The report on the historical climate is based upon three sources: climate data for the period 1961-1990 prepared for UKCIP02 and derived from sets archived at the UK Meteorological Office; modelled baseline data for the same period; and observed trends of historical meteorological data for two locations in the region, Plymouth and Cheltenham.

The report on the future climate for the region is based upon climate scenarios prepared for UKCIP02 for a range of different emissions scenarios for three time periods: around the 2020s, around the 2050s and around the 2080s. The scenarios compare the modelled climate for these periods with the modelled climate baseline period 1961-1990, for a range of climate variables. (eg temperature, precipitation)

Historical Climate

Observed Climate 1961-1990

These observed data derive from sets of observed data which are archived at the UK Meteorological Office. The full set comprises 26 weather variables or derivatives (see Figure 5.1 below). It can be accessed as datafiles from the UK Met Office (at www.metoffice.com/research/hadleycentre/obsdata/ukcip/index.html).

The future climate scenarios for the Southwest referred to in this report compare the potential future climate for a locality with the modelled climate over the period 1961-1990 for the same locality. So, the historic data for 1961 to 1990 provides a baseline against which future climate can be reported.

Clearly, certain of these variables have more particular relevance for some 'impact domains' in the region than do others. For example, the length of the Annual Growing Season is of particular relevance for agriculture in the region. For most people, however, simple temperature or rainfall data will have more immediate significance, and so it is these data that are presented in the summary maps.

The Observed UK Climate Data Set (1961-90)
Climate Variables Reported

1	Monthly Mean Air Temperature
2	Monthly Mean Maximum Temperature
3	Monthly Mean Minimum Temperature
4	No. of days with Frost in month
5	Heating Degree Days per month
6	Growing Degree Days in month
7	Intra-Annual Extreme Temperature Range
8	Annual Growing Season Length
9	Summer 'Heat Wave' Duration
10	Winter 'Heat Wave' Duration
11	Summer 'Cold Wave' Duration
12	Winter 'Cold Wave' Duration
13	Monthly Mean Vapour Pressure
14	Monthly Mean Wind Speed (from AD 1960)
15	Monthly Mean Sea Level Pressure
16	Monthly Hours of Bright Sunshine
17	Monthly Total Precipitation
18	Rain Days in month
19	Wet Days in month
20	Snow Days in month
21	Max. No. of Consecutive Dry Days in a Year
22	Greatest 5-day Precipitation Total in a Year
23	Simple Daily Intensity on Raindays per Year
24	Number of Days with Snow Cover
25	Monthly Mean Cloud Cover
26	Number of days with Ground Frost

Figure 5.1
The Observed UK Climate Data Set (1961-90)
List of Climate Variables Reported

For the purposes of this study the data have been extracted for four of these climate variables: daily mean temperature, maximum temperature; total daily precipitation; wind speed at 10 metres. *(These are reported in the figures below)*

One of the significant features of the baseline data is the way in which variability within the region is revealed for different aspects of the weather. Although the data are only reported within a 50 kilometre square grid it is still possible to observe: the difference between climates that are essentially maritime and those that are more land based; variability from north to south and from east to west; and the influence of topography, particularly the height and exposure of locations such as Exmoor and Dartmoor.

This reinforces the understanding that the region is very diverse, and highlights the importance of taking account of location within the region when considering potential changes in climate and consequential impacts.

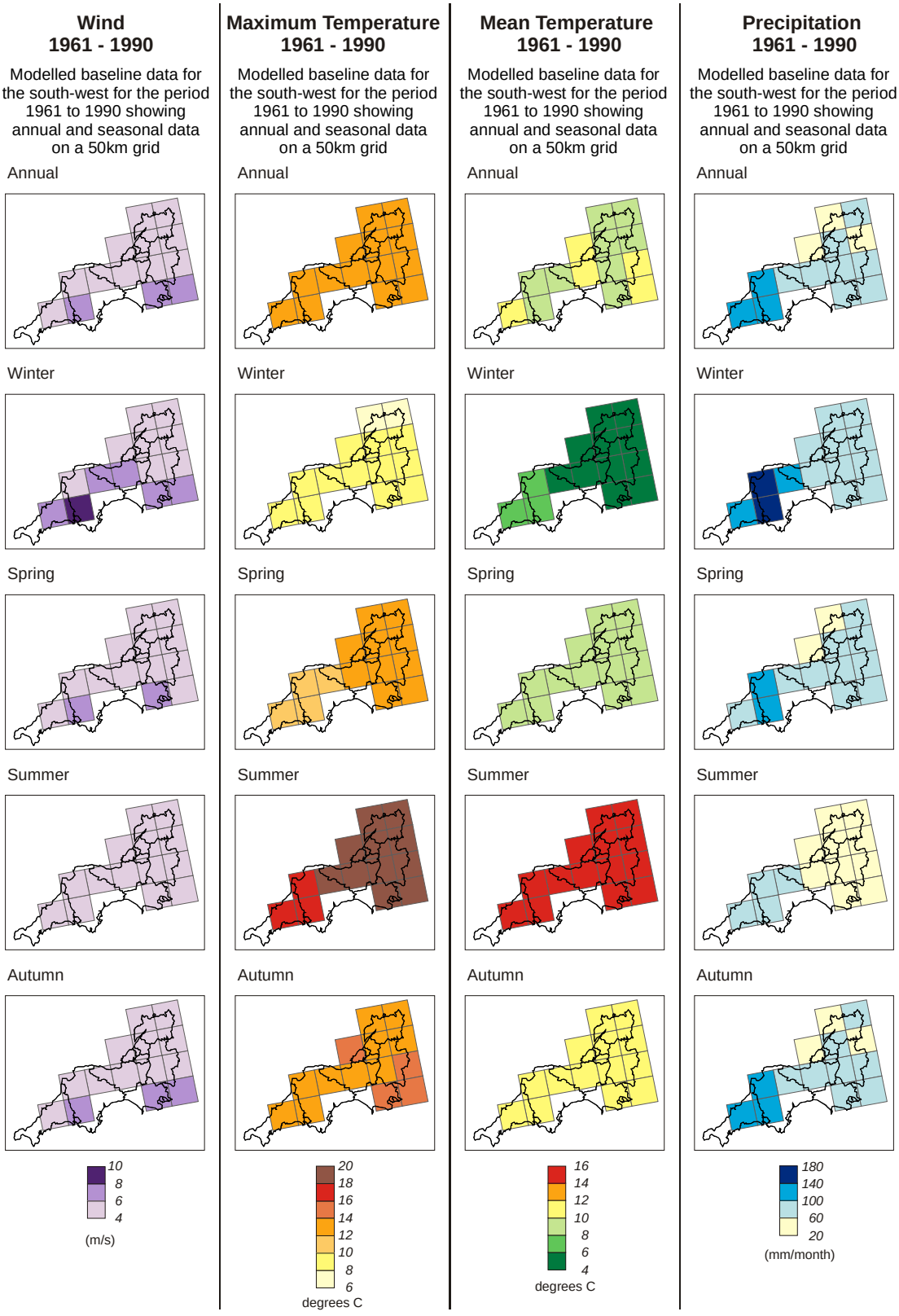


Figure 5.2
Four sets of maps showing modelled baseline data for 4 climate variables (Wind, Maximum Temperature, Mean Temperature, Precipitation) for the period 1961-1990 for Annual, Winter, Spring, Summer and Autumn on a 50km square grid (UKCIP02).

Historical Climate

Observed Local Trends

(Analysis of Meteorological Data undertaken by Dr Len Wood, University of Plymouth)

Past climate records in the South West were analysed to reveal how the region's climate has changed in recent times. This section considers historical meteorological data for two urban locations at opposite 'ends' of the region: for Plymouth (Devon) and for Cheltenham (Gloucestershire).

The longest temperature series in the South West is for Plymouth where records have been kept since 1874.

A warming trend of 0.8^{O}C can be seen in Plymouth over the last 125 years.

Annual mean temperatures show a large variability (Figure 5.3). A warming trend of about 0.8 ^{O}C from the 1880s to 1940s is evident, followed by a cooling period until the 1960s. The last two decades have shown a warming of 0.6 ^{O}C, with a quite rapid return to the annual mean temperatures of the 1940s. Overall, a warming trend of 0.5 ^{O}C can be seen in Plymouth over the last 125 years. Four of the ten warmest years within the 125-year record in Plymouth have occurred since 1989 (1989, 1990, 1995, 1999).

Seven of the ten warmest years within the 60-year temperature record in Cheltenham have occurred since 1989.

Cheltenham's temperature record is only from 1930 (Figure 5.4) but shows a warming trend of 1^{O}C over the last 60 years with annual mean temperatures higher today than they were in the 1940s. Seven of the ten warmest years within the 60-year record in Cheltenham have occurred since 1989 (1989, 1990, 1994, 1995, 1997, 1998, 1999).

Cheltenham's temperature records show a warming trend of 1^{O}C over the last 60 years with annual mean temperatures higher today than they were in the 1940s.

Seasonal temperature records in Plymouth, which are shown in Figure 5.5, indicate that winter (DJF) mean temperatures have been more variable than summer (JJA) mean temperatures over the period 1874-2001. Early in the record the trend shows winters becoming warmer, and summers cooler up to the turn of the century. There then follows a cooling trend for winters from the 1920s to 1960s, followed by a warming in recent decades. Summer temperatures do not show such a marked warming in recent decades, which indicates that the annual mean temperature rise found at Plymouth results from milder winters.

Figure 5.6 shows the sea surface temperature anomalies (departures from the 1961-90 average) in the Southwest Approaches over the period 1880 to 2001. The record is highly variable and no long-term trends are evident. However, all anomalies since 1995 have been positive, which may indicate a trend towards warmer waters.

Records of annual rainfall are available from 1874-2001 in Plymouth (Figure 5.7) and from 1930-1999 in Cheltenham (Figure 5.8). There is a similar variation in annual rainfall over the period 1930-99 for both localities. The trend has been for an increase in annual rainfall since the drought of 1975-76. However, the longer record of Plymouth shows two periods of similarly increasing rainfall at the beginning of the century and in the 1920s.

A comparison of summer and winter rainfall at Plymouth (Figure 5.9) shows no long-term trend to wetter winters and drier summers, or vice versa. Winters have become wetter and summers drier only over short periods of a few decades.

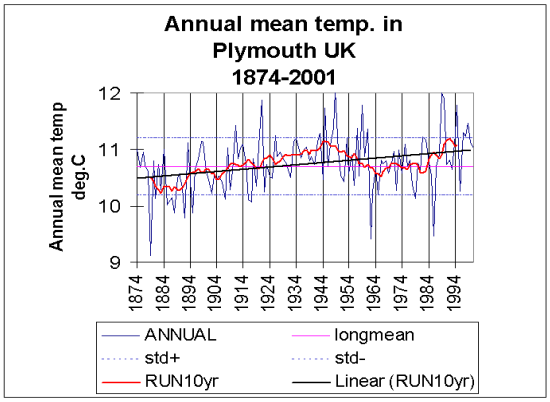


Figure 5.3
Annual Mean Temperature in Plymouth 1874-2001

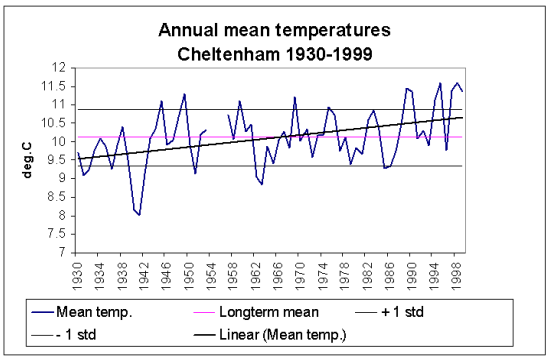


Figure 5.4
Annual Mean Temperature in Cheltenham 1930-1999

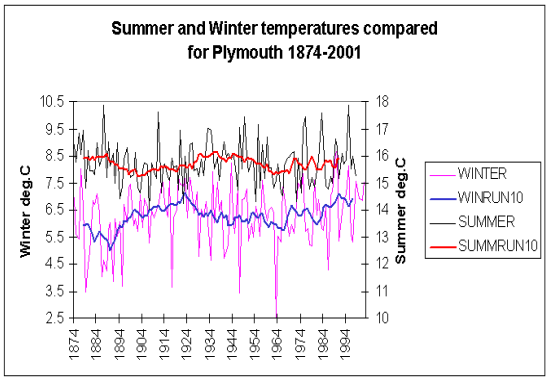


Figure 5.5
Summer and Winter Temperatures Compared for Plymouth from 1874 to 2001

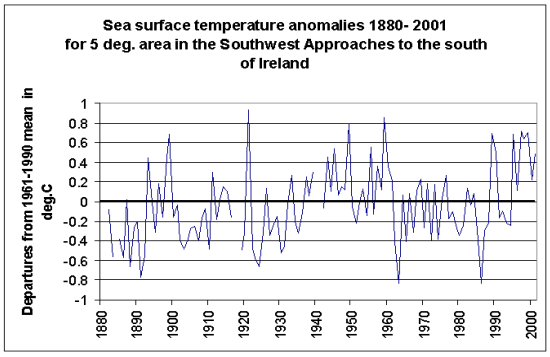


Figure 5.6
Sea surface temperature anomalies (departures from the 1961-90 av.) in the Southwest approaches 1880 to 2001

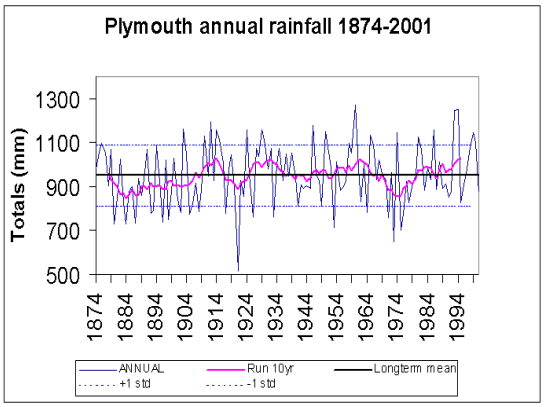


Figure 5.7
Annual Rainfall in Plymouth 1874-2001

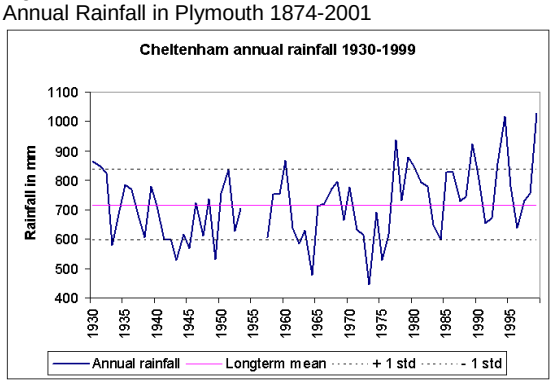


Figure 5.8
Annual Rainfall in Cheltenham 1930 to 1999

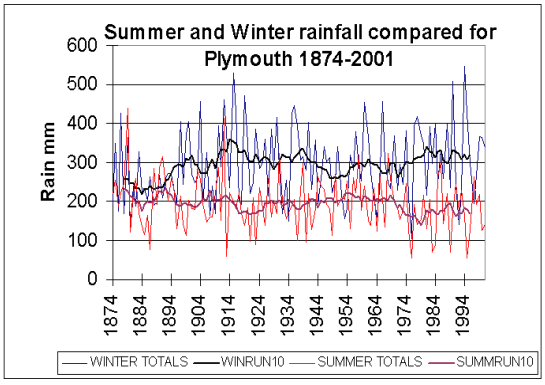


Figure 5.9
Summer and Winter Temperatures Compared for Plymouth from 1874 to 2001

Figures 5.3 to 5.9

Various graphs showing historic climate data for Cheltenham and Plymouth.

Future Climate

Future Climate in the South West Region

The tables on the following page broadly summarise the anticipated changes in the region's climate over the next 50 to 80 years. Figure 5.10 provides a simple summary **by season** of potential climate impacts in the South West region for the next 50 to 80 years. Figure 5.11 provides a simple summary **by climate variable** of potential climate impacts in the South West region for the next 50 to 80 years.

For more information, see the climate scenario maps displayed in Figures 5.14, 5.15, 5.16, and 5.17.

Future Climate

Data Sources

The climate scenario data for UKCIP02 are available as raw data or as national maps from UKCIP (www.ukcip.org.uk/scenarios/). They are based on new global emission scenarios published in 2000 by the Intergovernmental Panel on Climate Change (IPCC, 2000). For the purposes of modelling the future climate, four 'emissions scenarios' were used in the UK Meteorological Office's Hadley Centre model to generate climate scenarios for UKCIP:

- Low Emissions;
- Medium-Low Emissions;
- Medium-High Emissions;
- High Emissions.

The emissions referred to include those of so-called greenhouse gases added to atmosphere as a result of human activities (such as carbon dioxide, methane, CFCs, etc.) and believed to have a warming effect, but also include those that may have a counter effect (such as emissions of sulphate aerosols). The different emissions scenarios are based on assumptions about different rates of global economic growth, population size and efficiency of resource use, and form the basis for the latest IPCC reports (see IPCC 2001). Using the Hadley Centre model, climate scenarios for each of these emissions scenarios were then generated for the UK (for UKCIP02) for three thirty-year time periods around the 2020s, around the 2050s and around the 2080s. Data have been prepared for the scenarios using the 15 climate variables in the table below (Figure 5.9).

The UKCIP02 Scenario Data
Climate Variables Reported

1	Maximum temperature
2	Minimum temperature
3	Daily mean temperature
4	Total precipitation rate (mm/day)
5	Snowfall rate (mm/day)
6	Wind speed at height of 10 m (m/s)
7	Relative humidity (%)
8	Total cloud in longwave radiation (fraction)
9	Net surface longwave flux (Wm^{-2})
10	Net surface shortwave flux (Wm^{-2})
11	Total downward surface shortwave flux (Wm^{-2})
12	Soil moisture content (mm)
13	Mean sea level pressure (mb)
14	Surface latent heat flux (Wm^{-2})
15	Specific humidity (g/kg)

Figure 5.9
The UKCIP02 Scenario Data
List of Climate Variables Reported

Surface Marine Climate

Under the Medium-High Emissions scenario an overall warming of up to 3 ^{O}C is shown in maps for around the 2080s for sea surface temperatures around the South West**.**

Future Changes in Sea-level

The Southwest region has a very long coastline, and the Southwest peninsula is sinking relative to the sea (i.e., mean sea level is increasing more rapidly in Southwest England than estimates of 'global' sea-level rise). For Southwest England regional isostatic subsidence is of the order of 0.6 mm per year.

The climate changes anticipated in the Hadley Centre models predict additional (global) sea-level rises of between 14 to 18 cm for the 2050s, and between 23 cm (Low Emissions) and 36 cm (High Emissions) for the 2080s. The majority of this anticipated rise is generated by thermal expansion of ocean water, with minor additions caused by melting of land ice (and not, for example, by melting of Antarctic floating ice, or of Arctic floating ice, which make no change to global sea levels). Melting of the West Antarctic ice sheet could make a difference to sea level but in the period beyond that encompassed in this report (see UKCIP, 2002).

The cumulative net sea-level change for around the 2080s for Southwest England therefore varies from plus 16 cm under a Low Emissions scenario to plus 76 cm under a High Emissions scenario.

Summary of anticipated climate changes likely to affect the Southwest (adapted from UKCIP02)

Figure 5.10 by Season
Figure 5.11 by Climate Variable

Season	Months	Anticipated Climate around 2050s	Anticipated Climate around 2080s
Spring	(MAM)	• Warmer by 1.0 to 2.0°C	• Warmer by 1.5 to 3.5°C
		• Precipitation totals similar to present	• Precipitation totals similar to present
Summer	(JJA)	• Warmer by 1.5 to 3.5°C	• Warmer by 2.0 to 5.5°C
		• Drier by 15 to 30%	• Drier by 25 to 55%
Autumn	(SON)	• Warmer by 1.5 to 3.0°C	• Warmer by 2.0 to 5.0°C
		• Drier by 0 to 10%	• Drier by 5 to 15%
Winter	(DJF)	• Milder by 1.0 to 2.0°C	• Milder by 1.5 to 3.5°C
		• Wetter by 5 to 15%	• Wetter by 10 to 30%
			• Snowfall decrease by 70 to 90%

Figure 5.10
A simple summary by season of potential climate changes in the SW region for the next century

Climate Variable	Likely change by around the 2050s (from UKCIP02 low and high emissions scenarios)
Temperature	• Annual warming 1.0 to 2.5°C (1.5 to 4.5 °C by 2080s) • Greater night-time than day-time warming in winter • Greater warming in summer and autumn than in winter and spring • Greater day-time than night-time warming in summer • Years as warm as 1999 (+1.2°C become more common)
Precipitation	• Winters 5 to 15% wetter (10 to 30% wetter by 2080s) • Summers 15 to 30% drier (25 to 50% drier by 2080s) • Heavy rainfall in winter becomes more common • Greater contrast between summer (drier) and winter (wetter) seasons • Winter and spring precipitation becomes more variable • Snowfall totals decrease significantly • Summers as dry as 1995 (37% <average) become more common
Cloud Cover	• Reduction in summer and autumn cloud, and an increase in radiation • Small increase in winter cloud cover
Humidity	• Specific humidity increases throughout the year • Relative humidity decreases in summer
Soil Moisture	• Decreases in summer • Slight increase in winter soil moisture
Storm tracks	• Winter depressions become more frequent, including the deepest ones
North Atlantic Oscillation	• The North Atlantic Oscillation (NAO) tends to become more positive in the future, giving wet, windy and milder winters

Figure 5.11
A simple summary by climate variable of potential climate changes in the SW region for the period around the 2050s

Climate scenarios for the South West

The detailed representation of climate scenarios for the South West is reported on the maps on the following pages. Figure 5.14, Figure 5.15, Figure 5.16, And Figure 5.17.

We have presented data on those climate variables that probably have most meaning for most people. These are:

- average daily temperature;
- maximum daily temperature;
- total daily precipitation;
- average wind speed.

For illustrative purposes we have used just two of the emissions scenarios:

- Low emissions;
- High emissions.

The maps show the anticipated climate for two seasons (Summer and Winter) and an annual figure.

In all cases the maps compare the modelled data for the three future time periods (around the 2020s, around the 2050s, around the 2080s) with modelled data for the baseline period of 1961 to 1990.

Maps are presented using a grid of squares at 50km x 50km resolution, for grid squares that are predominantly land.

As displayed, each set of maps can be studied to reveal the relative influence of four key parameters:

1. Spatial disposition;
2. Seasonal effects;
3. Emissions effects;
4. 30-year effects.

The climate scenarios are compared with modelled baseline conditions and show the magnitude of anticipated changes, not absolute climate data.

Other Climate Data Issues

Probabilities

Although 'average' climate conditions will be of relevance for many of the impact domains, the frequency of 'extreme' weather events may be of much greater significance for other domains. For example coastal defences are vulnerable to extreme storm events and extreme flood events. It is not possible to predict the timing of these extreme events. However, some indication of the probability of a specific locality experiencing certain conditions can be determined from a series of probability curves, which are now available. Figure 5.13 below illustrates the probability of daily rainfall exceeding certain figures. In the observed baseline period there was a 1% chance of daily rainfall exceeding 18mm/day in the summer months. In the period around the 2080s there is a 1% chance of daily rainfall exceeding 12mm/day in the summer months.

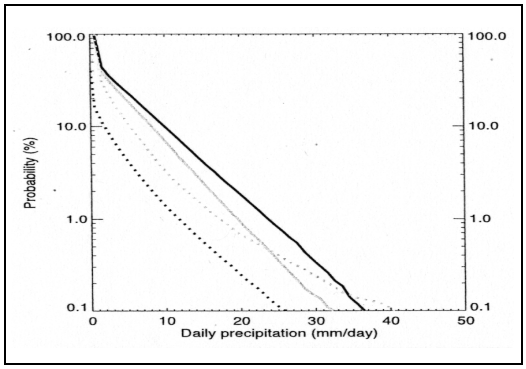


Figure 5.13
The probability of exceedence of daily precipitation totals for the Southwest Region. The recent historic baseline is shown in grey and the scenario for medium–high emissions in the 2080s is shown in black. The probability expressed is the probability of the event being exceeded on any given day for summer (dashed lines) and winter (solid lines).

Another example from within the region illustrates the same principle. In Gloucestershire, whereas there was a less than 10% chance of the daily summer temperature being greater than 30 ^{O}C in the baseline period, in the 2080s there is an anticipated 20% likelihood that the daily maximum temperature will exceed 30 ^{O}C.

Alternative climate scenarios

The future climate data for this report are predicated upon the climate-scenario data generated by the Hadley Centre models for UKCIP. Alternative scenarios, such as a shutdown of the North Atlantic heat conveyor (see Broecker, 1997), which might then plunge the UK back into an 'ice-age' climate, are not considered likely by UK Meteorological Office scientists *(Geoff Jenkins, personal communication)* and are therefore not considered in this report.

For further scientific discussion of the contribution of carbon dioxide to climate change, of natural forcing factors in climate changes, of the use of 'proxy' climate data, and of future climate scenarios, readers are referred to refereed scientific papers reproduced in Chambers & Ogle (2002a, b, c, d). For the basis of the Emissions Scenarios and global climate changes anticipated, see IPCC (2000, 2001).

Changes in south-west England mean annual, winter and summer temperatures (as compared to the 1961-90 average) for the thirty year periods around the 2020s, 2050s and 2080s for the UKCIP02 Low Emissions and High Emissions scenarios.

These are modelled results at 50km resolution for grid cells representing areas that are predominantly land.

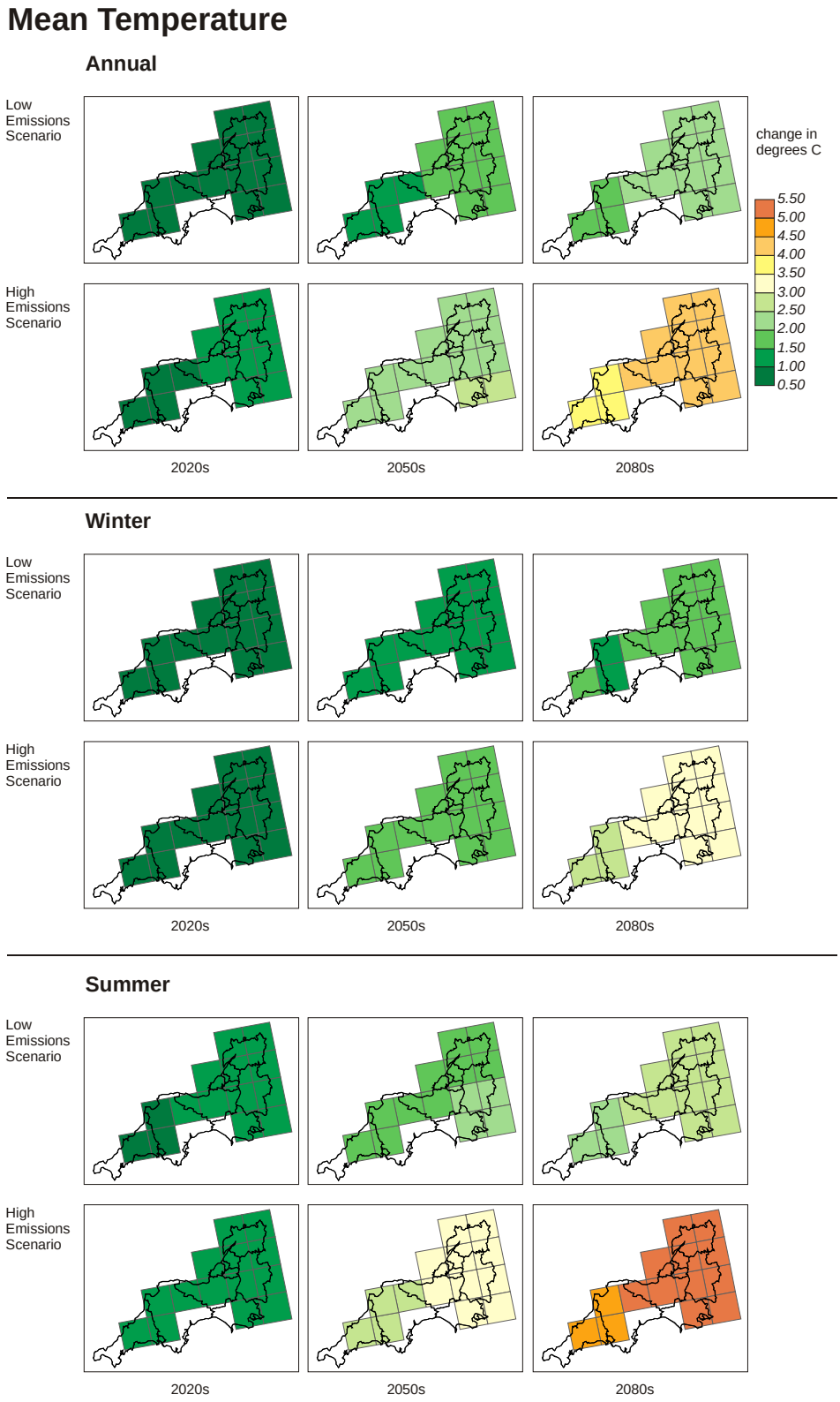


Figure 5.14
Changes in South West England Annual, Winter and Summer Average Temperatures as compared to the 1961-1990 modelled baseline for the thirty year periods around the 2020s, the 2050s and the 2080s for the UKCIP02 Low Emissions and High Emissions Scenarios. (UKCIP02).
These are modelled results at 50km resolution for grid cells representing areas that are predominantly land.

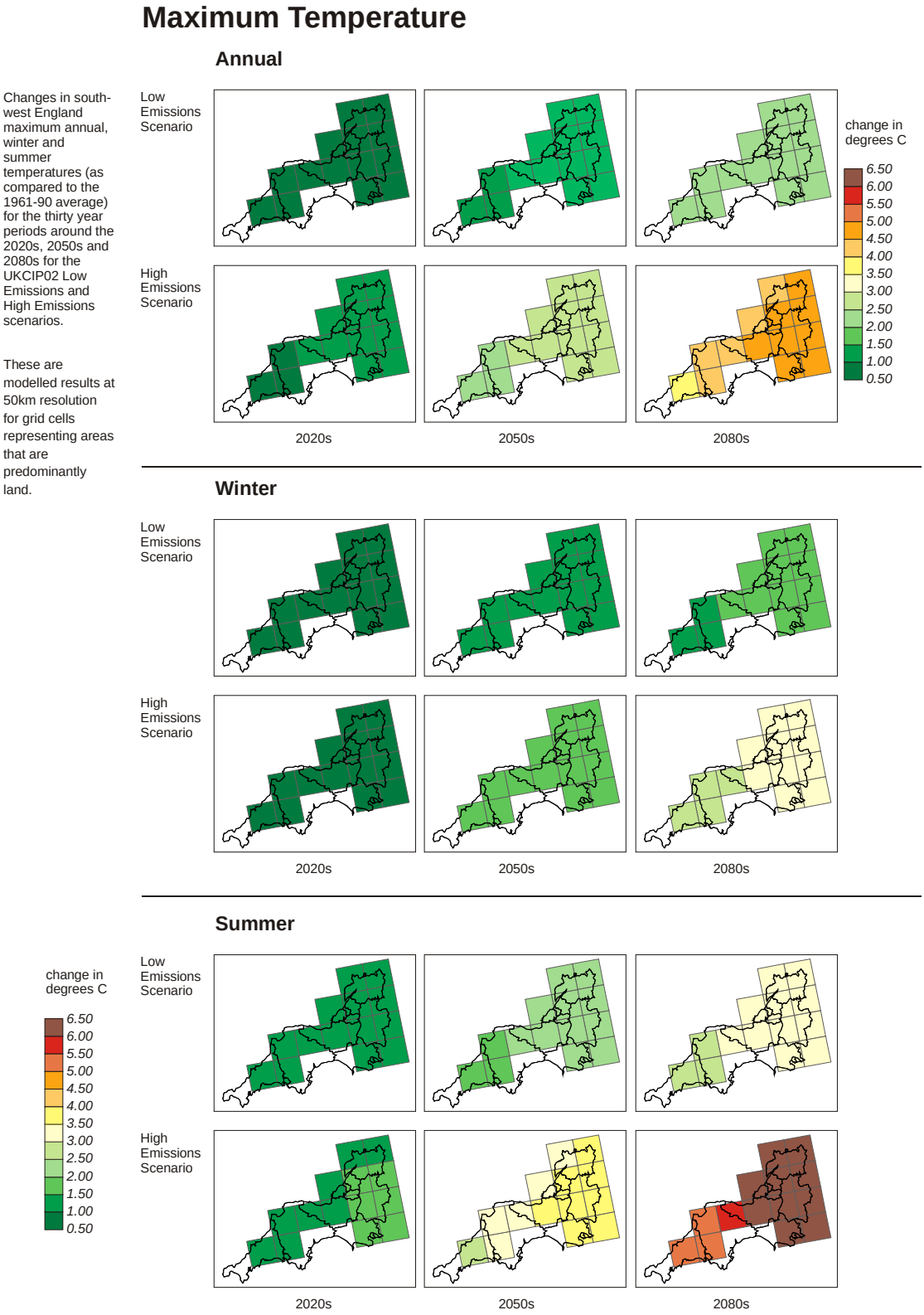
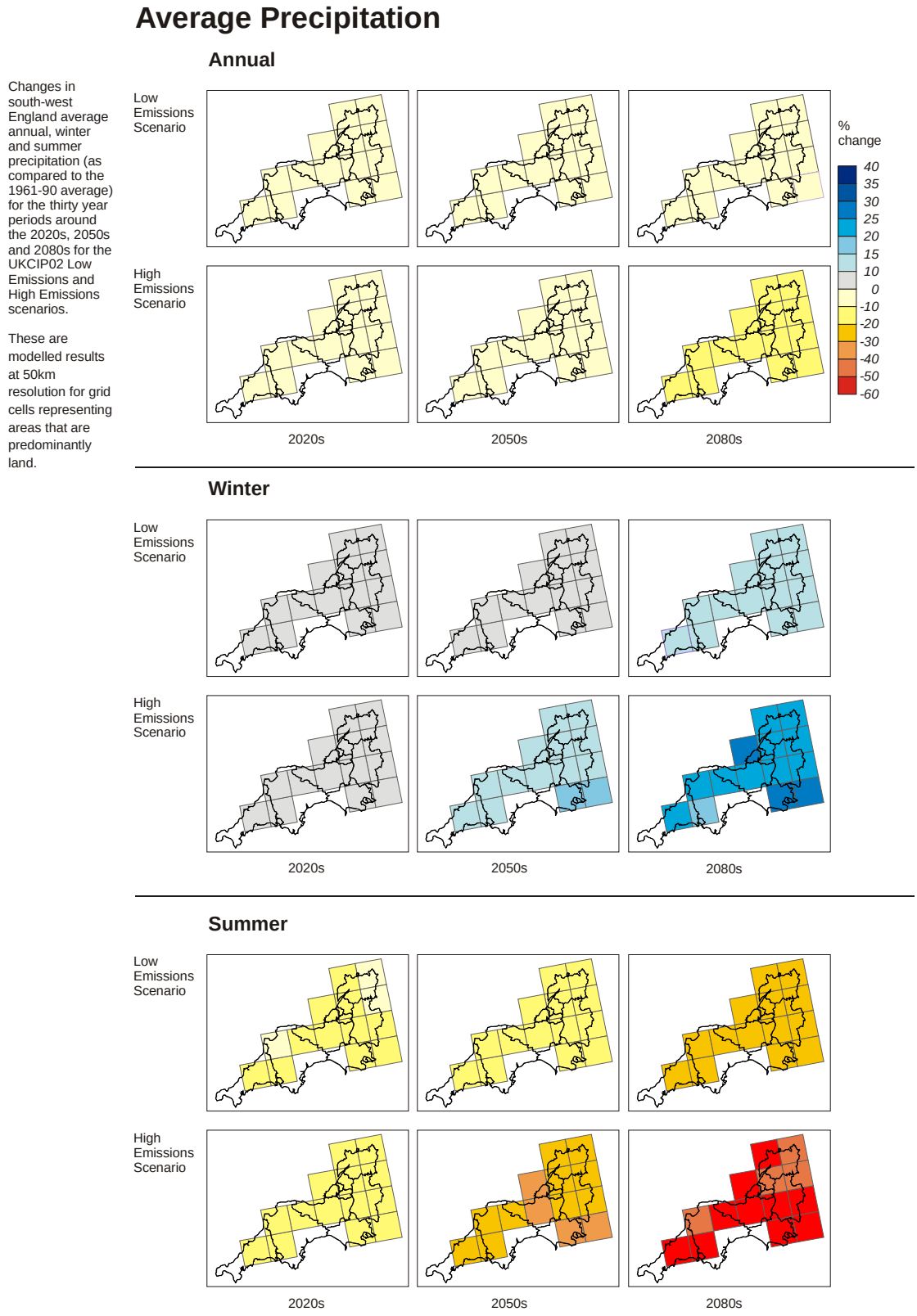


Figure 5.15
Changes in South West England Annual, Winter and Summer Maximum Temperatures as compared to the 1961-1990 modelled baseline for the thirty year periods around the 2020s, the 2050s and the 2080s for the UKCIP02 Low Emissions and High Emissions Scenarios. (UKCIP02)
These are modelled results at 50km resolution for grid cells representing areas that are predominantly land.



Changes in south-west England average annual, winter and summer precipitation (as compared to the 1961-90 average) for the thirty year periods around the 2020s, 2050s and 2080s for the UKCIP02 Low Emissions and High Emissions scenarios.

These are modelled results at 50km resolution for grid cells representing areas that are predominantly land.

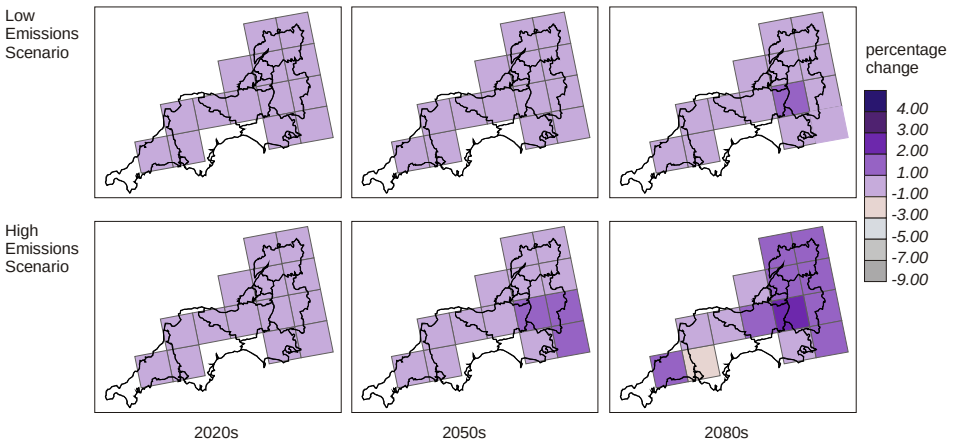
Figure 5.16
Changes in South West England Annual, Winter and Summer Precipitation as compared to the 1961-1990 modelled baseline for the thirty-year periods around the 2020s, the 2050s and the 2080s for the UKCIP02 Low Emissions and High Emissions Scenarios. (UKCIP02)
These are modelled results at 50km resolution for grid cells representing areas that are predominantly land.

Wind Speeds

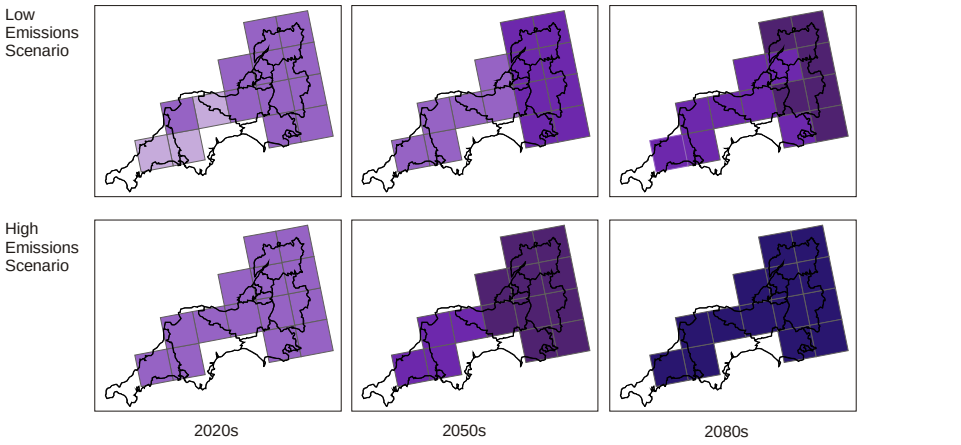
Annual

Changes in south-west England annual, winter and summer wind speeds at 10m (as compared to the 1961-90 average) for the thirty year periods around the 2020s, 2050s and 2080s for the UKCIP02 Low Emissions and High Emissions scenarios.

These are modelled results at 50km resolution for grid cells representing areas that are predominantly land.



Winter



Summer

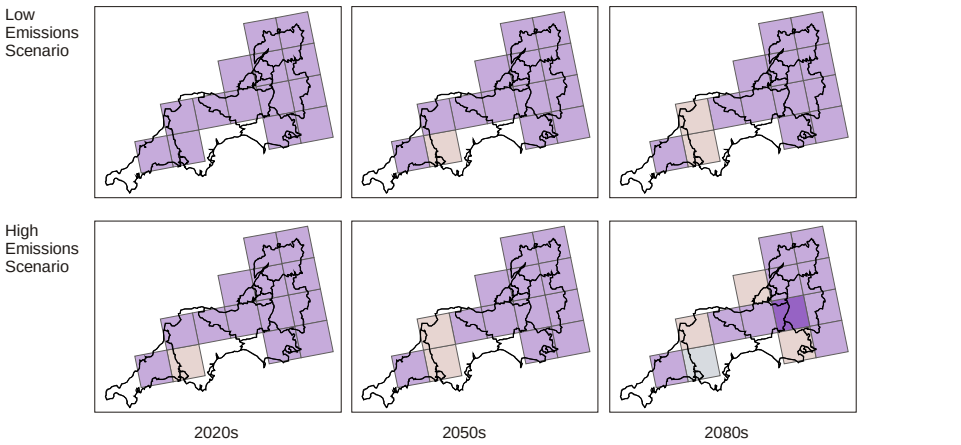


Figure 5.17
Changes in South West England Annual, Winter and Summer Wind speeds (at 10metres) as compared to the 1961-1990 modelled baseline for the thirty-year periods around the 2020s, the 2050s and the 2080s for the UKCIP02 Low Emissions and High Emissions Scenarios. (UKCIP02)
These are modelled results at 50km resolution for grid cells representing areas that are predominantly land.

CHAPTER 6

NATURAL ENVIRONMENT DOMAINS

LIKELY IMPACTS AND POSSIBLE ADAPTATION RESPONSES

Introduction

This section considers those domains in the South West which fit broadly under the heading of the natural environment. Such headings are necessarily arbitrary but have proved useful in progressing and reporting on the study. So, the natural environment section explores the following impact domains:

1. Agriculture and Horticulture
2. Biodiversity and Habitats
3. Coastal Issues
4. Forestry
5. Marine Fisheries
6. Rivers and Riverine Flooding
7. Water Resources.

(For details of the methodology adopted for researching and reporting on these domains please see the Appendix.)

This introductory section precedes the detailed consideration of each domain and considers some of the general issues that relate to climate change and its impact on the natural environment. A brief discussion of the baseline in the region is followed by a summary of climate change impacts on the domains and a summary table of recommendations.

Baseline

The 'natural' environment of the South West region is one of its greatest assets, contributing to the attraction of the region for tourists, and accounting for some 13% of business establishments in the region that are involved in one or more of the agricultural, hunting, forestry and fishing sectors.

The far South West with its many small coastal resorts is a tourist magnet, especially in summer, although Newquay is fast becoming a year-round surfing resort. The 'natural' beauty of the Cotswolds in the north of the region also attracts many tourists, and the Forest of Dean in Gloucestershire is well used by tourists, cyclists and walkers. In all parts of the region, however, most tourism is based on the private car, and its widespread use has implications for the further development of the tourist potential of the region without compromising its 'natural' qualities.

The region is blessed with two National Parks, several large AONBs, and long sections of heritage coastline. The upland areas of the National Parks — Exmoor and Dartmoor — have largely been deforested for millennia, but Dartmoor in particular contains pockets of probable former wildwood. There are a disproportionately large number (compared with other regions) of sites managed by The Woodland Trust.

With the exception of the more linear stretches of protected coastline and some river-valley woodlands, many of the protected sites for nature conservation in the region are 'islands' of semi-natural habitat in a sea of agricultural landscape. However, in south Dorset, urban encroachment on areas of semi-natural heathland is perceived as a greater threat than that of agriculture.

The South West has a regional Biodiversity Action Plan (unlike most other regions), but its practitioners in nature conservation are hampered in fully realising the plan by various perceptual, institutional and practical barriers to planning for biodiversity in the wider countryside (Watts, 2001).

The whole question of biodiversity in the region is one that merits further discussion. Biodiversity is usually seen as a quality or attribute that is perceived as being inherently 'good' (i.e. more is better). Some of the region's most prized semi-natural areas are, however, in reality dominated by relatively few vegetation species (heather moorland and *Sphagnum* bogs being two examples) and have relatively low vegetational biodiversity. On the other hand, other areas have much greater vegetational diversity (such as chalk- or limestone grassland) but are far from 'natural'. By that we mean that without continued grazing by livestock and by the (non-native) rabbit, many of these areas would quickly give way to scrub and eventually to woodland, which would in reality be the 'climatic climax' (final growth stage) ecosystem for most of the region.

Summary of Climate Impacts on Domains

Overall

The natural environment is probably the most conspicuous and visible receptor for the impacts of weather. In both public and professional realms it is the natural environment that first comes to mind in considering the impacts of climate change, for example through coastal and river flooding, water supply and demand, natural habitats, and potential changes in agricultural crops. For these, and other, reasons it is the aspect that

has received the greatest attention in earlier studies of climate change impacts.

Biodiversity

With regard to bio-diversity in the region it is clear that changes are already taking place. The range and variety of species will not just be affected by how we manage protected and designated areas but how integrated land use and management strategies can be developed. Difficult choices are required from those with management responsibility. We have encountered many conservation specialists who have difficulty in accepting the potential impacts of climate change and seek (Canute like) to hold onto protected species and habitats in the face of significant changes in the weather. Even during the course of the study we have observed a change in this attitude, and a much clearer recognition of the inevitability of climate change and the need for more radical responses.

Agriculture

The effects of climate change on agriculture are now broadly understood. These include an extended growing season, the potential for new crops, an increased requirement for water for summer irrigation, a potential loss of competitive advantage compared with other locations, and reduced die-off of pests and diseases due to warmer winters. Some of these changes are already occurring but within the farming community generally there is not much awareness or concern. At present there are more pressing issues on the agricultural agenda, including BSE, the aftermath of Foot and Mouth disease, the implications of the Curry Report and changes to the Common Agricultural Policy.

Forestry

Existing, established woodland trees generally are likely to survive changes in climate but new planting may require consideration of different species or different nursery regimes.

Coastal Issues

The main impacts on the coast will mainly be to do with coastal erosion and the reduced depth of beaches arising from increased sea levels and storm surges. Difficult decisions are required from those with responsibility for the management of coastal defences. Abandon; manage retreat; or defend robustly are the main options in the vulnerable locations. Again an integrated approach is required.

Marine Fisheries

As with agriculture the marine harvest is already changing but there are again more pressing issues than climate change. Traditional species such as cod are migrating north whilst new, more exotic species are now present in southern waters. The other items on the fisherman's agenda include the recent pronouncements on EU quotas (belatedly designed to control overfishing), and the need to renegotiate the Common Fishing Policy. These have tended to pre-empt consideration of climate change impacts, despite the empirical evidence that change is already happening.

Rivers and Flooding

The main impacts associated with rivers and other watercourses concern flooding in its various forms. The recent experience of riverine flooding is still in the public consciousness and the planning system is now exerting further control on potential development in floodplains. Periods of intense rainfall also lead to problems associated with excessive run-off from the land, and flash flooding in both town and country, largely associated with insufficient capacity in existing drainage. Insurance companies are taking an increased interest in the financial consequences of flooding, and through premium pricing or new policy exclusions are likely to determine policy in this area.

Water Resources

Issues of both supply and demand are affected by increased rainfall in winter but reduced rainfall in summer. As usual storage across the seasons becomes the main problem, particularly when extended periods of summer drought will increase demand for domestic and agricultural irrigation as well as commercial and industrial use. The quality of water is also of concern as river flows reduce and pollutants increase. Nevertheless, the water companies in the region appear to have a clear understanding of the main issues and appropriate adaptation strategies.

Cross-sectoral Issues

The various domains that are grouped together in this part of the report are difficult to separate from each other. Indeed, decisions taken in one sector (e.g. agriculture) may have major repercussions in others (e.g. biodiversity; floods). A pilot project that has focused on the River Parrett in Somerset demonstrates this interconnectedness, and shows how important can be the role for integrated land management. Decisions taken on upland land use in a catchment can have major implications downstream, and this is exemplified particularly during and immediately after prolonged or high-intensity rainfall events. The role that forestry might play in intercepting precipitation and mitigating surface run-off, and the role that a more sensitive agriculture can play in providing refuges and corridors for species, are worth further investigation in the context of the climate scenarios for the South West. *(See further discussion of Cross-sectoral Issues in Chapter 10.)*

Recommendations for Natural Environment Domains

- Encourage the implementation of the South West Biodiversity Action Plan incorporating the findings of the Scoping Study.
- Monitor the quantity, frequency and impacts of run-off from agricultural land and uplands generally.
- Make full use of the principles established in the MONARCH and REGIS studies in their potential application in the South West.
- Avoid preconceived and fixated views on what should be found living in specific locations, and alongside what other species, in the face of natural, uncontrollable changes in climate and habitat.
- Site visits for all relevant sectors to those mainland European locations which currently experience climates similar to those anticipated for different parts of the South West region.
- Make use of historical and archaeological evidence, as well as contemporary evidence, in considering likely impacts of climate change on the natural environment.
- Undertake further research in order to improve the quality of data with regard to extreme events and probability, particularly with regard to coastal storms.
- Quantify need for increased summertime irrigation for South West a**griculture and horticulture.**
- Continual monitoring of climate change impacts to increase awareness in **agricultural** sector.
- Review the potential loss of competitive advantage for South West **agriculture.**
- Develop policy responses to address **biodiversity** issues by considering integrated land-use management (including integrated marine and coastal management).
- Review potential species loss, opportunities for range expansion, and climatic effects on landscapes in assessing impacts on regional **biodiversity.**
- Encourage further research into, and monitoring of, the erosion of **coasts** and beaches.
- Rationalise the current split in responsibilities for **flood and coastal defence** and work towards more integrated management.
- Assess the risk of remobilisation of toxic substances in **riverine/estuarine** sediments.
- Renegotiate Common **Fisheries** Policy in the light of species loss and relocation.
- Monitor the impacts of changing water quality/quantity in **rivers** on habitat and biodiversity.
- Create a searchable database of hydrological data on water quality/quantity data in **rivers** in the SW Region to be available to stakeholders including general public.
- Increase control on future development within **flood risk** areas, including increased status for the Environment Agency in the review of planning applications.
- Manage abstraction licences for **water supply** faced with increased demand for irrigation and industrial usage.
- Review impact of longer droughts and modelled 4% rise in household water demand by 2021 on regional **water supply**.
- Review capacity of **sewerage and drainage infrastructure** in the prospect of flash floods, flooding of sewer networks, and rising sea levels.
- Manage increased turbidity, nitrates concentration and *cryptosporidium* content in **groundwater** during wetter winters.

AGRICULTURE AND HORTICULTURE DOMAIN

Scope

Agriculture, horticulture and related issues of commercial food production and distribution, including management of agricultural land, and potential diversification of land use.

See Also

Biodiversity, forestry

Background

The South West has a land area of 23,829 $km^{2,}$ more than two thirds (70%) of which supports agricultural production, either solely or as part of a multi-functional land useto agriculture. This proportion is comparable to the level of agricultural land use across the UK, though the region has a higher proportion of semi-natural grazing land (moorland, heath) than in other regions of southern Britain. The land-based industries play a major role in maintaining and preserving the region's distinctive and varied countryside and landscape. Because of its present climate horticulture forms an important part of the agricultural economy. Glasshouse production tries to capitalise on this climatic comparative advantage.

The region has the second largest agricultural workforce and proportion of agricultural employment in the country, and the third highest share of agricultural output in regional GDP. Agriculture thus directly sustains 3.7% of the regional workforce, generating 2.2% of regional GDP.

Despite the relatively non-agricultural nature of regional employment, there are localities within the region with comparatively significant proportions of agricultural employment. The highest proportion at county level is in Cornwall at 7.3% of the workforce although much higher concentrations exist at district level.

"Farmers are already changing their buying patterns and adapting their practices"

Agricultural Co-operative, Cornwall

The South West has a particularly large concentration of businesses in the agriculture, hunting, forestry and fishing sector, accounting for almost 13% of all business establishments in the region. Agriculture in the South West is thus less profitable and more labour intensive than that in other significantly rural region. Remote rural parts of the South West have experienced slower economic growth than more accessible areas. These areas have the lowest wages and experience significant levels of seasonal unemployment, partly due to the importance of agriculture in their economy.

Key Issues

- Elevated carbon dioxide levels could enhance growth of some crops.
- Longer growing period offers potential for increased productivity, but increased summer drought may offset this through reduced growth of crops and forages.
- Potential for novel crops such as sunflower, grapevine and bio-fuels including vegetable oils.
- Potential increase in pests and diseases, including species new to the region.
- Increased need for irrigation. This could be offset by on-farm storage of excess winter precipitation, but this will require financial outlay and man-hours in terms of reservoir construction.
- Potential for loss of competitive advantage for South West agriculture to other regions of the UK.
- Challenges and opportunities for inland fish farming. (Increased temperatures, reduced oxygen levels, new species).
- Increased heat stress for poultry and livestock, and also for employees.
- Intense rainfall may increase direct and indirect damage to crops and soils.
- Reduction in water quality due to leaching of nutrients, fertilisers, pesticides etc.
- Areas of agricultural land vulnerable to flooding from sea level rise – e.g. Somerset Levels, low-lying river valleys and coastal areas.
- Damage due to run-off – soil erosion, blockage of drains, damage to rural road network/field access. Impact on fish spawning streams (silting of gravel beds).

"There is a feeling that *'it* (climate change) *might not happen'* which discourages action"

Source unknown

Specific Climate Issues for the South West

- Flooding risks for the Somerset Levels and other low-lying and coastal areas.

- The risk of the South West losing the competitive advantage currently held, particularly in the extreme South West.
- Loss of prime land on the Isles of Scilly due to sea inundation and sand drift, as well as coastal erosion.

Risks that have been identified:

- Changing windows of opportunity available for land work, which will have effects on soil condition, compaction and run-off.
- Availability of water at crucial points in crop development.
- Damage to standing crops by heavy precipitation, high winds, flash floods etc.
- Increase in pest and disease damage due to low winter die-off, increased winter humidity and introduction of alien pest species through changing climate and the growth of novel crops.
- Worker health and safety issues.
- Sunburn and heat stress in livestock.
- Increased depth of roots due to dry conditions put the nutrients out of reach for some crops.
- Increased growth of weeds while the land is too wet to deal with them.
- Flash flooding increases the risk of slurry pollution events.
- Effects of poor land management due to unpredictable weather will have effects beyond the reach of the farm itself.
- Some crops currently grown on light soils (e.g. potatoes) may become inappropriate due to unpredictable weather events such as intense storms.
- As climate changes throughout Europe the SW's climatic comparative advantage may be lessen especially for glasshouse production.

"If there are not sufficient water reserve in the South West, there will be no way for farmers or growers to adapt"

Various, regional

Opportunities that have been identified:

- Increased geographical range and productivity of some crops such as maize.
- Potential for new crops such as grapevines, sunflowers and other oilseed crops.
- Potential for renewable energy generation.
- Potential for diversification – e.g. tourism potential.
- Less potential for snow damage to polythene tunnels.
- Reduced heating costs for glasshouse crops.
- Increased demand for salad crops during warm weather.

The Way Forward

Key drivers have been identified as primarily the Common Agricultural Policy (CAP) and other funding mechanisms. "Policy drives agriculture" is a common statement, and one that will need to be considered carefully before any change can be encouraged or expected.

Mention was made of the importance of the SWRDA, Government Office, and for Cornwall Objective One and even the Eden Project as key drivers for the sector. The importance of DEFRA as a policy driver was emphasised.

"Consideration needs to be given to the growth of water retaining crops on the Somerset Levels, but to bring this forward requires further incentives – a policy change."

Agricultural Development Officer, Somerset

It was stated that Building Regulations would be the proper format to shape future decisions on ensuring buildings are appropriate for future climatic conditions, and that water supply, one of the most important factors to affect agriculture, is very much in the hands of the supply companies.

It was stated that apathy on the part of the industry was one of the biggest barriers to change in the region. This was linked to the lack of capital and ready finance, without which the industry was unlikely to be prepared to take risks on an uncertain topic.

Farm income was recognised as a major barrier, as change requires time and money to implement. Without financial resources, labour is at a premium, which limits the time and motivation for increasing knowledge levels needed for change.

There is limited information available regarding soil management issues as they relate to climate change. Land capability will need to be better matched to soil type and capability so that appropriate land use under changing climatic conditions can be identified.

It is possible that there is a knowledge barrier, e.g. on alternative enterprises and the development of vertically integrated systems. This contrasts with the situation in New Zealand where farmers have gone from primarily sheep farming to not just growing grapes but producing high quality table wines within a few years.

There was a general consensus that the message of adaptation was reaching the farm level, and that in fact adaptation had already occurred. Reports from Cornwall, Devon and Somerset were that drilling times have already changed in many areas, but that there may not be a recognised link between changing practices and climate change.

While some knowledge is reaching the layman, there is a feeling that while academics are studying the weather and global warming, the debate still continues and there are no certainties on which to act conclusively.

There is an understanding within the industry generally that continual monitoring of the situation as it pertains to agriculture will be necessary for action to be proactive rather than reactive, although it was felt that this message was not coming down clearly from any trade organisation.

"Much depends on public and private sector clients' attitudes towards short-term changes in the nature of their ornamental (and edible) plant stocks and cultivation practices. Unenlightened attitudes are all too commonplace."

Garden Design & Maintenance company, Devon

While some reported that there was ample knowledge available, it was widely stated that there was a dependence on IT related access to information, which limited those who were likely to make use of it. Information needs to be made more accessible to the non-IT community.

There is a degree of "not wanting to know" the information that may be available, but where people are interested, the material is not relevant or focussed enough to be useful to them.

Recommendations for action

It was suggested that site visits to European locations experiencing comparable climates to those expected for the South West would be extremely useful to help the industry to adapt if the probability was suitably high to warrant the time and expense. Such visits would need external funding.

For the knowledge to reach throughout the industry there needs to be a continual "drip feed" of information through the trade journals and farming media. This is not yet happening in the South West.

More emphasis is needed to encourage the uptake of renewable energy options such as bio-fuel production, and the anaerobic digestion of slurry.

Relevant localised information is essential for the industry to move forward. This must be combined with top-level support in the form of both Policy and Funding.

An authoritative, localised study identifying key issues and recommendations is required, supported by appropriate Government intervention.

Challenges and Opportunities of Key Climate Impacts on Agriculture Domain

Climate Impacts		Challenges + Opportunities
Increased Summer Temperature	C	Reduced heating costs for glasshouse crops.
	C	Reduced Oxygen levels in fish lagoons.
	C	Increased risk of machinery operator accidents due to heat stress.
	C	Conditions for supply staff and glasshouse/ poly-tunnel workers may become unfavourable and may require new working practices.
	O	Increased costs associated with glasshouse horticulture and associated industries as cooling methods increasingly needed.
	O	Potential to farm more "exotic" fish species.
	O	Potential for innovative crops and products for changing markets.
Reduced Summer Rainfall	C	Potential inability of water system to cope with increased demands under reduced supply conditions without stringent conservation measures and improved storage, as well as changed on-farm practices/cropping regimes.
	C	Variability in water supply may increase stress to susceptible horticultural and arable crops.
	C	Potential for increased risk of fires on heathland and moorland grazing areas
	C	Also, potential for reduced forage for summer grazing, especially on soils of low soil available water capacity.
	O	Opportunities to increase use of new drought tolerant varieties.
Increased Winter Temperature	C	Reduced over-winter die-off of pests and diseases, encouragement for the spread of fungal diseases.
	O	Early growth will necessitate an earlier start to lawn management etc. providing increased business opportunities to management companies.
	C O	Later animal housing and reduced feed inputs represent a benefit to farmers but a loss to their suppliers.
	O	Soil temperatures in spring rise more rapidly resulting in earlier season growth of crops and forages.
Increased Winter Rainfall	C	Extra man-hours involved in remedial work (e.g. to flattened horticultural crops and plastic covers) will increase costs.
	C	Disruption of pesticide and fertilizer applications, due to waterlogged ground, leaching effects etc.
	C	Localised flooding will delay soil cultivation.
	C	Problems with slurry storage likely, especially in sudden rain events.
	C	Sowing regimes may be affected by soil moisture and workability, e.g. spring rather than autumn sowing may become more appropriate.
	C	Soil erosion problems likely to worsen.
Increased Sea Level and Tides	C	Some low-lying areas could be given over to sea defence, salt marsh and inundation.
	C	Some loss of coastal lowland growing areas likely.
Longer Growing Seasons	C	Earlier plant growth may require earlier attention regarding pollination and pest control.
	O	Potentially less need for glasshouses
Reduced Frosts	O	Potential for an increased growing season could mean increased sales for suppliers, e.g. of machinery, silage wrap, pesticides etc. (Although this would mean increased costs for farmers).
	O	Less frost damage should allow increased productivity.
	O	Potential for new crops presently precluded by frost risk.

Climate Impacts		Challenges + Opportunities
Flooding Increased	C	Implementation of River Parrett Catchment project to assist with flood control and water handling, resulting in loss of land.
	C	Distribution of supplies and produce may be affected adversely by localised flood events.
	O	Introduction of short rotation energy crops to assist with flood control.
	C	Increased threats to livestock grazing river floodplains
Potentially Increased Winds and Storms	C	Damage to buildings, polytunnels and glasshouses.
	C	Damage to standing crops and nursery stock.
	O	Potential for increased demand in windbreak plants for domestic and on-farm use. This would require careful selection, development and propagation of suitable species.

BIO-DIVERSITY, HABITAT, CONSERVATION AND LANDSCAPES DOMAIN

Scope

Protection, management and conservation of the natural terrestrial environment (flora, fauna) including habitats, landscapes, trees and community forests.

See also

Tourism and Leisure; Rivers; Forestry; Agriculture; Marine Fisheries; Coastal

Background

The South West region contains two National Parks (Dartmoor, Exmoor) and significant Areas of Outstanding Natural Beauty. It has a remarkable diversity of habitats, and contains a large number of plant, mammal, bird, amphibian and reptile species, including some national rarities (e.g., Cornish Heath, *Erica vagans*), species confined to the South West (such as the Dorset Heath, *Erica ciliaris*), and those mainly distributed in the South West (e.g. Bristle Agrostis, *Agrostis curtisii* [syn. *A. setacea*]; Britain's rarest reptile, the smooth snake *Coronella austriaca*).

The South West region's long peninsula creates a strong oceanic climate. Nevertheless, the climatic contrasts between the north east of the region and the far South West (e.g. Isles of Scilly) are in many cases greater than the climate changes shown for any part of the region between the 1961-90 baseline and the 2050's climate scenarios. This means that at first sight there might seem to be no particular difficulty in species adapting to the climate changes implied by the UKCIP02 scenarios. However, this ignores the effect of habitat fragmentation by the largely agricultural and urban landscape through which native plant and animal species might need to migrate as the climate changes. It also discounts immigration or spread of alien (non-native) species into the peninsula from abroad.

The effect of the warm Atlantic Ocean allows some southern and sub-tropical species to survive in the Isles of Scilly and in the coastal zone of the far South West. These species are likely to be favoured in the warmer climate scenarios. The principal native deciduous tree species that inhabit the area are towards the northern part of their geographical range within Europe, and so might cope with a warming climate without major difficulty. Those species whose distributions are principally to the north of the region and for which the South West is their southern or western outpost might be more severely affected regionally by climate change. This may be compounded by changes in agricultural practice driven by either economic, land-use policy or further climate-change considerations.

Heathland (wet and dry) communities in the South West range from the wet heath/bog complexes of mid-Cornwall, north to the Culm, then eastwards through the *Erica tetralix*, *Ulex gallii*, *E. ciliaris* boundary, across into the *U. minor–E. ciliaris* dry Dorset heaths. This cline is a unique feature of the region: is it feasible to conserve it long-term?

Source unknown

Key Issues

- In a warmer overall climate, species at the southern edge of their biogeographical range are probably most at risk of loss from the region.
- Warmer winters will adversely affect those species suited to a harsher winter climate.
- Reserves set aside for particular groups of species are fixed in space, but the species currently found there may not thrive under new climatic conditions, resulting in overall species loss and local extinction.
- Some regional Species Recovery programmes may be put at risk if the more extreme climate scenarios become reality.
- Biodiversity is strongly influenced by land use, and so policy responses should be developed in terms of integrated land-use management (including integrated marine and coastal zone management: see other domains).
- Agricultural changes resulting from adaptation response to anticipated climate change could have a profound effect (positive or negative) on biodiversity.
- The sector is well informed and believes in climate change scenarios, but is hampered by site-based legislation relating to a fixed interest at each site, and is guided by a National Vegetation Classification (the NVC, which lists groups of species that share similar ecological requirements), which is based on data from the 1970's and might not include potential species assemblages in a changed climate.
- The sector should apply similar criteria to coastal areas of nature conservation importance in respect of protection against sea level rise, as it calls upon others to apply to areas for development or agriculture (viz. avoid calls for unsustainable coastal protection)

Better use could be made of palaeoecological data to inform statutory agencies as to the changing species assemblages that have occurred in the region during the Holocene, and that might provide analogues for times of warmer climate.

Species loss

Of prime concern is that some species with northern distributions may be lost from the South West in a warmer climate. For example the MONARCH study simulates loss of the large heath butterfly from southern Britain (including the South West) in the UKCIP98 scenario for the 2050's (Berry *et al.*, 2001). It also implied potential loss of other species from southern Britain in a warmer climate. But the maps of simulated distributions for 1961-90 may give a false impression, and it must be remembered that the MONARCH study, while useful, was not based on the current UKCIP02 scenarios.

Several plant species feature in the South West in the simulated maps for 1961-90, while the simulated distribution maps for the 2020s and the 2050s show subsequent losses, but in reality several of these species are already absent from the South West. *Salix herbacea*, *Carex bigelowii*, *Geranium sylvaticum*, *Blysmus rufus* and *Linnaea borealis* were not recorded from the South West in the BSBI Atlas (Perring and Walters, 1976) — in fact the last-named is already absent south of the Yorkshire Dales — thereby exaggerating the "loss" of such species in the simulated distribution maps. The issue of potential loss of species must not be denied, but concern must be based on real present distributions. Interestingly, the MONARCH study showed benefits in the South West for the red squirrel (*Sciurus vulgaris*) — a BAP-priority species — under all scenarios, with expansion in its 2050's distribution across the region: "this [simulated] retreat in the north and concomitant expansion in the south is a most unusual [simulated] response that has not been seen with any other species" (Berry *et al*., 2001, p. 65). It also runs counter to the experience of a decline of the red squirrel's former southern distribution over the past 100 years during a period of overall climate warming (clearly, other factors may have been at work over the past 100 years).

A gradual loss of clubmoss species in the South West has been taking place over the last century (partly owing to habitat change), such that Alpine clubmoss was recorded on Exmoor and Dartmoor before 1930 but not subsequently (Perring and Walters, 1976). Climate change may result in extinction of remaining clubmoss species whose main distribution is more northerly in Britain but that presently have southern outposts on moorland of the South West region, for example *Huperzia selago* and *Lycopodium clavatum*.

Opportunities for range expansion

The warmer climate may provide opportunities for range expansion in the South West for a number of mobile species (especially birds and invertebrates) that presently may be towards the northern outpost of their range. There is already some evidence that this can occur if there is a sequence of warmer summers and/or milder winters, for which the Dartford warbler is a particular example.

In a climate of drier summers, arable cultivation on chalk downland may decline where there is no potential for crop irrigation, and this would provide a significant opportunity to expand the area of calcareous grasslands in the South West.

Source unknown

Climatic effects on landscapes

It is expected that as climate changes, so agriculture itself will change, with potential far-reaching consequences for landscapes. For example, the position of the moorland edge in the South West has varied over centuries according to a combination of economic pressures, agricultural demands (such as during the Napoleonic Wars) and climate change (such as during the Medieval Warm Period). It is the effect on agriculture of climate change that may have the greatest consequences for the character of landscapes in the region.

"… populations on the edge of their range are responsive to limatic changes which may render redundant resources which have been devoted to them. The rapid rise and fall of butterfly populations illustrates this clearly. Our efforts could be better spent on more tractable problems than trying to create the micro-climate of Spain on English grasslands"

(see http://www.eco-action.org/dt/hambler.html)

Risks that have been identified include:

- Nature Reserves established with particular rare species may lose that species if vulnerable to climate change or to consequences of climate change (e.g. fire incidence; drought incidence).
- Possible long-term changes in composition of plant communities and corresponding shift in fauna. Examples include heathland on Exmoor.
- Potential for species extinction as a result either of direct climate change effects, or of severe local weather events, and also failure to migrate between habitats to top-up reduced populations.

Opportunities that have been identified include:

- Reorganization of agriculture can and will provide opportunities for nature conservation objectives to be realized, provided climate change effects are taken into account.
- Local invertebrate rarities (including several southern grasshopper species, and the bee wolf — a solitary wasp and former Red Databook species) and some bird species (e.g. Dartford warbler onto Exmoor) could be favoured by warmer temperatures.
- Dorset heathland could be safeguarded by removing forestry from former heathland and so expanding the heathland habitat to act as buffer against increased fire risk. (Pers. Comm., English Nature).

Effects of climate changes on agriculture may impact also on biodiversity and on the practice of and opportunities for nature conservation, with such concepts as set-aside, stewardship, and successor schemes, etc., as intimated in the Curry Report, likely to have implications for biodiversity and nature conservation. However, there is the danger of possible over-emphasis amongst nature conservation organizations on loss of conspicuous species (e.g. colourful butterflies; conspicuous flowering plants) and under-emphasis on other types of less conspicuous or less-studied organisms whose distribution may be more severely affected either by climate change and/or by agricultural change.

The Way Forward

Mussner and Plachter (2002, p. 3) argue that a major reason nature conservation often fails is that there is no standard methodology. In fact, palaeoecological data (studies of ancient plant remains) suggest that while plant community formation is likely to be influenced by climate it is not determined by it. Consequently it is possible that if too rigid a protocol is used when dealing with community responses to climate change, effective conservation will not occur.

Watts (2001) investigated planning for biodiversity in the wider countryside and identified a number of competing issues. He argues that the traditional approach to nature conservation in England has been to protect a series of small, isolated sites, but that recent research has demonstrated this to be inadequate, suggesting a need to direct energies more towards conservation in the surrounding wider countryside. He points out that there are considerable difficulties associated with achieving biodiversity objectives in the wider countryside, as there is a heavy reliance on non-statutory planning mechanisms. His work contained case studies on particular habitats in the South West, including the Culm grassland in Devon, but the general principles have wider application in the South West region.

Perception of Adaptation Issues

Although climate change is widely perceived as an issue within the sector, the adaptation responses are less clearly developed at present, especially as nature reserves are fixed in space but mobile organisms are not. The MONARCH study suggested that climate change should be incorporated within Biodiversity Action Plans (BAPs). This may be an appropriate mechanism, but other opportunities, identified by Watts (2001) through case studies from the South West, might also be taken.

Examples of Good Practice:

- **Managed retreat of parts of southern coast, and of 'unmanaged' or 'natural' retreat at Porlock. (Recognising that sea-level rise will happen, and it is not always sustainable to defend the coast).**
- **The only mainland site of the ladybird spider (previously thought extinct in Britain but re-discovered in Dorset in 1980) has been extended, and studies conducted in terms of suitability of introduction to nearby sites based on continental parallels.**

One of the outcomes of the Wales UKCIP Climate Change Scoping Study was identification of the need to create corridors between habitats so as to ensure dispersal of organisms as the climate changes. Although there has been debate over the effectiveness of corridors in the dispersal of some wildlife, and whilst claims of the relevance of island biogeography to nature reserve design have been questioned (Hambler and Speight, 1995), this is not the general perception within the statutory and voluntary conservation agencies of the South West. Practitioners here believe both in applications of island biogeographical theory to nature conservation and of the desire for corridors between habitats. Indeed within the region, there is persuasive evidence that corridors such as rail routes have permitted the dispersal of alien species such as the Oxford ragwort (*Senecio squalidus*) and the butterfly bush (*Buddleja davidii*) throughout the rail-served parts of the South West, such that these species are now widespread and well established (Tikka *et al*., 2001).

The particular physical characteristics of the region suggest that creation of corridors between reserves may be an appropriate adaptive response to concerns over the biogeographical effects of climate change, although this would still result in (and could

indeed, facilitate) loss of northward migrating species from the region and the possible spread of alien 'nuisance' species.

Knowledge and Information Base

Parts of the sector are very well informed on climate change issues and many practitioners and supporters find the climate change scenarios credible. The Woodland Trust has sought to involve the public in monitoring of key phenological indicators (see www.phenology.org.uk). However, Wildlife Trusts are concerned that a significant proportion of potential supporters are sceptical of the role of human influence in climate change, and are not sufficiently persuaded by present campaigning literature that focuses on the topic. This may affect the capability of wildlife trusts to generate sufficient budget to deal with climate change issues.

Research Needs

There is a need for further research on effects of climate change on species and habitats in the region. Although part of this work will involve contemporary monitoring, and may also involve computer modelling, it is suggested that research should also incorporate analysis of long-term biological records (where available) and of other palaeoecological data. Dartmoor, Exmoor and the Somerset Levels in particular have long palaeoecological records, and other locations within the region have sediments amenable to comparable detailed study.

Recommendations for action

For those parts of the region (e.g. Exmoor) where long-term (>1000 years) continuous palaeoecological records can be generated, there could be an investigation into landscape changes and species responses to previous episodes of climate change (e.g. before and during the Early Medieval Warm Period), to act as an approximation for vegetation response to anticipated climate changes. While useful, it is recognised that the use of such data would need to be combined with other methods of study.

The MONARCH study suggested that a more forward-looking, flexible and dynamic approach to nature conservation is required to accommodate climate change, involving habitat management and landscape-scale responses.

Challenges and Opportunities of Key Climate Impacts on Biodiversity Domain

Climate Impacts		Challenges + Opportunities
Summer Temperature Increased	C	Increased incidence of fire, especially to Dartmoor, Exmoor and to Dorset heath and other heath areas.
	C	Increased risk to species that suffer in times of drought.
	C	Risk of expansion of naturalized aliens, such as *Fuschia* in Cornwall.
	C	Possibility that species at southerly limit of their range may be competitively excluded.
	O	Species ranges likely to be affected, with increased numbers of those presently at the northern limit of their range.
	O	Rare *Lepidoptera* at northern limits of ranges may be favoured.
	O	South West has *c*. 50% of UK resource of calcareous grasslands; these areas could be expanded if arable agriculture declines on chalk downland.
Summer Rainfall Reduced	C	Drying up of streams — both over hard-rock geology and groundwater fed, such as chalkland streams — and consequent loss of species. Possible threat to water vole in Wiltshire chalkland streams.
	C	Reptiles (e.g. smooth snake) and birds, e.g. nightjar, Dartford warbler, woodlark potentially adversely affected in Dorset heathland (SPA) by increased incidence of deliberate/accidental fires in dry summers.
	C	Wet heaths may suffer, as may blanket bogs and other wetlands.
	O	Change in agricultural practice may provide opportunities for achieving biodiversity targets, especially if more land is set aside from agriculture.
	O	Removal of commercial forestry from heathland areas would create larger areas of heath and might act as a buffer against forest fire incidence.
Winter Temperature Increased	C	Species with their southern breeding limit in South West may become excluded (e.g. red grouse believed recently extinct on Exmoor, and not suitable for reintroduction under anticipated climate scenarios; golden plover now transitory and no longer breeding in South West).
	C	Plant species that need sustained cold period of winter dormancy may be adversely affected.
	O	Some species may be favoured by milder winters (e.g. Dartford warbler)
	O	Need for monitoring of species changes could lead to increased job opportunities.
Wintertime Rainfall Increased	C	Changing distribution of seasonal precipitation may affect agricultural crop regimes (Spring-, not Autumn-sown), and so affect wildlife in winter.
	O	Delivery of Biodiversity Action Plans through changes in agricultural regime; may also provide opportunities for reappraising biodiversity targets.
Sea Levels and Tides Increased	C	Potential loss of coastal and estuarine habitats and increased erosion of cliffs with loss of characteristic species.
	O	Opportunity for integrated land management in the South West estuaries and in Somerset Levels (and inland) to manage effects of increased winter precipitation and of high tides; managed retreat may include encouragement of saltmarsh creek systems to absorb tidal energy.
Longer Growing Season and Reduced Frosts	C	Species that require sub-zero period to break seed dormancy or encourage growth could be adversely affected. (Crowberry, *Empetrum nirgum*, requires cold winters for successful growth).
	O	Opportunities for species with pronounced southern distributions to become more widespread (but possibly at expense of other species).

Climate Impacts		Challenges + Opportunities
Flooding Increased	C	Flood risk to river bank-dwelling species.
	O	Integrated land management to regulate flooding would have a positive impact on biodiversity.
Potentially Increased Winds and Storms	C	Potential threat to Chesil Beach and its saline lagoon (danger of breach and consequent loss of international SPA/RAMSAR site; also a candidate Special Area of Conservation)
	C	Windthrow of forest and other trees.
	O	Field-layer species favoured in areas of wind-thrown forest. Opportunities for butterflies in resulting forest mosaic.
	O	Opportunity for sustainable management on coast of Somerset Levels, which would encourage biodiversity.

COASTAL DOMAIN

Scope

Key activities occurring within 1km of the land/sea interface including issues of coastal erosion, management and defence.

See Also

Tourism and Leisure, Rivers, Fisheries, Bio-diversity and Transport.

Background

The coastal zone of the South West region is fundamental to its economy and its inhabitants' quality of life. Of all the UK's regions, it is the South West that is the most influenced by the sea. The importance of the coastline to the region's economy is emphasized by the publication of "South West Coast: A Prospectus for the Future" produced by the South West Coastal Issues Group in 2002 with the support of several key regional stakeholders.

The South West of England's 1,020 km of coast extends from the Bristol Channel to Land's End and along the English Channel coast to Christchurch, and includes the Isles of Scilly and the Isle of Lundy. Parts of the region therefore have a truly maritime nature with the longest seaboard and the highest ratio of coastline to land area of any region in the UK.

Many of the principal urban areas of the region, which include Bristol, Plymouth, Exeter, Torbay and Bournemouth/Poole, are situated on or very near to the coast. Bristol/Severnside is one of the UK's largest commercial ports; Plymouth is the UK's largest naval base; and Bournemouth's tourist trade is second only to London in terms of hotel accommodation.

The national and international significance of the region's coast is shown by its range and number of environmental designations:

- A UNESCO World Biosphere site (Braunton Burrows in North Devon), the only natural UNESCO World Heritage Site in mainland UK (the Dorset and East Devon Coast), and a potential further World Heritage Site near the Cornish coast (the historical tin and copper mining area surrounding Redruth/Camborne).
- The UK's highest number of coastal and marine Special Areas of Conservation (49) and Special Protection Areas (59) which form part of Europe's Natura 2000 network.
- England's only Marine Nature Reserve (the Island of Lundy) and all but two of the UK's Voluntary Marine Nature Reserves.
- One third of its area (and a high proportion of the coast) designated as Areas of Outstanding Natural Beauty (AONBs), one of the nation's National Parks (Exmoor) bordering the Bristol Channel coast, and 60% of the country's Heritage Coast.

In addition, the South West has:

- Nearly half (187) of the UK's top beaches (as listed in the Marine Conservation Society's Good Beach Guide) whose quality consistently exceed the national average.
- Over 400 kilometres of the coast owned by the National Trust, including 40% of the total length of the Cornish seaboard.
- The South West Coast Path which is the longest National Trail in the UK, and a huge range of coastal leisure and watersports activities available.

Key issues

- Rising sea levels and potential increased storminess will increase rates of coastal erosion. Protecting coastal assets (or relocating them) may be costly if the effects of climate change are sudden rather than gradual.
- Increased wave heights and potential storminess may lead to damage to coastal amenities including piers, promenades, beach cafes etc. Flooding caused by storm surges and sea level rise may damage coastal rail lines and roads. The unpredictable coastal dynamics may lead to erosion of some beaches. These problems are likely to be particularly acute in the region due to the fact that the landmass is subsiding.
- Natural assets in the coastal zone may be lost, such as wetlands, mudflats, saltmarshes, beaches and sand dunes. The flora and fauna associated with these will also be affected.
- Existing areas of saline intrusion may become more extensive, though more as an indirect result of changing water balance than as a direct consequence of sea level rise, except on the most low lying coasts.
- Retreating from coastal areas may not be viable in many areas of the SW such as the Isles of Scilly and protecting the area at risk may be uneconomical in many places. The resulting costs of maintaining and building new coastal defenses are likely to be significant.

Specific Climate Issues for the SW

Of major significance to the South West are the potential impacts of climate change on its functions, all of which depend upon its physical characteristics, appealing landscape, cultural heritage, natural resources, and rich marine and terrestrial biodiversity. Climate changes such as rising sea levels, increased wind speeds and storms and resultant storm surges will significantly effect the coastal zone. In addition, changes in seasonal temperatures and rainfall patterns will also have less direct but equally important impacts.

Risks that have been identified:

Rising sea levels and possible increased storminess are likely to increase rates of coastal erosion. Natural assets in the coastal zone may be lost and areas of saline intrusion will increase, particularly in low lying coastal areas. Many beaches too may be 'squeezed' by rising sea levels, which could threaten their viability – particularly those which are only exposed at low tide. Managers of areas vulnerable to sea level rise will face stark choices on how to manage those sites in future.

Opportunities that have been identified:

Increases in tourism may bring a boost to the economy in the coastal zone. There may be increased opportunities for developing outdoor recreation and watersports. There may be further opportunities for offshore wind power development. In addition, there maybe opportunities for new crops and a longer growing season may lead to improvements in agriculture in some coastal areas.

Specific locations vulnerable to climate change include:

- Somerset Levels – The use of LIDAR is needed to determine absolute level and thus flooding risk
- Steep-sided Cornish Valleys – e.g. Polperro and Pentewan. River and flood defence is needed to improve defence against flash floods.
- Isles of Scilly – The islands are particularly vulnerable to sea level rise and storm damage leading to impacts on whole community and its economy.
- Natural coastal assets – e.g. Loe Pool, the largest freshwater lake in Cornwall may be flooded by saltwater.
- Dorset coast – coastal erosion of cliffs is damaging infrastructure and creating dangerous landslides onto beaches.
- Quays and harbours – e.g. Devoran Quay and Mullion harbour on the Lizard peninsula. Rising sea levels and increased storminess could threaten quays and harbours.
- Estuaries – e.g. Helford, Camel, Gannel catchment. Estuaries may be silted up due to changes in water flow. Businesses may be effected by decrease in boat traffic due to storm events.
- Beaches – Beaches in the region may be eroded and surf breaks may be altered by shifts in sediment e.g. Fistral Beach. Opportunities may be available due to increased tourism.

The Way Forward

- There is a continuing need to incorporate accurate measurements of land level subsidence into sea level rise calculations.
- With increased risks of storms, tidal surges and flooding frequency, there is concern about rising costs of insurance and compensation. This has the potential to impact on development within the coastal zone, and so is likely to engender concern and thus both change and research.
- Inland flooding can exacerbate coastal flooding, especially where there is a high spring tide or surges.
- There is a need to establish ownership of coastal defences and the land they are on in some circumstances.
- There is a need to further establish the value of land/environment in relation to the cost of defending it.
- There is a need to establish a system of publicly accepted justification for which areas of land should be sacrificed and which defended.
- There is a growth in Integrated Coastal Zone Management (SMPs, LEAPs etc), but such plans are not statutory and could be more effective if they were.
- Need for an integrated governance for decision making. Integrated Coastal Zone Management (ICZM). SMP's, LEAPS's e.g. Porlock beach/marsh.

Knowledge and information base

The value of the coastal zone to the South West's inhabitants, and the enormous pressure on it, provide strong incentives for a greater scientific understanding which can ensure efficient and sustainable management. Research undertaken within the coastal zone to assess the impact of climate change is vital. However, it is essential that links are made between the physical impacts of climate change and the effects these have on the local economy. For example damage to the coastal

railway at Dawlish (the only Rail link into the SW from the North and East) would have considerable impacts on the economy of the region. In addition coastal managers need to take into account future changes in sea levels and increases in storminess when planning coastal defence. Some areas may have to be sacrificed to rising sea levels and this will provide some difficult choices for the future.

Recommendations

- Utilise opportunities for artificial reefs for surfing and diving as well as for recreational fisheries for exotic southern species (e.g. tuna) brought about by climate change.
- Invest in research into offshore renewable energy sources - wind, wave energy and reassess the environmental and economic effects of the Severn Barrage.
- Carry out more accurate measurements of land level subsidence to improve the models for rise in sea level.
- Encourage further research into the erosion of coasts and beaches; a careful balance will be needed between protecting certain assets and retreating from others where costs of sustaining coastal defences or replenishing beaches becomes uneconomic.
- Rationalise the current split in responsibilities for flood and coastal defence and work towards more integrated management.
- Monitoring of coastal erosion and research into coastal defence needed as well as research into the movement of sand and shingle to ensure the maintenance of beaches.
- Assess the risk of remobilisation of toxic substances (e.g. heavy metals) in riverine/estuarine sediments.

Challenges and Opportunities of Key Climate Impacts of Coastal Domain

Climate Impacts		Challenges + Opportunities
Summer Temperature Increased	C	Increased tourism (if brought about by this aspect of climate change) may lead to environmental damage within the coastal zone (e.g. litter and surface erosion to coastal footpaths, damage to flora and fauna, etc).
	O	Increased tourism in the coastal zone and islands may lead to a boost in the economy and an increase in watersports, environmental tourism and outdoor activities.
Winter Temperature Increased	C	Negative impact on flower farmers on Isles of Scilly as their competitive advantage due to early flowering is lost to other areas.
	O	Potentially more tourism on short winter breaks.
Summer Rainfall Reduced	C	Water supply problems particularly on Isles of Scilly.
	C	Negative effects on flora and fauna in coastal zone due to droughts and possible increased erosion of coastal paths.
	O	Increased tourism as above.
Winter Rainfall Increased	C	Flooding in coastal zone areas leading to damage to natural assets and infrastructure e.g. subsidence leading to disruption to transport services.
	C	Increased run-off and leaching from agricultural land potentially damaging to flora and fauna in coastal zones of land and sea.
	C	Remobilisation of metalliferous mine wastes affecting bathing water quality and inshore fisheries
Sea Level and Tides Increased	C	Erosion of cliffs and beaches damaging natural assets as well as infrastructure and archaeological heritage.
	C	Loss of beaches and coastal footpaths in the South West could damage local economy. Cliff side hotels are also particularly vulnerable.
	C	Damage to coastal defences including extensive protection to farmland.
	C	Damage to quays and harbours
	C	Flooding of Somerset levels and Isles of Scilly damaging infrastructure and natural assets.
	C	Increased water in harbours and estuaries may lead to increased sediment and need for dredging.
	C	Damage to transport routes due to coastal erosion (e.g. at Slapton Ley)
	C/O	Changes in tides, sediment and sea levels may affect surfing breaks, creating new ones or making existing ones less practical or worthwhile to use.
	O	Erosion of cliffs may expose previously unseen archaeological remains.
	O	Creation of new habitats by inundation of sea water.
Larger Growing Seasons + Reduced Frosts	C	Negative impacts on agriculture in coastal zone e.g. damage to horticulture
Flooding Increased	C	Increased risk of flooding to coastal towns e.g. Pentewan, Helston. Salt water flooding of natural assets (e.g. Loe Pool). Loss of saline lagoon habitats and associated flora/fauna due to saltwater inundation.
Potentially Increased Winds and Storms	C	Storm surges leading to flooding of coastal areas may damage harbours, quays, marine businesses and natural assets. Publicity of areas damaged by storms can lead to a negative image and detrimental effects on tourism.
	C	Many coastal hotels and businesses get a lot of trade from boats (e.g. Helford estuary) which severely declines during storms and strong winds.

Climate Impacts		Challenges + Opportunities
Potentially Increased Winds and Storms	C	Small businesses which are numerous in the coastal zone could be badly effected as they will not include extreme events in business planning
	C	Damage to infrastructure in coastal areas e.g. homes, cafes, shops, hotels, road (e.g. Slapton Ley) and rail networks (e.g. Dawlish).
	C	Increased erosion of natural assets e.g. beaches and cliffs.
	C	Storm events on the Isles of Scilly damage the whole economy.
	O	Potential to develop “storm-watching” tourist trade.
	O	Increased wind speeds can be beneficial for wind farms and may lead to further opportunities for development of on and offshore wind farms.

FORESTRY DOMAIN

Scope

The forestry sector including areas of managed woodland both for timber production and for amenity forest.

See also

Agriculture; Biodiversity

Background

Forestry within the region varies from Forestry Commission plantations of softwoods (e.g. Sitka Spruce – *Picea sitchensis*) to areas of managed broadleaved (hardwood) trees, principally of native species, such as oak (both *Quercus robur* and *Q. petraea*) but also of species possibly introduced to parts of the region (such as beech, the extent of whose natural, native distribution in the South West is disputed). Forestry occupies upland areas (as discrete 'blocks', such as in parts of Dartmoor, Exmoor and the Mendips), lowland, and includes some large areas of variable topography (such as the Forest of Dean).

Depending upon the criteria chosen (e.g., whether commercial forest products are produced), forestry might not easily be separable from areas of amenity woodland, or woodland reserves. Within the South West, for example, are areas of (largely, broadleaved) woodland owned or managed by the National Trust and especially by the Woodland Trust, which has a greater density of its sites in this than in any other UK region. For the purposes of this review, the focus has been on the commercial forest sector, but the scope includes also amenity forest.

Forestry is an economic activity that operates over relatively long timescales (in relation to other economic activities). It can take several decades or even hundreds of years for a tree to reach maturity, but the timber (or other) harvest is usually taken before full maturity and certainly before senescence. Return periods of 20 to 50 years for weather events therefore routinely have to be factored into site assessments (e.g. through calculating exposure values; assessing drought susceptibility, flood risk), and plantations must be capable of withstanding severe storm events.

Broadleaved trees are more susceptible to damage from major storms if these occur when the trees are in full leaf. For evergreen conifers (i.e., all plantation conifers in Britain, with the exception of larch), windthrow can be a major problem, and so any increase in the incidence of very severe storms may be problematic.

However, forestry is used to experiences with extreme weather events (for softwood crops grown for minimum of 20- to 40-years in marginal environments) and is used to assessing risks, and so is one of the sectors potentially well informed on the possible effects of climate change. Up until recently, however, the issue was not perceived as a major problem. Other issues have been higher up the forestry agenda, but within the next five years it is anticipated that the regional conservancies will be responding to the climate change agenda, prompted by work done by Forest Research.

Key Issues

- Until recently the sector has been slow to appreciate the gravity of the issue of climate change and respond accordingly.
- Forestry practice is set in the context of (inter-)national Forestry and Woodlands Strategy, in compliance with the Helsinki Accord, but this has no explicit reference to climate change.
- Likely to be a major shift in perception and in adaptation response within the next five years.
- A key driver for change may be the recent publication *Climate Change: Impacts on UK Forests* (Broadmeadow, 2002).
- Established forests are reasonably robust, and resilient to climate change.
- Establishment of new plantations of trees could be affected by soil moisture deficits.
- There is possible greater susceptibility to damage by green spruce aphid under all the climate scenarios suggested.
- There may possibly be greater susceptibility to *Phytopthera*.
- There are possible problems of imported diseases in a new climate regime.
- A major barrier to perception is conflicting reports in some of the broadcast media, which leads practitioners to believe there is no consensus on the direction and magnitude of climate change.
- Floodplain forestry may be a suitable adaptation response for continually flooded agricultural land. However, conifers could cause acidification of water bodies which would have negative water quality impacts.
- A possible barrier to adaptation response is in defining what constitutes a 'native' broadleaved species in a warmer climate scenario.

Potential risks

Awareness of climate change in this sector is slightly higher than in the late 1990s, and is probably higher than in many other sectors investigated in this study. Nevertheless, across the forestry sector as a whole, climate change is not yet taken seriously. (Pers. Comm. Anon.)

Although established forest trees are resilient to climate change (Broadmeadow, 2002), establishment of new forestry (or new planting within felled forest) is more susceptible. Under the more extreme temperature scenarios from UKCIP02, some native species may be put beyond their natural range in the UK. This may include beech in the southeast of England, although within the South West its native status is in dispute and the temperature effect may be less marked. So far as other native species are concerned, these are towards the north or north-west of their European geographical range (e.g. oak) and so are not threatened immediately in the climate change scenarios.

A major barrier to a shared perception of concern is the conflicting reports in some of the broadcast media, which leads practitioners to believe there is no consensus on the direction and magnitude of climate change. It is hoped that the recent Forestry Research publication (by Broadmeadow, 2002) will help to counter this, along with the release of the UKCIP02 data.

The major barrier to change in practice is the 40-50 year lead-time. Of the challenges presented above, wind damage is seen as a potential problem in amenity forests if severe storm incidence were to increase.

Positive Benefits

A potentially positive response from the climate change scenarios is an increased rate of forest growth. However, the causes of increased growth rate are difficult to disentangle, and may be due more to silvicultural practice rather than climate change, but a CO_2 fertilization effect is also possible. Unfortunately, faster growing trees may in some circumstances prove more susceptible to windthrow (damage to forests caused by strong winds involving roots being pulled from the ground and the whole tree being toppled).

"[Grey] squirrels are more of a threat to lowland forests [in the South West] than climate change ever will be."

District Forester

The Way Forward

The effect of climate change on forestry is summed up very well in a new publication entitled Climate Change: Impacts on UK forests, edited by Mark Broadmeadow. Forestry Commission Bulletin 125, Edinburgh. This has been published this year (2002) in association with the Institute of Chartered Foresters.

There is clearly a need to take predicted climate change into account in making long-term decisions about species choice and management systems. Advice before planting is available from the Forestry Commission, but local site assessors are best placed to evaluate individual sites. Overall, the pace of climate change can be accommodated satisfactorily with most species currently planted in the South West (except beech). Conifers have a 50-year rotation time, so no problem is envisaged for these, especially Douglas Fir (e.g. in Forest of Dean), although Sitka Spruce is slightly more of a concern.

There is a possibility that beech will not be living in a suitable climate when mature in 80-100 years (although it should still have climate space in the South West; see Broadmeadow, 2002). The precautionary principle suggests a policy that includes diversification of species and age structure, so as to spread risks. There is great potential for floodplain forestry in low-lying flat areas of the South West (eg in parts of Somerset), and there may be potential for urban forestry in the major conurbations, although space (and land prices) may be at a premium. On floodplains it is possible to plant willows as a robust land use, resistant to flooding; whilst in the upper parts of a catchment, forestry can be used to intercept precipitation, increase evapo-transpiration and reduce run-off, although this may have the effect of reducing river flows and availability of water resources for other purposes. Forestry can therefore be seen as a major tool for use as part of integrated land management schemes (see for example the River Parrett catchment).

In international discussions that have followed the Kyoto Protocol, carbon offset, by planting trees, is seen by some as a major mitigation policy. Some see the planting of forests as a method of sequestration of CO_2, but in reality this is neither a long-term mitigation solution, nor a long-term adaptation response, as CO_2 is only locked up for as long as the resulting wood is unburnt or undecayed.

Research Needs

Although climate change modeling in the UK is well funded, the implications of climate change for forestry and woodland ecosystems in the South West are largely unresearched. The impacts on woodland species and ecosystems in particular are uncertain, and remain to be researched in detail.

Recommendations

- Educate practitioners in the forestry sector, by reference to Broadmeadow (2002).
- Research the implications of climate change for forestry and woodland ecosystems in the South West.
- Research the impacts on woodland species and ecosystems in particular.

Challenges and Opportunities of Key Climate Impacts in Forestry Domain

Climate Impacts		Challenges + Opportunities
Summer Temperature Increased	C	Possible increase of fire incidence, or more intense fires, in coniferous plantations.
	C	More visitors to forests, so potentially greater fire setting and fire risk.
	C	Increased risk of pathogen attack.
	C	Extension of range of insect vectors of pathogens.
	O	Some insect pests may themselves suffer.
	O	Growth rate high on floodplains.
	O	Greater volume production.
Winter Temperature Increased	C	*Hylobius* and *Hylastes* beetle numbers may increase (affect new trees at ground level).
	C	Green Spruce Aphid may overwinter in greater numbers.
	C	Greater Grey Squirrel numbers and consequent damage.
	O	Less damage from winter cold.
Summer Rainfall Decreased	C	Decreased growth rate in areas susceptible to summer droughts.
	C	Drought crack damage to conifers.
	C	Soil moisture deficits leading to plant stress and abnormal root growth.
	O	Opportunity to introduce more drought-tolerant species
		NB Increased CO_2 levels will increase growth while causing stomatal closure and thus reducing water loss.
Winter Rainfall Increased	O	Decreased soil quality from increased wintertime precipitation
Sea Levels and Tides Increased	C	Only a problem where forests are planted in coastal locations; not significant in South West, except in instances of new floodplain forestry.
	O	Floodplain forestry (willows) could be an adaptation response for agricultural land that is continually flooded and so becomes uneconomic to farm.
Longer Growing Season and Reduced Frosts	C	Risk of unexpected Autumn frosts becoming more damaging as a result of later hardening and predicted diurnal temperature ranges in the south, due to plant conditioning to the "new" normal conditions. This is also a consequence of increased CO_2 levels.
	C	Norway Spruce may cease to be a productive species (not a feature of timber production in South West; grown for Christmas trees).
	O	Increased growth rate (also as a consequence of increased $C0_2$.)
Flooding Increased	C	Root damage. Makes trees then more susceptible to summer drought.
	C	Alternating flooding and drought places stress on trees, possible making them more susceptible to *Phytopthera* infections
	O	Flood plain forestry could be an adaptation response for agricultural land that is continually flooded and so becomes uneconomic.
Winds and Storms Potentially Increased	C	Need to minimise risks, as gusts of more than 40 m per sec result in widespread damage. Amenity forests susceptible.
	O	Potential impact not thought to be that great in commercial forests, as forestry is already conducted in a windy climate. Continuation of best practice thought to be sufficient.

MARINE FISHERIES DOMAIN

Scope

Coastal commercial fisheries and associated activities. Some consideration of inland fisheries included for completeness of cover.

See Also

Rivers, Tourism and Leisure, and Coastal.

Background

The South West region's coastal waters mark a boundary between warm southern and cool northern areas. This creates an abundance of different species in one of the richest marine and coastal habitats in the world. Therefore, marine fisheries are particularly vulnerable to climate change and may face significant challenges to this important part of the local economy.

Although the fishing industry is in relative economic decline, 42% of England's fishing operations are in the South West. The main fishing ports are Newlyn, Brixham and Plymouth. In 1997 the region's ports landed fish from UK vessels to the value of £62.8 million and accounted for more than half by quantity and value of all fish landings in England (with Newlyn in the lead). Fishing dominates the identity of many of the small coastal settlements, playing a vital role in the region's history and image. For every person employed in fishing there are another 3.5 jobs in distribution and processing.

The South West has a mixed fishing fleet with no one species dominating landings. In general they are low volume high value species which are popular outside the UK, for example; species such as megrim, hake, sole and monk. The region also has the highest concentration of landings of pelagic species such as mackerel, pilchards and sprats.

Shellfish landings are also substantial, of which crabs and lobsters are important. Half of all shellfish waters in England and Wales are in the South West (9 out of 18). The EC Shellfish Waters Directive controls their quality and in 1998 the South West had 100% compliance. In the last survey in 1995 all but one estuary in the region was classified as good, a high level of quality only equaled by the Southern Region.

South Devon is one of the major centres for crab, in particular Brown Crab, in the UK. 100% of the crab caught goes for live export, except during September, October and November when around a third is sent to be processed in factories around the region. The crab must be transported live which restricts the market, as they must be relatively close to home if the crab is to survive the journey.

Approximately 90% of the fish landed in the region are exported to other parts of the country and direct to the continent. The market in the South West is mainly for fresh fish, very little frozen fish, and limited value-added industry.

Fish from Newlyn are transported by lorry to other parts of the UK, or in most cases are taken via Plymouth or Poole to the continent. Brittany Ferries are reluctant to take fish lorries from Plymouth especially during the summer months (as the smell would not be pleasant for passengers), therefore it means a long journey by road from Newlyn to Poole. The South West is highly dependent on its road and ferry links but these are presently inadequate for the rapid transportation of a perishable product, which is vitally important to the region's economy.

Key issues

- Rising global temperatures are likely to reduce the overall productivity of the oceans, affecting species across the entire marine food chain, from plankton, to many fish species and seabirds. Such changes would exacerbate current pressures on fish stocks, and would have serious consequences for fisheries in the region, which are important to the local economy.
- There is recent evidence to demonstrate that fish species are changing in local waters. Fish are unable to control their body heat internally, but do so by swimming to waters that suit their temperature optimum. Fish are particularly sensitive to small changes in temperature, causing changes in distribution at the extremities of their ranges.

"Recently spotted off the South West coast are the Knobbed Triton (the largest marine snail), Sea Slug, Long Snouted Sea-horse, Trigger Fish, Garfish and the Sunfish.
New records of fish caught in the last 10 years include Pandora, Couche's Sea Bream, Spanish Mackerel, Long-fin Tunny, Basking Shark, Hammerhead shark and Thresher Shark. None of these species is commercial."

Tony Stebbing
University of Plymouth

- New research shows increasing numbers of new southern fish species appearing in Cornish waters over the period 1960-2001 (Stebbing *et. al*. J. Mar. Biol. Ass.UK 2002)
- With the warming of the North Atlantic, there will be significant losses of indigenous South West species to the north (e.g. sea trout or cod may be lost altogether from these waters.)
- Research has shown that recruitment is inversely related to temperature for a number of cod populations, particularly those at the southern extremity of their range. (e.g. CEFAS has shown significant losses of fertility in cod as the southern North Sea has warmed.)

Specific Climate Issues

Significant impacts can be expected on fisheries. Rising global temperatures are likely to reduce the overall productivity of the oceans, affecting species across the entire marine food chain. Such changes would exacerbate current pressures on fish stocks, and would have serious negative consequences for fisheries in the South West, which are important to the local economy.

Areas particularly vulnerable are those in which a high proportion of the community is involved in the fishing industry. These naturally tend to be coastal areas, and as such are also vulnerable to increases in sea level and potential storm events.

Risks that have been identified include:

- Changes in fish stocks and populations could have significant impacts on local fisheries. Fish production will suffer if wetlands and other habitats that serve as nurseries are lost with sea level rise.
- Stocks of more northerly species such as cod, sprat and plaice may decrease.
- Increasing sea levels and storm events could damage harbours and quays.
- Estuaries may become silted up leading to permanent dredging to ensure access.
- Increasing pollutants from concentrated river flow during droughts and from leaching of agricultural land during high rainfall may lead to poorer inshore water quality.
- The remobilisation of metalliferous mine and industrial wastes due to storms and increased winter rainfall may pollute inshore waters and have potential impacts on fisheries (larvae), and shellfish stocks.
- Climate change impacts are likely to exacerbate existing stresses on fish stocks - notably overfishing and pollution.

There is however, potential for development of recreational fisheries for exotic southern species (tuna, shark) which would allow diversification and boost the tourism industry.

There may be new warmer water species for aquaculture (clams, goose barnacles, seaweeds etc).

Artificial reefs for surfing and diving may be developed, and diving in particular could benefit from the appearance of "rarities" with no commercial value.

Changes in fisheries policy will have dramatic impacts on the local fishing industry, although it cannot be absolutely predicted how these will take effect under changing climatic conditions.

Any strengthening or weakening of the Gulf Stream as a consequence of climate change will affect the degree of warming of waters around the region, although it is noteworthy that the UKCIP02 scenarios do not show any evidence for cooling.

"UKCIP forecasts suggested that with warming, species will shift their distributions pole-ward at rates of 50-80 km per decade. While this is a crude estimate, it proves right for the observed northward advance of 60 km per decade of the Sailfin Dory over the period 1960 to 1995."

Tony Stebbing, University of Plymouth

The Way Forward

- As one fishery disappears due to loss of the species from the region's waters, fishermen are likely to move on to other species.
- A new vision is needed for fisheries management involving stakeholders and government agencies.
- There is increasing need to renegotiate Common Fisheries Policy in light of climate impacts.
- There has been little work to date on the effects of climate change on commercial fish species, but the upcoming regional-led MarClim study will be of great benefit in this area of research.
- A major barrier to be addressed is that according to stakeholders in the region, fishermen are unlikely to plan long term for changes in fish species and will adapt on a 'day-to-day' basis. In other words, the industry is likely to be reactive rather than proactive without significant external inputs.
- While it is likely that fishermen will adapt to changes in fish species around the region's coast, reductions in the overall productivity of the oceans will exacerbate current pressures on fish stocks and thus the industry as a whole.

Recommendations

- Encourage the development of artificial reefs to capitalize on the appearance of exotic species for diving and recreational fisheries. This will result in immediate benefits to the industry regardless of the pace of climate change as it is known that exotic species are already appearing regularly in South West waters.
- Thermal boundaries for fish species are known and therefore research should be enhanced into shifting geographic ranges, which are presently less well understood.
- Continuous monitoring of key determinants of environmental quality is essential to monitor change in the region and encourage proactive industry responses.

- Existing databases (e.g. ERICA, operated out of the Cornwall Wildlife Trust) providing long-term data should be maintained, developed and utilised.
- At the present time very little is known about the changes in fisheries in the region due to climate change. Further research is required to provide a baseline of stocks and species presently found in the region. In addition, continuous monitoring and the upkeep of databases is required to identify changes in fish species and stocks as well as to monitor temperature changes in the marine environment.

Challenges + Opportunities of Key Climate Impacts to Marine Fisheries Domain

Climate Impact		Challenges + Opportunities
Summer Temperature Increased	C	Changes in fish stocks in response to warming of inshore waters may result in the loss of certain commercial fisheries and the development of others.
	C	An extended tourist season due to warm weather may lead to fish being exported to the continent via Poole rather than Plymouth more frequently as the ferry companies will not transport fish lorries from Plymouth during summer months, when the tourist trade takes priority.
	C	Trout farming is known to be highly sensitive to changes in water temperature and quality. Changes in air temperature and in the nature and frequency of rainfall events could have a significant impact on aquaculture.
	C	Increased water temperatures may also reduce microbial quality, leading to a deterioration of shellfish growing areas in the region.
	O	If sea temperatures increase, there may be scope for aquaculture of new species, which may offer opportunities for the industry to diversify and reduce pressure on existing stocks.
	O	Increase in southern species of fish and unusual sightings e.g. sunfish, sharks etc. may be beneficial for tourism.
Winter Temperature Increased	C	May extend the breeding seasons of specific species, again leading to changes in the fisheries present in inshore waters.
	C	As for increased summertime temperature.
	O	May also enhance existing fisheries by extending breeding seasons.
Summer Rainfall Reduced	C	Aquaculture in the UK is largely tied to the farming of salmonids (e.g. rainbow trout, Atlantic salmon), mussels and oysters. Salmonids are particularly susceptible to changes in water quality and climatic conditions. Temperature influences growth and, among salmon, the timing of sexual maturity.
	C	Low rainfall will lead to low river flow and hence a concentration of the pollutants within rivers. This could lead to follow-on effects to marine life when pollutants are carried out to sea.
Winter Rainfall Increased	C	Potential detrimental impact of repeated CSO discharges into vulnerable coastal waters, particularly in areas with bivalve shellfish.
	C	Potential for increased leaching of nitrate based agrochemicals into vulnerable inshore waters, which combined with elevated wintertime temperatures, may increase the susceptibility of these areas to planktonic blooms. Vulnerable species are bivalve molluscs, particularly scallops and oysters. Closure of scallop fishery would have ongoing impacts on other inshore fisheries with the displacement of effort.
	O	Inshore shellfish stocks may increase if fishing effort is reduced which may enable more proactive management.
	C	Soil runoff from areas adjacent to subtidal and intertidal areas could lead to silting up, species being smothered, increased water turbidity and shore erosion.
Sea Level and Tides Increased	C	The increase in seawater in estuaries could change the dynamics of the salt/freshwater interface and hence impact on the flora and fauna within.
	C	May lead to silting up of estuaries causing access problems and need for dredging.
	C	May lead to erosion of harbours and ports affecting fishing fleet.

Climate Impact		Challenges + Opportunities
Potentially Increased Winds and Storms	C	Storm damage to harbours, quays and ports may effect fishing fleet.
	C	Marine life of both subtidal and intertidal areas could suffer from an increase in sediment movement.
	C	Reduced days at sea for both fishing vessels and fisheries patrol vessel
	O	Reduced fishing effort may enhance fishing stocks currently under pressure

RIVERS, FLUVIAL FLOODING AND DRAINAGE DOMAIN

Scope

Impacts of climate change on river and catchment processes involving the transfer and storage of water and sediment in water courses.

Primary effects on water quantity in water courses including flooding, low flows, surface drainage; and urban drainage. (see also Water Resources Domain)

Physical flood and low flow impacts on water courses in different scales of catchments and physiographic settings.

Human activities exposed to increased flood risk.

(Some reference is also made to effects on water quality and biodiversity in water courses although this is mainly addressed in the Water Resources Domain)

See Also

Water Resources, Coastal, Transport, Biodiversity.

Background

The hydrological character of selected catchments in the South West can be summarised as follows:

River	Basin area (km^2)	Q_{MED}	Q_{MAX}	Q_{95}
Exe (at Thorver-ton; 1956-2002)	600	175	493 (Dec 1960)	1.96
Lower Severn (at Haw Bridge; 1975-2002)	9884	493	872 (Dec 2000)	20.51
Frome (at Frenchay; Bristol; 1961-1988)	149	29	70 (July 1968)	0.170
Tone (at Bishops Hull; 1961-1993)	204	67	113 (Sept 1968)	0.708

Q_{MED} - median annual maximum flood (FEH; shorter dataset than Q_{max})

Q_{MAX} - maximum flood

Q_{95} - flow exceeded 95% of time

Dates indicate length of gauged record for maximum flood

Figure 6.1

Hydrological Character of River Catchments in SW

Source: *Flood Estimation Handbook* (CEH, 1999)

When considering physiographic characteristics, catchments in the South West region occur at a range of scales, with a diversity of geological and physiographic settings (see following table).

Location	Hydrological regime	Specific examples
lower Severn estuary with its gathering grounds in mid-Wales and the Midlands	attenuated patterns of flood storage; high tidal range (Severn bore)	areas of flood risk e.g. Tewkesbury and Alney Island, Gloucester
low-lying areas of the Somerset Levels	extensive areas of floodplain 2 m below high tide level of the Severn estuary	e.g. River Parrett and Tone catchments
chalk landscapes of Wiltshire and Dorset	broad flat bottomed valleys with meandering rivers	e.g. River Avon and Wylye
small, steep sided catchments, draining upland moors rising to 600m with bedrock at or near the surface	flashy runoff response to intense rainfall	e.g. River Lyn at Lynmouth; River Pol at Polperro
wide valley floors with Quaternary deposits	drainage into former workings for aggregate extraction	Cotswold Water Park

Figure 6.2

Physiographic character of River Catchments in SW

It should be noted that the South West region which is the focus of this study does not coincide with Environment Agency's catchment-based regions. The study area therefore encompasses parts of the Environment Agency's South West Region and part of the Midlands and Thames Regions.

Water quantity and quality in water courses

The following baseline information is taken from the Environment South West RDA Observatory Web site.

In terms of water quantity, river flows can be measured against their long-term average to identify yearly trends. A low point in river flows in 1996 corresponds with low annual rainfall. Since then, flow rates have recovered and most of the monitored rivers currently have flow rates greater than their long-term average.

Water abstraction has already had an unacceptable environmental impact by reducing river flows (e.g. on the Rivers Wylye, Avon at Malmesbury, Piddle, Allen, Tavy and Taw). Low flows on the Wylye, Malmesbury Avon and Piddle are caused by groundwater abstraction by Wessex Water. A statement of intent to restore acceptable flows on these stretches of river by March 2003 has been agreed by the Environment Agency, Ofwat, English Nature and Wessex Water.

Other low flow problems of major public concern are on the River Bourne, Nine Mile River and the River Nadder. These are being addressed by the Environment Agency's National Environment Programme and in Environment Agency (2001) Regional *Water Resources for the Future* strategy.

In terms of water quality, river flows in the South West region are generally good, which is important for water supply, wildlife, visual amenity and recreation. In a recent survey (2001), the South West had the highest proportion of 'very good' quality rivers and the lowest proportion of 'bad' quality rivers in England.

Almost all of the region's rivers are of very good or good chemical and biological quality (82 % in 2001 and 87 % in 2000, respectively). River water quality has improved significantly since 1990 and compares favourably with the average (69%) for England and Wales. Significant improvements include parts of the River Wylye (Wiltshire), River Axe (Somerset), and River Tavy (Devon). Cornwall has the highest proportion of chemically good or very good quality river stretches in the region, based on the Environment Agency's *General Quality Assessment* (GQA) scheme that measures the chemical and biological quality of rivers. There are, however, some reaches that are mining-affected and of poor quality.

A key water quality issue is eutrophication caused by an excessive build-up of nutrients (mainly phosphorus and nitrogen derived from human activities) and affected by water quantity/dilution as well as quality. Eutrophication in rivers and shallow lakes tends to be evident through algal blooms and alterations to aquatic life through reduction in oxygen levels. Cotswold Water Park has problems with blue green algae in some of its shallower lakes. Pilot *Eutrophication Control Action Plans* (ECAPs) have been set up on Slapton Ley and the Hampshire Avon (Environment Agency, 1998c).

The lower sections of the River Creedy and Exe, Bristol Avon, Hampshire Avon, Taw Estuary, River Cober/Loe Pool and the Truro/Tresillian Estuary are affected by large sewage works and are designated as sensitive areas (eutrophic) under the Urban Waste Water Treatment Directive that limits the levels of nutrient discharge.

Salmon are present in rivers throughout Devon and Cornwall, and in the chalk streams of Dorset and Wiltshire. Their numbers are not significant in Somerset and Gloucestershire as the catchment geology and generally lower gradient of the rivers is not ideally suited to salmon.

Coarse fish populations are significant in rivers to the east of the Region (e.g. the Dorset Stour, Hampshire Avon and Bristol Avon). Many natural and artificial stillwaters and canals provide important fisheries.

Flooding

Flooding incidence can be considered in terms of causal and intensifying factors at basin, network or channel levels. Flooding can be broadly conceptualised in three categories: (a) flooding associated with river and stream channels including the 'main river' channels monitored by the Environment Agency; (b) local flooding due to saturation and sheet run-off from rural slopes; and (c) flooding of storm sewers as a result of urban or rural run-off (with significant responsibilities for sewer planning and maintenance held by water companies). Principal concerns expressed in the South West involve the first category. However, on a more local scale the other types of flooding are potentially very significant to property and transport infra-structure (especially the road network). Sustainable Urban Drainage Systems (SUDS), piloted by the Environment Agency, form a useful and expanding means of addressing urban drainage flooding as well as improving water quality and amenity. Greater planning consideration in the urban environment is being directed to increasing land permeability so ensuring that infiltration is optimised (cf. surface runoff).

Historically major floods have been caused by both longer duration rainfall events in larger catchments (e.g. River Exe, Dec 1960; River Avon, Bath and Bristol, July 1968) and intense convective storms in smaller catchments (e.g. August 1952 flood, River Lyn, Lynmouth; see Newson, 1975). The latter event was one of the most extreme floods in a small UK catchment and has been important in establishing UK flood envelope curves.

In the South West region, riverine and coastal floodplains account for between 5 and 10% of the land (see 1999 Indicative floodplain map of England and Wales, IoH, Wallingford and Environment Agency). The Environment Agency Web site supplies mapping of areas at flood risk to 1 in 100 year, or largest recorded, for fluvial events and 1 in 200 year, or largest recorded, for tidal floodplain, but these figures are based on historical data rather than predicted climatic conditions.

Where there are floodplain defences, these frequently require costly and ongoing maintenance. There are 450 km of estuary and sea defences in the region and on 4,000 km of 'Main River', there are 2,800 km of fluvial main river defences. In 1999/2000, over £20 million was spent on flood defences in the South West. Cities (e.g. Exeter, Bath and Gloucester) and towns (e.g. Brunton) have locations alongside rivers with some properties currently vulnerable to flooding (see *Exeter Flood Plan; Brunton Flood Plan*). Some areas, e.g. the lower River Severn at Gloucester, are undefended from major floods while being a focus for urban regeneration efforts.

Work with local communities and indigenous industries to develop new economic opportunities, methods, equipment etc to help them cope with changing circumstances, including the adverse effects of climate change.

Environment Agency's Water Management Strategy Action Plan for the Parrett catchment . 2002

There are conflicting imperatives. The South West faced its worst flooding for 53 years during the winter of 2000/2001 (*Environment South West, 2002*). Since 1996, the numbers of planning applications for residential developments on floodplains in the region has been increasing (*Environment Agency 2000b/c*). Climate change predictions indicate that for some areas in the South West, the flows/levels that presently define a 1 in 100 year flood may occur 1 in 10 years.

Climate change research studies suggest that a 20% increase in river flow would mean that the flows/levels that presently define a 'once in 100 year' flood would occur around 'once in 40 years'.

Key Issues

- Potential climate change impacts on water courses in the region are very varied in both the nature and scale of their impacts and in the range of stakeholders affected.

Water quantity and quality in water courses

- Water temperatures in water courses in the region will rise in response to increasing air temperatures, but also as a consequence of changes in other meteorological parameters such as cloudiness and relative humidity.
- Changing river discharges, especially more extreme low flows in summer months, will encourage higher stream and river temperatures. In some watercourses, future rises in mean and maximum water temperatures might be expected to be the same as those in air temperature. In contrast, in others the increase in water temperature will be significantly less than that experienced in air temperature. Larger rivers at downstream locations are likely to see greater changes than some headwater streams.
- Given the uncertainty surrounding the predictions of many climatic variables, not least precipitation, and the complexities of downscaling to small catchment areas, assessments of the major components of catchment hydrology (including water transfer and storage) in a warmer world have a number of uncertainties. In water courses, it is probably the quantity rather than the quality elements of the hydrological cycle for which the impact of future global warming can be predicted more readily, and with greater certainty.
- As the quality of water is strongly influenced by the quantity, predictions of future water quality are less certain. This is because uncertainties in predicting impacts on the processes affecting water chemistry, sediment transport, etc. are superimposed on the uncertainties in predicting flow volumes. Even quality parameters that are relatively simple to predict, such as water temperature, cannot be predicted with complete confidence in the future. This is because information on future values of key controls, such as solar radiation inputs is insecure, and knowledge of likely future changes in channel morphology and riparian vegetation is incomplete.
- Rather more subtle and complex changes in water chemistry may be associated with changing climatic patterns. These include the impact of higher winter soil temperatures and greater winter precipitation, as well as higher summer temperatures and lower summer rainfalls. Cycling and storage of chemicals in catchment ecosystems could be influenced by changing hydrometeorological conditions, as well as more directly by planting of different crops in response to climate change.
- Initial research has suggested that for the Severn catchment (partly in the study area) increases in peak flow of around 20% for a given return period could be experienced within 50 years. In PPG 25, these are recognised as preliminary findings with further work required. The national guidance indicates that these predictions give added incentive to maintain current defences, where they are justified, and to adopt robust and sustainable solutions

where defences are replaced. (*National Planning Guidance - PPG 25 Development and Flood Risk*).

- Such considerations also add importance to the need to evaluate the potential impact of extreme events even where it may not be economic to contemplate high levels of protection. (*National Planning Guidance - PPG 25 Development and Flood Risk*).

The key is to be upbeat and indicate varying degrees of confidence. We need to start planning for 50 years plus, but there are major problems in getting people to think this distance ahead.

Somerset Moors and Levels Partnership

- River managers in the region need up-to-date and systematic assessment of the potential impacts of high and low climate change scenarios on the quantity and quality of flow regime to develop management strategies in a climate change context. This information includes: changes to the quantity and quality of average flow patterns and low flow conditions; and the nature and scale of changes in flood magnitude, frequency, seasonality and duration across a range of physiographic settings.

- The impact of increased flooding on other catchment processes including soil erosion, sediment mobilisation and yield and land slipping also requires investigation. Changes in river flow regimes may lead to changes in river morphology with both deposition and erosion being potentially affected. Changes to sediment supply and patterns of river sedimentation are potentially exacerbated by land use practices.

- Land use changes may also make soils more susceptible to erosion, and increased winter precipitation and storminess could also encourage the mobilisation of more sediment into rivers. Some soils that may be mobilised have the potential to be contaminated by metals from mine wastes (particularly in Cornwall and West Devon). Actual soil erosion has increased in recent years to about 6% of arable land, with half of all land in the South West at risk (*Environment South West; RDA Observatory Web site*).

- Secondary impacts include changing patterns of biodiversity in water courses/water bodies and the changing suitability of these habitats for specific species (cf. those environments currently experienced). For example, inland transgression of salt marshes may occur in former floodplain areas with increased sea levels. The relationship between sea level rise, deposition in estuaries and ecological impacts may also be complex.

- Land use and climate change have the potential to be either antagonistic or synergetic in their impact on water courses. Land use practices that exacerbate the impact of climate changes need to be identified and managed to reduce impacts. This involves practices that reduce vegetative cover during periods with predicted greater frequency of intense storms or increase the proportion of permeable surfaces through sub-urban development.

- Flood risk managers' activities within the context of the South West region have to evaluate: (a) the potential human and economic impact of increased extreme events even though it may not be financially feasible to consider higher levels of protection; (b) the relative merits of structural measures to mitigate against increased flooding in comparison to measures that involve adjusting of human activities.

- Mechanisms need to ensure more timely links between research into climate change impacts on rivers and the development of informed policy for river and flood risk management.

The options appraisal should encourage the construction of flood defences that can be easily modified, through incremental changes, in response to growing confidence about the impacts of climate change, thereby maximising the efficiency of future investment decisions.

Environment Agency, Lower Severn Area

- There are important opportunities to capitalise on recent public experience of flood risk and so improve public understanding in the region of changing patterns of flood risk in a climate change context.

- The potential impact of changing flood patterns on existing exposed human activities and vulnerable floodplain groups in the region needs to be established for different climate change scenarios. This is particularly critical given the potential for withdrawal of insurance cover or increase in insurance costs in the Severn area after the insurance guarantee expires at the end of 2002. The impact of possible changes in

the frequency and intensity of extreme floods on the insurance industry is being appraised nationally.

- The appropriateness of existing engineering structures and design standards relative to predicted changes in flood magnitude and frequency needs to be reappraised.
- A methodology is required for the evaluation and implementation of floodplain areas with the potential for managed retreat (within the options of hold, retreat or advance defences). Shoreline Management Plans provide a vehicle for this type of assessment in estuarine environments.
- Transport infrastructure will be exposed to an increased risk of flooding and associated problems from excess precipitation and damage, as well as increased storminess.
- Unsustainable floodplain development needs to be prevented in areas of increased flood risk. The planning system must be reviewed and adjusted to ensure this control. Environment Agency evidence as to the flood risk of the site needs more weight in the planning process.
- If the substantial extra housing in the region (see State of Environment Report) is to be implemented then the hydrological impacts need evaluation in the context of changing rainfall intensities. Urban developments tend to increase flood peaks and decrease the lag time of peaks. This provides a challenge to ensure sustainable urban drainage systems (SUDS) in a climate change context. SUDS options need to be evaluated and designed carefully on a case-by-case basis and may not be suitable in every situation.
- Selected floodplain activities may require relocation from floodplains with debated degrees of compulsion. New sustainable land uses on floodplains may need to be established.
- Lower flows mean lower levels of dilution of contaminants and resulting lower water quality. Consent conditions for both water abstraction by Water PLCs and pollution inputs by riparian users to water courses, both regulated by the Environment Agency, could be applied more tightly.

Flooding

- Specific floodplain locations within the region (e.g. River Exe, lower River Severn) are potentially vulnerable to increased riverine flooding. *(See also Coastal Impact Domains.)* Future inundation by extreme floods may well include locations beyond current flood experience, and therefore outside current Environment Agency floodplain mapping.
- Changes to storm surge patterns may also have impacts to riverine environments and flood risk through tidal lock in estuarine areas with a high inter-tidal range.
- Levels of flood protection offered by existing flood defences will reduce.
- Organisations tend to base decisions on past data rather than future-based predictions.
- There is a risk that insurance companies could withdraw from insurance of properties on floodplains that demonstrate increasing flood risk, which, combined with problems in dealing with uncertainty may mean no or slow action among some stakeholders.
- The opportunity exists to shift in particular circumstances from structural engineering measures to more sustainable measures including behavioural approaches such as effective flood warning systems.
- There is scope for the Environment Agency's public awareness campaigns to be refocused from highlighting risk towards taking risk reduction measures.
- There are opportunities for agencies involved in emergency flood risk planning to work together in preparatory, emergency and review stages (and so improve efficiency of operation).
- Integrated management of floodplains can work to reduce flood risk and enhance biodiversity.
- Potential for climate change can be used to aid the business case for investment in infrastructure (e.g. transport). It may not be economic to upgrade protection for a site that floods once every few years. If future flooding is likely to occur more often, it may cost less in the long run if some investment is made now.
- Increased application of Sustainable Urban Drainage Systems (SUDS) and permeable ground surfaces should be considered in urban environments as a means of counteracting potential under-capacity in storm-sewer systems resulting from higher rainfall intensities / frequencies.
- Responsible authorities, land-owners and regulators should work in an integrated fashion to ensure that inappropriate land-use management does not exacerbate the potential for increased rapid overland flow and surface flooding.

The Way Forward

Flooding in the South West needs to be addressed on an integrated catchment-wide basis and in a sustainable manner (Environment South West, 2001). There are tensions between engineering solutions that work to 'control nature' by maintaining and increasing defences and adaptation agendas.

There is a need to adopt 'robust and sustainable solutions' in situations that allow this. Environmentally sustainable solutions involve increasing storage capacity by restoring floodplain, modifying catchment runoff or causing increased conveyance by deepening and widening the channel.

There are strong organisational steers (e.g. within Environment Agency regionally and insurance industry) and media pressure to get local, regional and national government and environmental regulators to respond to evidence of increased flood risk associated with climate change. In planning for flood risk in specific areas (e.g. on Somerset levels and lower Severn), there is strong evidence for local public ownership of flood problems borne of recent experience of extreme floods in the last 5 years.

National guidance PPG 25 has a section on climate change and sets development and flood risk at least partly in this context. National government policy on river management for flooding needs to be implemented to meet the needs of changing flood risk at catchment scale within the region.

Local Authorities need to prevent further exposed development on floodplains unless it can be demonstrated that property is not affected by increasing levels of flood risk and the problem of increased flood risk is not exported upstream or downstream.

Integrated planning and flood defence strategies need to be considered at a catchment scale as outlined in English Nature Position Statements and developed by the Environment Agency, English Nature, Local Planning Authorities and Drainage Boards.

Catchment Flood Management Plans (CFMPs; an initiative developed by DEFRA and Environment Agency) are being developed to provide a strategic vehicle for considering holistic approaches to flood management at a catchment scale. Best practice is for these to consider climate change impacts as part of their broader remit. In addition, there are Shoreline Management Plans (SMPs), which are multi-organisation, high level strategic plans (comparable to CFMPs) that encompass estuarine areas. These plans have potentially overlapping regions. For the lower Severn, the SMP extends upstream to Hawbridge, the CFMP extends downstream to Gloucester and there are also CFMPs for tributaries that extend to the estuary.

It is important to establish ways in which potential impacts of changing flow regime, water quality (including temperature) and sedimentation patterns can be capitalised on or managed in terms of biodiversity and specific species habitats.

The government and the devolved administrations have already started to respond to the threat of climate change by building adaptation into many of their policies. Examples include revising the approach to development on floodplains, improving flood warnings and increasing public awareness of flood risk and further research into the potential impact of extreme flood events.

Continuing dialogue on effective adaptation strategies should be encouraged - among Environment Agency (at regional and national level), Local Authorities, business, insurance industry, probably through a number of facilitator routes including the SWRDA, GOSW and professional bodies. Good practice needs sharing nationally.

Barriers to change

There are a number of barriers to organisational and individual change in flood risk planning including:

- The cost of increasing the design limits of existing structures or adding to new engineering measures for flood risk management. For example, in the Severn estuary, most structures are currently 1 in 100 year but some are around 1 in 10. The latter are defences where capital improvement by the Environment Agency cannot currently be justified.
- The sheer number of organisations involved in flood risk management including Flood Defence Committees, the Environment Agency, Local Authorities and Drainage Boards. This issue is currently under governmental review.
- Catchment boundaries in the region (the most appropriate unit for managing land and water) do not necessarily coincide with government regional and sub-regional; boundaries when approaching flood issues at a catchment level (e.g. Severn estuary).
- The propensity for organisations to consider shorter timescales in planning for climate change e.g. 10 year rather than 50 year over which more significant hydro-meteorological changes are likely to take place.
- The difficulties in organisations dealing with uncertainty and probability in assessing the impact and issues associated with flooding in different climate change scenarios.

This being said, the majority of river managers in the South West are well aware of the potential impacts of climate change on the river environment. For some managers, climate change means primarily engineering solutions, building larger structures to higher design limits, rather than adapting human usage of areas with increased flood risk.

Perception of changing flood risk within a climate change context is of variable strength within Local Authorities. Sustainability agendas are frequently higher profile. Some policy statements on flood defence make no reference to a climate change context and changing flood frequency.

There is improved awareness by the general public about flood risk issues in a climate change context. However, the link to improved adaptation to flood risk needs to be strengthened in public awareness campaigns.

Knowledge and Information base

There is probably enough basic information for rivers in the region to attempt modelling of how future climate change will impact on river flows, groundwater levels and other quantitative aspects of the hydrological cycle. There is much less detailed baseline information on the quality of rivers in the South West on which to base future predictions.

Accessible future-based information on flood and low-flow impacts is required at a regional level.

Example of Good Practice

Community based residents groups (eg Alney Island Gloucester) are acting to raise awareness of adaptation needs. This is important in raising awareness of practical steps to reduce flood damage and taking ownership of the problem.

There is considerable scope for basic research into how aspects of water quality will change with global warming and for assessing the ecological impacts of those changes in rivers and other freshwater ecosystems.

There are no South West region-specific policy documents relating flood defence and climate change. There are, however, a number of government policy documents in this area and evidence that the sector is accessing and using the 2002 scenarios published by UKCIP, within a regional context. Sources used in considering adaptation possibilities include the general media, UKCIP, DTLR, DEFRA. Specialists are using Hadley Centre and IPCC technical reports, conferences held by UKCIP, ICE and BHS and papers to Local Flood Defence Committees.

Environment Agency flood awareness promotions, recent flood experience and media coverage of recent extreme flood events within the region and UK mean that the lay public has had more exposure to information about flood risk than e.g. five years ago. The Environment Agency will be producing indicative flood risk outlines for the 1:1000 year floods and plans to put these on the Web by September 2003. Further investigation is required to see if this information retains high profile or is converted into action to reduce losses.

Other stakeholders involved in flood hazard management are variably informed about climate change impacts. Wide ranging education and training need targeting at specific areas of the sector e.g. some county councils.

There is a need for higher resolution data relating changing meteorological inputs to a catchment's hydrological response. The implications for water quantity and quality in water courses can then be evaluated along with appropriate adaptation needs and strategies at a regional level

There is a need to work towards improved flood risk identification in a climate change context. Strategic planners for flood risk require more detailed specialist information. The UKCIP 2002 report covers the changing frequency of the extreme daily rainfall event. Transport managers, for example, need information about change in frequency of extreme 5, 7 or 10-day events above a specific threshold and implications of prolonged rainfall on flood risk.

Recommendations

- The impact of changing water quality/ water quantity (flood and low flows) on habitat and biodiversity should be systematically monitored in a climate change context e.g. impact of changing temperature profiles on fish resources.
- A searchable database of hydrological data on water quality/quantity data for the region should be made available to stakeholders including the general public. Ideally this should draw on historic data, numerical modelling and future predictions, possibly in a GIS-based system. The information presented should be Web-based and have a 'Science and Society' flavour with interpretative tools. There is nothing currently with this interactive flavour available although the Web-based SW Regional Observatory has general environmental information and synthesis.
- Regularly updated statistical analysis of rainfall and river flow data using both historical and ongoing hydrological data should be undertaken, building on data and methodologies in the FEH Handbook (CEH, 1999).

Examples of Good Practice

Somerset Levels and Moors (Parrett) is one of five pilot study areas being carried out nationally to develop methodologies for the production of Catchment *Flood Management Plans*. The Somerset Levels and Moors Partnership has involved stakeholders in appraising the impact of high and low emission scenarios for the 2050s on activities within the catchment.

- Experimental catchments should be set up within the South West to monitor the impacts of climate change on catchments with different physiographic and land use contexts. The monitoring resources of the academic community, the Environment Agency and regional Government need to be focused to maximise potential for useful scientific data to inform catchment management.
- The experience of recent extreme floods needs to be capitalised on in improving organisational and individual practice in adaptation for flood risk. This work is already in progress within the Environment Agency.
- Floodplain mapping for flood risk should consider potential maximum probable flood scenarios in a climate change context. Status, resolution and limitations of the mapping on the Environment Agency Web site should be explicitly stated. This work is already in progress within the Environment Agency.
- There needs to be strong control on future development within flood risk areas under potential climate change scenarios. The status of the Environment Agency in the review of planning applications for flood risk should be reviewed nationally. The implementation/success of current planning regulations for vulnerable land uses (e.g. caravan parks) in flood risk areas within the region should be reviewed and evaluated.
- Models of good practice in planning for floods at a catchment scale (through Catchment Flood Management Plans) should be implemented as soon as possible in other catchments with land uses at risk from flooding.

Challenges and Opportunities of Key Climate Impacts on Rivers, Flooding, and Drainage

Climate Impact		Challenges + Opportunities
Summer Temperature Increased	C	Increased soil moisture deficits lead to shrinking of peat soils in the Somerset Levels, lower surface levels and make flood waters harder to evacuate.
	C	Issues of health, contamination and spread of disease may occur on floodplains that have recently suffered flooding.
	C	Water temperatures in water courses rise in response to increasing air temperatures (also cloudiness and humidity).
	C	Changing river discharges, especially more extreme low flows in the summer months, will encourage higher stream and water temperatures.
	C	Changing thermal regimes of rivers are likely to have diverse ecological implications as water temperature has a strong impact on virtually every facet of the freshwater fauna and flora.
	C	Changes in water temperature may deplete dissolved oxygen levels and reduce the assimilative capacity of watercourses. It will alter chemical processes, e.g. rates of denitrification, in streams and rivers.
	C	Increased evaporation from surfaces of shallow lakes (e.g. Cotswold Water Park) will occur. Where high levels of nutrients are present, this may encourage increased incidence of blue/green algae.
	C	Changes in water temperature may make river water a less efficient coolant in industrial processes.
	C	As river temperatures warm, game fish may become stressed and summer growth could be reduced compared to present conditions. Rising winter water temperatures may also have an impact on game fish spawning and subsequent egg and alevin development.
	O	Longer working periods will exist for the maintenance of design standards of operational flood defence works (funding dependent).
Summer Rainfall Reduced	C	Lower summer flows in rivers will lead to higher concentrations of dissolved constituents in water courses and reduced capacity to dilute effluent discharges.
	C	Reduced water resources will exist for abstraction from water courses and for the natural environment (although still risk of summer storms)
Winter Temperature Increased	C	More rapid snowmelt can lead to potential increase in flood risk
	O	Slight benefits are involved in flood defence maintenance – increased germination of grass seed sown out of season following earthworks.
Increased Winter Rainfall	C	More robust designs will be required for rainwater disposal systems above and below ground.
	C	Decreased erosive resistance of flood embankments and soils with low vegetation cover to intense rainfall events will have implications for sedimentation of watercourses.
	O	More water will be available in rivers but needs capturing and storing with incentives from water companies.
	O	Farming practices can adapt to ensure winter ground cover so that sediment is not flushed rapidly into water courses in intense winter rainfall.

Climate Impact		Challenges + Opportunities
Increased Sea Level and Tides	C	Impacts on the magnitude, frequency, timing and duration of tidal lock on estuaries will have implications for the evacuation of increased fluvial flooding from upstream areas.
	C	Tidal limits will migrate inland and affect boundary conditions leading to problems associated with river hydraulics
	C	Estuarine sediments could remobilise and some, in Cornwall and Devon, may be highly contaminated due to mining related sedimentation.
Longer Growing Seasons and Reduced Frosts	C	Changes in farming practice (e.g. choice of crops) could affect flood risks due to increased runoff and erosion.
	O	More maintenance work on flood defence structures could be achieved on-site during winter.
Flooding Increased	C	Improvements will be required to existing drainage systems and re-assessment of present criteria for new drainage systems in case higher specifications are required (especially urban).
	C	Reduced effectiveness of existing defences may lead to the need for additional works to maintain existing defence standards.
	C	Channel widening and dredging may only partly match predicted increases in flood magnitude and required channel capacity to evacuate flows downstream.
	C	Increased flooding may enhance potential for increased scour around in-channel structures (e.g. bridge piers) with subsequent increased maintenance requirements.
	O	There is opportunity for introducing sustainable urban drainage systems in new developments, e.g. use of porous materials to allow more percolation of winter rainfall.
	O	There are commercial opportunities for enterprising businesses working in flood proofing, flood protection technologies or engineering structures for flood defence.
	O	Advice to developments and planners on flood risk has significant regard for climate change effects.
	O	Flooded aggregate-extraction pits provide opportunities for integration in flood storage schemes in Catchment Flood Management Plans. Appropriate water management and extensions to capacity may be necessary.
	O	Potential to encourage new approaches of adaptation e.g. possible removal of properties most at risk from flooding, re-creation of floodplains, greater use of washland schemes; control over detrimental land management practices etc.
	O	Potential for climate change to be used to aid the business case for investment in the infrastructure.
	O	Greater public awareness of danger of flooding will occur through experience with greater consequent support for the Environment Agency's work.
	O	Management of floodplains in a climate change context can help meet biodiversity targets (e.g. through floodplain retirement strategies).
	O	There is opportunity to integrate estuarine and coastal defence strategies for effective management of flood risk.
Potentially Increased Winds and Storms	C	Increased storminess contributes to increased risk of flooding and exacerbates impacts. This requires allowance in design of flood defences.

WATER RESOURCES

Scope

The availability of and demand placed on water as a resource for industrial, domestic and general supply, for maintenance of aquatic environments, for generation of renewable energy (hydropower) and for safe and sustainable disposal of sewage effluents and by-products.

This section deals with both the quality and quantity aspects of water resources though some aspects of water quality are also referred to in the section on Rivers, Flooding and Drainage domain.

(Some reference is also made to effects of flooding on foul-sewer systems, though flooding as an issue is addressed principally through the Rivers, Fluvial Flooding and Drainage Domain)

See Also

Rivers, Fluvial Flooding and Drainage; Coastal; Natural Environment

Background

Water resources are managed principally through the suppliers and distributors (the Sewage and Water Companies (part of Severn Trent, part of Thames Water, Wessex Water, South West Water); the water-only companies: (Bournemouth and West Hampshire, Bristol Water, Cholderton and District) and the two regulatory bodies (the Environment Agency and OFFWAT). Sectors, companies and organisations with particular interests in water as a resource include *inter alia* those involved in hydropower, food and drinks manufacture, brewing, chemical industries, mineral extraction, and paper production.

In terms of hydrology and water resources the South West region can be divided into three areas roughly paralleling the South West Region's three principal water company areas (Severn Trent: Gloucestershire; Wessex Water: Bristol and Avon area, Wiltshire, Dorset and Somerset; and SW Water: Devon and Cornwall).

These areas are characterised by significantly different topography, geology and catchment sizes which influence variably all water resourcing aspects outlined within the scope. Water supply in the Gloucestershire area of Severn Trent is dominantly through river abstraction and ground water. In the Wessex area groundwater forms 80% of the supply, with 20% derived from surface sources (reservoirs and river abstraction), whilst in the South West Water area, 90% of the supply is from surface sources and 10% from groundwater.

The South West Water area is served by a network of 17 smaller and older upland reservoirs utilised now to provide the main winter water to local demand centres. Since the 1970s, three additional strategic reservoirs have been constructed to supply water throughout the peninsular; these act as contingency resources used when local supply is required to maintain river flows. The eastern area (Somerset, Wiltshire, Dorset and Avon area) is served by 12 impounding reservoirs and abstracted water from five main rivers.

Key Issues

- Maintenance of critical river flows during dry conditions.
- Management of abstraction licences with potential increases in irrigation and industrial demands.
- Impact of longer and increased frequency of droughts on water supply;
- Modelled 4% rise in household water demand by 2021 factoring in climate change.
- Increased turbidity in groundwater water during wetter winters.
- Increase flushing of nitrates into the groundwater during wetter winters.
- Potential increase in *Cryptosporidium* content of groundwater during wetter winters, with consequent human health impacts.
- Uncertainty in replenishment rate of aquifers.
- Potential salinity increases in borehole and river-mouth abstraction points as a consequence of rising sea-levels and/or storm surges.
- Potential flooding of sewer networks.
- Potential need for re-engineering of sewer outfalls as a consequence of rising sea-levels.
- Difficulties in winter land-access for disposal of sewage sludges on agricultural terrain.

The Current Situation

The limited number and specialised nature of the principal 'players' in controlling aspects of water resources has ensured that the potential impacts of climate change have been considered in depth. Sophisticated analytical

tools and diverse strategies have been adopted by the water companies and regulators.

Numerous reports have been produced both by the Environment Agency and by the water companies, often in collaboration, such as in the joint UK Water Industry Research Group / Environment Agency report by Arnell *et al.* (1997). This nationally based study provided water companies with a method to include climate change impacts in the third asset management plan (AMP3) discussions with the Environment Agency at OFWAT (Lonsdale, 2000).

Additional studies on water resources and demand prediction are underway and will inform AMP4 negotiations. In terms of climate change, the 2020's UKCIP scenarios are seen as the most relevant as the 2050s and 2080s scenarios lie significantly beyond the water industry's thirty year planning horizon.

South Western part of South West	North and East part of South West
Significant areas of high elevation	More subdued elevation
Heavily dissected, steep sided valleys	Broader, shallower angle valleys
Rapid run-off, flashy response rivers	Generally less prone to flash floods
Largely impermeable bedrock	Permeable bedrock areas
Principally surface water resources	Significant groundwater resources

Demand Issues

Demand changes in the water industry are thought to be the most significant area of sensitivity to climate change (EA, 1999: 41). The social trend towards lower household size is thought likely to lead to a significant increase in domestic water demand. Increasing living standards also create greater *per capita* water use. In one of the few studies of demand Herrington (1996) applied a micro-component approach to assess the impacts of climate change on domestic use and forecasted a 3-6% increase in demand by 2021, with a suggestion of a marked increase in peak demand.

With 6000 new homes built per year, the South West Water company area is the second fastest growing water company area (after Anglian Region) in the UK.

In the South West Water Region the industrial demand for water is, however, below the national average but tourism is a significant factor in terms of water demand. In the Wessex Water region the Dorset Coast area (e.g. around Poole) places an additional tourism demand slightly above the national average for the sector, whereas the peninsular South West exhibits a highly pronounced (30%) summer population bulge increasing the resident population of 1.5 million by 0.5 million in each week of summer (more than 8 million visitors per year). The potential impacts of this increase fall largely on the infrastructure in terms of meeting peak demand, although current predictions do not place the impacts beyond that already accommodated by planned infra-structural improvements. There is, nevertheless, a need for an updated study in terms of the new UKCIP02 climate scenarios.

Extension to the tourist season as a result of milder and drier spring and autumn seasons and the increased popularity and marketing of 'short breaks' may also place additional demand on the water supply. It is anticipated that this extension will not influence supply adversely as it falls in season where river abstraction is possible and unused river flows would otherwise return water to sea.

In the South West Water area with no new schemes considered, demand predictions suggest that water will 'run out' in 2011; with climate change modelled, water runs out in 2006-7, i.e. the effect of climate change is to pressurise the planning strategy by up to five years. Additional pump storage, leak-reduction and conservation strategies are in place to address this as part of the ongoing strategy.

The Swindon area forms one of the most rapid growth centres in the South West and water resources may become an issue in the longer term. Discussions over the need for a new reservoir in the Thames catchment have been ongoing for some years whilst the possibility has been raised of using a restored Stroudwater canal and the Costwold Canals to transfer water from the River Severn into the Thames basin, utilising freshwater that would otherwise have been 'lost' to the sea.

Water conservation presents a significant problem in estimating what impact individual users have in terms of water saving. The impact of domestic water saving schemes (hippos etc.) is uncertain as there is limited knowledge of the number of schemes used whilst double-flushing is thought to be an issue. There is also some concern that successful home-based water saving may result in insufficient dilution of solid wastes in the foul-sewer.

Principal Water Resource Issues

In no priority order, the three principal issues associated with water resources are (i) water supply and management; (ii) water quality; (iii) sewage transfer, treatment and disposal. (iv) maintenance of flow levels in rivers and water levels in aquifers.

(i) Water Supply and Management

Leakage

Historically, one of the main issues associated with water supply and management has been the issue of leakage. The major water companies in the South West have invested significantly in minimisation of leakage over the last decade. This is reflected in a major reduction in the forecast and actual demand for water since the late 1990s

Water companies report that by 2003 leakage will be reduced to or below the economic threshold where cost benefit analysis determines that further leakage minimisation is not cost-effective. Wessex Water report that leakage reduction has turned a late 1990s deficit into a surplus that, without consideration of the effects of climate change, is predicted to last beyond 2030.

If future climate change were to have significant impacts on water resources then the water companies and regulators would need to re-evaluate the threshold of this economic limit. Scope remains for further adjustment as leakage in some areas is predicted to shift from 27% to 15% by 2005.

Precipitation Information

Water companies and the Environment Agency have invested significantly both in terms of their own and contracted research in assessing the potential impacts of climate change on water resources. The main enviro-climatic parameters that are of concern are potential summer rainfall reduction, winter rainfall and evapotranspiration (as determined particularly by ambient summer temperatures).

Most UKCIP98 (the first generation) climate change scenarios (Hulme and Jenkins, 1998) for the 2050s showed an increase in annual average rainfall with, in terms of precipitation, increasingly wetter winters apparently offsetting drier summers. However, the latest UKCIP02 scenarios informing this study suggest that the effective shift is towards an annual *reduction* in precipitation (by up to 10%).

In the RegIS study of water resource issues in East Anglia and the North West, modelling has been undertaken to assess the vulnerability of groundwater recharge to 1998 predictions (Holman *et al*., 2001). However, despite the increased precipitation overall in these models, the consequences of concurrent "more clement" conditions were thought to lead to an increase in the length of the growing season such that the duration of the winter recharge period is reduced.

In addition, soils take longer to absorb water in the autumn and begin to dry out sooner in the spring. These factors are important in governing whether or not increased annual precipitation would necessarily lead to an increase in groundwater recharge and total annual river flow.

By inference, the latest scenarios (UKCIP02: Hulme et al., 2002) with an annual *reduction* in precipitation, indicate that such groundwater recharge and annual river flow will tend more to deficit than the earlier work suggested. Detailed work is needed in the South West, where intra-regional water resources are strongly dependent on a single water source type.

Results for the Wessex area in which the modelled duration of the 1976 drought was extended suggest that climate change would reduce the water yield from 426 Ml/d (million litres per day) to 403Ml/d (i.e. a reduction of 5.4%) by 2020.

One issue in the water resource industry is the process whereby precipitation data are converted into hydrological data pertaining to river flows and aquifer / reservoir replenishment potential. Again using the 2020's UKCIP98 scenarios (Arnell *et al.* (1997)), both Wessex Water and SW Water have fed these results into hydro(geological) models to facilitate long term supply estimation.

Complex catchment-response models have been used by other companies (e.g. Severn Trent) but these require more work and are less readily transferred from catchment to catchment. Potentially more work on rainfall-runoff models may be useful in the region.

Water Storage

The most critical of the hydrodynamic climate variables is viewed as summer temperature and precipitation. In the South West where tourism significantly swells the population (in parts of Devon and Cornwall the population can increase by 33% in summer) and 'short-break' stays may increase in response to more clement weather, especially early and late season, availability (water yield) and demand drivers work together to stress the supply system. Balancing these opposing drivers is at the route of resource strategies for the water companies. Climate change is recognised as a factor that may be significant perhaps within the planning horizon rather than immediately.

A significant control on the vulnerability of water stores to the potential impacts of climate change is the responsiveness (or recharge rate) of the reservoir / aquifer. In the South West smaller stores generally behave as one-season critical (i.e. they fill in just one season) and are potentially less sensitive to climate change than the (usually larger) reservoirs that take two or more seasons to fill. Indeed in many cases, the small reservoirs may fill during a single storm, and certainly early on under current winter precipitation conditions. However, these smaller reservoirs tend to reach their lower volume limits earlier in the dry

season and prescribed minimum levels must be maintained to ensure river flow continues.

The larger reservoirs and aquifers provide sufficient 'usable' storage to sustain excess demand over summer recharge lows. However, in terms of efficiency of use and distribution, being gravity rather than pump-driven supplies (pumping costs - energy consumption - for some reservoirs approach £3k-£4k per day) the smaller reservoirs close to the demand centres are the most economic. Water security issues - guaranteeing a supply - means that the alternative larger pumped stores are necessary to supplement or replace the local supply as the small reservoirs are drawn down to their prescribed minimum levels. Additionally, some areas are only supplied by the local 'small' reservoir without access to a wider distribution network and so reserves must be maintained for these.

Most of the water company research has been based on the UKCIP98 climate scenarios where the winter precipitation increases exceed the summer decline, creating an annual increase in precipitation total. However, the UKCIP02 scenarios predict an overall reduction in annual precipitation totals, suggesting further work is needed to assess water resource issues.

The potential impacts from the former scenario are complex and depend on the critical factors governing reservoir/aquifer recharge. Currently most small surface stores fill during the annual cycle, often in localised stores and the wetter winters predicted will not supplement the supply. In contrast, some larger groundwater reserves (although reasonably responsive to precipitation) and the larger surface reservoirs currently do not fill on an annual cycle and so wetter winters may benefit these.

In broad terms, the principally groundwater-supplied Wessex Area may 'benefit' from such recharge especially in Wiltshire and Dorset, although in terms of the annual supply cycle, Somerset - being dominantly surface water supplied (e.g. Clatworthy reservoir) - may be less 'climate change proof'. In Devon and Cornwall with 90% surface water supply, 75% of surface storage is in three strategic reservoirs (Wimbleball – 21,320 Ml; Colliford - 28,540 Ml; Roadford – 34,500 Ml) with the remaining 25% of surface water in 17 smaller reservoirs. Wetter winters will again advantage supply in the larger stores, whilst the smaller reservoirs will be more susceptible to demand pressures, not having the benefit of enhanced winter top-ups.

Using the UKCIP98 scenarios aquifer recharge is shown (Arnell *et al*., 1997) to be highly dependent on the particular climate model and the geology of the aquifer. Thus groundwater recharge in Permian sandstones (e.g. the East Devon aquifer) may increase by as much as 14% by the 2020's, whilst recharge of chalk aquifers as in Dorset and Wiltshire may decline by up to 6% (see EA, 1999: 40).

In the Wessex area, dominated by groundwater supply (the Wiltshire and central western Dorset aquifers supply most of the area – c. 80% of the demand), most surface and especially aquifer stores are large, tending to be two-season critical (although the surface reservoirs are mix of large and small stores). Currently the Wessex area is therefore more vulnerable to droughts of two years duration.

The smaller stores with small catchments frequently experience no summer inflow in the present climate regime. Drier summers will therefore have no additional impact in terms of water harvesting, although increased evaporation under warmer conditions may have additional small effects. The reservoir supply (12 surface stores) in the Wessex area are mostly based in the catchments draining higher rainfall semi-uplands of Somerset.

In Hampshire winter flow 'excess' in the River Avon has been utilised to top up the Blashford Lakes (formerly gravel pits). Pipe links have been established which permit transfer of groundwater to the Somerset reservoirs in dry summers.

Given the importance of the groundwater resource, Aquifer Storage and Recovery (ASR) trials have been adopted in Dorset. ASR treats surplus surface water to drinking water standards when supplies are plentiful (principally winter) and returns this to the aquifer for use in peak demand periods. In full operation an ASR scheme is predicted to supply in excess of 20 Ml per day (enough to supply towns the size of Weymouth). Schemes such as these may prove increasingly important where abstraction excess and drier summers lead to late season low flows. Historically this has been a sensitive issue, for example in the rivers Avon (at Malmesbury), Wylye (south Wiltshire) and Piddle (Dorset).

Abstraction and Pump Storage

In the South Western part of the region, the impermeability of the regional geology and the steep and heavily dissected nature of much of the terrain ensures that there is minimal or no steady base flow and a need for significant surface storage. The lack of steady base flow also necessitates the reservoirs use as river-regulation points. This creates an additional demand on water availability as reserves are required to maintain river flows. Reservoirs therefore release water to maintain flow, and additional abstraction points are located near the mouth of major rivers (e.g. Wimbleball reservoir releases water to the R. Exe, which is abstracted to supply Exeter; Colliford reservoir releases to the R. Fowey; and Roadford reservoir to the R. Tamar which is pumped to N. Devon).

Abstraction points are sited as close to tidal limit as possible, to maximise the effective catchment. The Environment Agency monitors environmental and flow conditions to ensure that appropriate flow levels are maintained. Management of these abstraction licences is an important process, particularly if demand patterns or summer water availability patterns change. This tends to be a summer issue although some areas (e.g. Cornwall which currently receives most of its winter water via river intakes) could become vulnerable if multi-season droughts became more frequent.

In addition to downstream abstraction strategies, water supply is also managed through pump storage schemes that significantly enhance the water harvesting potential of a catchment. Here, where the reservoir occupies one limb of a catchment, abstraction pumps are sited downstream of additional tributaries to utilise water from parallel, un-dammed catchments. During periods of high flow, water is pumped from rivers to top up the local reservoir. This thereby maximises the effective catchment without having reservoirs in all tributaries. This is done as long as flow permits (i.e. minimum discharge) and top up is needed. For example, a tenfold increase in Wimbleball reservoir's effective catchment is achieved through an abstraction license permitting pumping between 1st Nov and end March. This permits the water to be drawn down from the reservoir at a greater rate, more secure in the knowledge that a winter replenishment is readily achievable. In effect this turns a multi-season reservoir into a single-season reservoir.

Offsetting Costs

Operation of these schemes is expensive, however, and the energy used in the Wimbleball pumping scheme costs £3k-£4k per day. Increased useage of these schemes will therefore impact on energy consumption and ultimately water pricing. To some extent this may be offset by local hydropower schemes: a good example is provided by the R. Tavey which at one time was generating England's cheapest electricity whilst supplying power for several hundred houses. As this shows, where water availability permits, water companies have the opportunity to mitigate against climate change.

Roadford and Burrator reservoirs generate energy continuously on river-compensation flow via supply release. If at certain times of year the supply control curves permit, release can be made specifically for power generation. This is particularly appropriate in reservoirs constructed relatively recently as each reservoir has a 50 years planned lifetime. New reservoirs therefore have over-capacity in their early life and can release water to generate power without prejudicing water supply. Such generation also favours the water companies in terms of the climate change levy.

Sea Level Rise

Rising sea level is a potential issue in a component of the integrated water resources strategy. Two potential operations are at risk. First, the abstraction of the low-flow compensation water at the mouth of major rivers (e.g. the River Exe). Abstraction generally occurs as low down the system as possible, i.e. close to the tidal limits of a particular channel.

Sea level rise solely or in combination tidal surges may lead to a greater incidence or further penetration of up-river saline penetration on the high tide. This could result in periodic shut-down of the major abstraction pumps. As several abstraction points are relatively close to current maximum saline incursion limits, this is viewed as a long-term threat. Nevertheless water companies may need to consider the potential for such intrusions when undertaking AMP 4 review.

A more significant threat is the potential for saline intrusion of key aquifers. The most significant of these is the East Devon aquifer (supplying 10% of SW Water's supply). Two locations may be at significant risk. First, the Otterton boreholes related to the River Otter. Two production bore holes supply water with 11 observation boreholes surrounding these used to measure water conductivity and water. This monitoring is in place so that warnings can be issued, enabling automatic abstraction cut backs.

Secondly, additional problems may occur in the Permian sandstone aquifer at Dawlish (which is a first resort local source with good quality and cheap water), which is environmentally acceptable - the Otterton water would otherwise flow out of cliffs.

Sedimentation

Climate change and changing agricultural practice may have a direct influence on land-erosion and subsequent re-sedimentation within reservoirs. Potentially this could impact on long-term resource planning by reducing the available storage volume of sensitive reservoirs.

(ii)Water Quality

Chemical

Whilst maintenance of water supply is perhaps the most readily appreciated issue in terms of potential vulnerability to climate change, the maintenance of water quality may in fact pose a more substantial problem. The principal

modes of vulnerability are associated with an increase in leached agrochemicals, surface sediment and contaminant run-off and a potential increase in water-borne pathogens.

Nitrates and phosphates are the principal agrochemical inputs which are monitored in relation to drinking water standards and the concentration of nitrates in particular has been shown to have a strong seasonality, with significantly elevated levels occurring in winter months.

It appears that higher groundwater levels result in higher concentrations, with soil nitrates being captured from by rising groundwater to flushed through following intense rainfall. However, there remains significant uncertainty in many instances as to the relative importance of:
(i) inputs increasing as a result of flushing/leaching of agrochemicals following higher precipitation; and
(ii) relative concentrations decreasing as a result of increased discharge (see EA 1999: 41).

Nitrate levels are considered more of an issue in the groundwater dominated Wessex Water area than in the peninsular South West that also has a less significant proportion of land use associated with arable agriculture. Wetter winters, as predicted in the UKCIP02 scenarios are thought likely, by Wessex Water, to lead to an increase in nitrates during winter months.

Biological

In the SW Water area a potentially greater concern is the increase in water-borne pathogens, in particular *Cryptosporidia*. The oocysts of the *Cryptosporidia* which can cause severe gastro-intestinal disruption are too small to be filtered from the water at a rate sufficient to meet water demand. They are also not easily detected by direct monitoring. However, the close association between *Cryptosporidium* occurrence and suspended sediment concentration allows the Drinking Water Inspectorate (DWI) to require automatic shut-down mechanisms at abstraction points that are triggered when water turbidity exceeds a prescribed value.

Increased rapid run-off as a result of potential storminess increases and wetter winters may result in increased incidences of *Cryptosporidium* contamination. It is thought probable that more clean-up plants will be required to counteract the potential increase in *Cryptosporidium* events.

A notable *Cryptosporidium* event occurred in the South Hams area of Devon in 1995, following heavy rainfall after a prolonged dry period.

Algal blooms and eutrophication (excessive nutrient enrichment) also have the potential to increase in response to the warmer and drier conditions predicted by UKCIP02 scenarios.

The latter is a particular problem to conservation and biodiversity, but also impacts on water quality. In addition to nutrient status, the decreasing solubility of gases in warmer waters, with consequent reduction in the dissolved oxygen holding capacity is a major factor controlling eutrophication. Algal blooms however are more serious in terms of water supply and can lead to harmful toxicity levels within standing water masses such as lakes, canals and reservoirs.

Elevated temperatures occurring when water levels are low can lead to a lack of oxygenation and turn-over in the water column. Shallow water is particularly sensitive in this respect and depleted reservoirs may be more vulnerable. It is possible that some reservoirs may need minimum water levels to be revised. The Roadford, Clatworthy and Upper Tamar reservoirs have all experienced bloom and eutrophication impacts and more work may be needed to investigate the potential elsewhere.

Agricultural catchments are particularly vulnerable to eutrophication and algal blooms as increased nitrate and phosphate levels enhance the conditions for their occurrence. The increase in temperatures is likely to see an increase in early and late season phytoplankton growth as the favourable temperature range is 10^{o}C to 20^{o}C with a decline in growth rate occurring only after 25 ^{o}C (Arnell *et al*., 1994).

Organic Material

Other water quality issues (EA, 1999) linked to climate change relate to:
(i) treated sewage effluent
(ii) changes to soil matrix; and
(iii) agricultural waste products and manures.

Agricultural activity in the South West forms significant sources of pollutants. However, in many areas sewage treatment works form the primary source of pollutants in rivers (EA, 1999) and the treated effluent contributes much of the biochemical oxygen demand (BOD) and ammonia load which reduce dissolved oxygen concentrations. Higher water temperatures lead to increased rates of biological activity with a tendency to reduce in-stream oxygen levels, although the potential enhancement of aquatic plant growth and photosynthesis could offset this. Temperature-driven reduction of in-stream oxygen levels could be compounded by a decrease in water levels.

Given that sewage treatment works are more efficient at higher temperatures it is uncertain whether climate change will have positive, negative or neutral effect on this aspect of water quality. Nevertheless, at certain times of the year if river flows are greatly reduced sewage

treatment plants will have a negative effect on water quality due to the lack of dilution. This will be compounded by the fact that population increase is significant in dry periods due to tourists and therefore sewage treatment works are treating higher flows of concentrated sewage.

Drying, however, has a pronounced effect on soils particularly where clay-rich. Shrinkage and cracking during desiccation is followed by swelling after rain. The cracks and fissures remain sometime after the onset of rain. Nutrients and other active chemical agents which would otherwise by adsorbed by the clay particles or taken up by plants, are more readily transported to the groundwater and water courses.

In the water companies a major concern principal relating to climate change is the potential for increased winter precipitation to magnify the run-off related risk of point-source agricultural pollution.

(iii) Sewage Treatment and Disposal

The impacts of climate change on sewage treatment work capacity and size of sewers are regarded by water companies as being probably of greater significance than direct water resource issues. The network of foul sewers is largely 19th or early 20th century and its capacity and state of repair are such that significant investment is required. The impression given by the water companies in the South West Area suggests that this issue may not have received as much attention as in the Lower Severn area in the north of the Region.

The main issues are seen as:

(i) over-flow of the foul sewer into settlement areas
(ii) overwhelming of sewage treatment works by river flooding, direct run-off or interception of urban storm run-off by foul sewers
(iii) overwhelming of storm sewers by surface runoff intensities greater than design capacities;

(iv) over-performance of treatment plants setting the norm against which water quality targets are set and therefore potentially requiring investment in plants that are not 'over-performing'.

Domestic and settlement-area contamination frequently occurs following flooding. Whilst consented sewer outfalls (CSOs) permit sewage overflow into rivers during floods, the issue of backing-up still occurs when water levels are high. Individual properties can be protected against sewer back-flooding by the introduction of one-way valves. New-build and re-plumbing schemes may be advised to incorporate such valving where properties are low-lying. However, localised flooding is increasingly caused by run-off excess which is inherently less predictable; the identification of properties at risk is not straightforward. Siting of new CSOs is probably best considered down-stream of settlements to minimise potential contamination.

Overwhelming of sewage treatment works by river flooding, direct run-off or interception of storm run-off by urban foul sewers is an area of concern particularly in relation both to increased winter precipitation and the potential increased storminess. Whilst many sewage treatments plants are over-sized to accommodate for growth and safety margins there is still potential for plants to be overwhelmed as a result of increased run-off likely though climate change. In the AMP4 price review, water companies may push for climate change to feature in the costing of over-sizing of sewage treatment plants.

Over performance of sewage treatment plants is commonplace, though varies depending on water company strategies and in some instances the outflow may have a positive influence on the water quality downstream. As climate change may be a driver to generally lower water quality (increased nitrate fluxes, temperature increases, eutrophication etc.) there is a potential concern that over-performance may be required or may need enhancement.

Regulators such as the Environment Agency may need to tighten consent in order to follow protocols such as the Habitats Directive which requires 'no deterioration' in the quality of water courses. In contrast to this, where 'over-performance' is not occurring, summer low-flows may impede future consents to discharge from sewage treatment plants. Whilst low flows will impact on treated sewage discharge in all catchments, smaller, lower category plants, usually in smaller catchments are most likely to fall into this category and the peninsular South West (Devon and Cornwall) is most likely to be at risk here.

Sewage sludge remaining after the fluid element has been discharged is posing an increasing problem. Disposal at sea is no longer permitted and the British retail organisations (especially the supermarkets) are concerned about disposal on agricultural land. Frequently the supermarkets insist that their suppliers' land does not receive sewage sludge dressings, and in all instances where sludges are disposed on land the supermarkets require prior treatment. Where land is available, wet ground conditions prevent the disposal of the sludges as access is not possible. Climate change is thought likely to exacerbate this difficult issue, with additional threats posed by rapid nitrate wash-through following winter dressing.

iv) Maintenance of flow levels in rivers and water levels in aquifers

Low flows in rivers have been discussed in the above section in relation to water quality and supply and in the Rivers, Flooding and Drainage Domain. Additionally, it is important to stress the significance of the Environment Agency's Catchment Management Plans (CMPs) and abstraction management strategies that have responded to the potential for climate change. The latter are particularly important in relation to consents for agricultural and industrial abstraction that may have particular impact on headwater drainage systems and local aquifers.

Perceptions and levels of understanding

Climate change is an issue owned convincingly by the water companies and the Environment Agency. Studies have been undertaken to assess water resource predictions etc. using the UKCIP98 scenarios.

Public awareness of the water resource issue is increasing through the educational role of the Environment Agency and the water companies. The level and consequences of this knowledge (e.g. use of grey water, hippos etc.) is, however, uncertain and partial. More effort is needed in terms of education and this is reflected strongly in the findings of the Cheltenham Climate Change Forum (2001), both in terms of water resources and more generally.

The Way Forward

In general terms there appears to be a good degree of cooperation between the water industry and its environmental regulator (the Environment Agency). OFWAT reports that it is following the climate debate with interest and takes advice from the Environment Agency on all matters connected to climate change. It is clear that water companies and regulators need a common base – to agree climate change is an issue and then engage in an in-depth three-way debate. There is some disquiet surrounding the opposing demands requiring the water companies to assume responsibility for water conservation whilst encouraging householders to move to water metering (e.g. 34% of SW customers are on meters). In effect, companies are asking for water -conservation with a reduction in their income as the consequence.

In terms of water supply, a trend towards hotter, drier summers is the most significant climate prediction. The UKCIP98 scenarios did not reveal any major, unconsidered issues associated with water supply. The research and development agendas of the water companies have responded well to these predictions, but continued work is required to assess the UKCIP02 scenarios.

A critical issue may be the difference in predicted annual rainfall trends, and its significance for recharge vs. draw-down as discussed above. However, it does seems probable that only the longer droughts will be of particular significance, with the impact of predicted rainfall variability - in particular seasonal shifts - being of lesser importance. These longer droughts, which were not predicted in the UKCIP98 scenarios, would challenge the 2-season reservoirs and the pump-storage schemes that have converted larger 2-season stores into operational 1-season reserves.

Recommendations

The climate change issues have clearly been taken seriously in the water resources sector. Indeed, whilst there are clear areas of potential disagreement between the water companies and their regulator (the Environment Agency), the public-private partnership that these organizations have developed should be viewed as an example of good practice in the climate change debate. It is clear that much of the research informing climate change science is derived from the research teams established by the Agency and by the water companies, both separately and in partnership.

Greater effort is needed to enhance the public (i.e. the domestic consumer's) knowledge of the potential impact of climate change and their individual abilities both to adapt to and mitigate against climate change.

Climate Change as an economic and environmental driver needs to be factored into policy more strategically by OFWAT than is currently the case.

Challenges and Opportunities of Key Climate Impacts for Water Resources Domain

Climate Impact		Challenges + Opportunities
Summer Temperature	C	Increased evaporative losses from surface water stores.
Increased	C	Increased risk of water demand rises leading to reservoir draw down.
	C	Increased risk of algal blooms and eutrophication in reservoirs containing reduced water levels and low inflows.
Summer Rainfall	C	Increased risk of water demand rises leading to reservoir draw down.
Reduced	C	Increased risk of algal blooms and eutrophication in reservoirs containing reduced water levels and low inflows.
Winter Rainfall	C	Increased run-off may lead to over-stressing and backing up of sewer network.
Increased	C	Problems with transfer of sewage sludges to agricultural land though difficulty in spreading and land access.
	C	Increased potential for nitrate flushing into water stores and courses.
	C	Increased potential for soil erosion and sedimentation.
	O	Greater potential for increasing water releases for hydropower.
	O	Greater potential for one-season recharge of larger reservoirs and aquifers.
Sea Level and Tides Increased	C	Potential for saline incursions into water abstraction plants near river mouth (e.g. Exeter).
	C	Potential for saline incursions into groundwater abstraction boreholes (e.g. Dawlish).
Longer Growing Seasons and Reduced Frosts	C	Potential for an increased growing season could lead to more intensive land use and greater incidence of winter ploughing, with associated sediment erosion into reservoirs and storm sewers.
Flooding Increased	C	Potential over-loading of sewage treatment plants.
	C	Floods can lead to over-stressing and backing up of sewer network.
	C	Distribution may be affected adversely by localised flood events.
Potentially Increased Winds and Storms	C	Increased potential for soil erosion leading to elevated turbidity and cryptosoridium contamination of drinking water.

CHAPTER 7

SOCIETY AND INFRASTRUCTURE DOMAINS

LIKELY IMPACTS & POSSIBLE ADAPTATION RESPONSES

Introduction

This section considers those domains in the South West which fit broadly under the heading of 'society and infrastructure'. Such headings are necessarily arbitrary but have proved useful in progressing and reporting on the study. So, the section explores the following impact domains:

1. Built Environment
2. Health
3. Heritage
4. Housing
5. Transport
6. Utilities

(For details of the methodology adopted for researching and reporting on these domains please see Annex 2.)

This introductory section precedes the detailed consideration of each domain and considers some of the general issues that relate to climate change and its impact on 'society and infrastructure'. A brief discussion of these general issues is followed by a summary table of recommendations.

Physical Infrastructure

The physical infrastructure of buildings, bridges, power transmission lines, transport (road, rail, air) and heritage (both natural and built) is vulnerable to most aspects of climate change. The necessary lead-time and investment periods justify serious risk assessment based on UKCIP02 scenarios. Whilst changes in average conditions (e.g. increased rainfall in winter) will have some effect on infrastructure, it is mainly changes in extreme conditions that will have the greatest impact. For example, although the UKCIP02 scenarios do not suggest any significant overall changes in windiness and storms, the likelihood of extreme one-off wind and storm events will increase, and it is these that will cause physical damage. The main impacts are therefore likely to include flooding (riverine, coastal and urban) and wind damage.

Climate change will affect energy demand, with reduced heating requirements in the winter, probably offset by increased demand for summer cooling. Of particular importance to the region is the potential opportunity for renewable energy: biomass, vegetable oils, solar, hydroelectric, wind and wave power are all areas upon which climate change will impact. More work is required to understand better the subtle impacts of the different climate variables.

Lifestyle

Lifestyle will influence climate change (through patterns of energy usage, transport etc) and be influenced by it (through choices in holiday patterns and destinations, increased *al fresco* eating etc). Such changes are elusive and there is little literature on the subject. Nevertheless we can look to examples of societies and cultures that operate in the type of climates that we anticipate, as an indication of the way that society in the region may develop.

We have identified some possible lifestyle impacts in the South West. These include the increased use of bicycles and walking as modes of transport; increased use of external spaces in urban areas (with a consequent impact on the street scene); increased outdoor recreation (with potential improvements in general health); but exposure to radiation and associated cancer risks. More research is required to track possible lifestyle changes and their wider implications.

The Management of Change

The management of physical infrastructure will be dealt with in very different ways. Existing structures may need modification to accommodate new weather conditions, but in most cases it has been judged that the cost of modifying existing structures to cope with increased vulnerability is too great to justify this type of investment. Obvious exceptions include improvements to certain flood defences. On the other hand, new buildings and structures can be designed with these future scenarios in mind. Technical standards, codes and regulations need to change to reflect the anticipated climate.

Adaptation responses must be managed in a way that does not exacerbate the global warming phenomenon by increasing greenhouse gas emissions. In the built environment there is the potential need for increased cooling in summer: conventional responses would install fans, air-conditioning or similar cooling devices, all of which will increase energy consumption, and therefore increase global warming. This is a vicious circle that must be avoided.

There are philosophical and political implications, as well as economic ones, in considering how best to manage some of this change. Generally decisions will be more easily made in the public sector, particularly at the large scale, if climate change attains sufficient priority. Some aspects of the private sector can be controlled by legislation, regulation, fiscal policy etc. Perhaps the biggest challenge will be influencing individuals and householders to adapt to the changing climate in ways that do not make the global climate even more challenging.

Recommendations for Society and Infrastructure Domains

- Review regional infrastructure for transport and utilities in order to identify further areas of vulnerability to climate change over a long time scale.

- Review opportunities for increased production of renewable energy as a result of potential climate change: e.g. wind, water turbine; solar; biomass; wave; tide; biofuels.

- Undertake further research into lifestyle changes associated with climate change, including the implications for the socially excluded.

- Change relevant codes and standards to reflect anticipated climate conditions, particularly with regard to increased summertime temperatures, grey water systems, and increased exposure to driving rain and wind damage from extreme events.

- Invest in research into offshore **renewable energy** sources - wind, wave energy, and reassess the environmental and economic effects of the Severn Barrage.

- Design **new buildings** to anticipate reduced heating load in winter and passive cooling in summer.

- Investigate passive or low energy techniques for increasing ventilation rates and cooling for **existing buildings** in higher summertime temperatures.

- Increase awareness amongst those with responsibility for developing and managing **housing** stock: (including housing developers, Registered Social Landlords, local authorities, Housing Corporation, designers, and owner-occupiers).

- Include adaptation to climate change within regional strategies for **sustainable construction.**

- Review potential impacts of extreme events (storms, floods, high temperatures, etc.) on **transport infrastructure** (road, rail, air, shipping) and undertake appropriate risk assessment.

- Review enhanced specifications of maintenance regimes for **transport infrastructure** (road, rail, air, shipping).

- Encourage pedestrian and cycling modes of **transport** where improved climate conditions permit.

- Undertake feasibility studies for alternative and diversionary routes for those strategic **rail and road routes** that are threatened by climate change impacts and extreme events, and lobby at national level as appropriate.

BUILT ENVIRONMENT DOMAIN

Scope

The design, construction, maintenance and use of all building types; other engineering structures and systems (except transport and utilities infrastructure). Aspects specific to the location, design and construction of housing are dealt with in the section on Housing Domain.

See Also

Housing, Utilities, Heritage, Water Resources, Environmental Technologies.

Background

Data on the existing regional building stock is elusive. Available data is split broadly between housing and other building types. There were approximately two million dwellings in the region at the 1991 census. The amount of non-domestic floorspace in the region is indicated in the 1994 figures below.

Use Category	Floor area (,000 $m^{2)}$
Offices	5,000
Retail	9,000
Warehouse	7,000
Factory	18,000
Others	17,000
Total	**56,000**

Around 50% of the retail provision and 40% of the office provision pre-dates 1900.

Industrial development reflects the national pattern of 19th century factories and warehousing being replaced by new post-war industrial estates, many of which are in new, out-of-town locations. Overall the trends towards national and international approaches to building construction mean that most of the recent (post 1950) buildings will have national rather than regional characteristics.

It's really good that you are doing this study in this way. Its not until we take a look at climate change in this sort of detail that we realise how important it could be.

Architect in SW Region

There is a growing expertise in, and examples of, 'Sustainable Construction' in the region. Architects such as Fielden Clegg Bradley, Gale and Snowden and The Somerset Trust for Sustainable Development provide regional expertise and examples of good practice. (See also Future Foundations.)

Key Issues

Adaptation issues in the built environment must be addressed within the wider context of the construction industry to have any meaningful effect. This is reflected in many of the points raised below:

- The design and construction of buildings continues to keep pace with general economic growth, and will continue to make up a large proportion of the national and regional economy.
- The expected lifespan of new and existing buildings (say 20 to 100 years) allows issues related to the built environment can be considered over a similar time period to that of current climate change predictions.
- Building Stock is replaced at about 1% per annum. So, as well as considering design strategies for new-build, it will be important to consider the refurbishment and maintenance of existing buildings to accommodate climate changes.
- Restructuring of the industry will lead to larger UK based companies and the general European-isation of the industry. This will apply to contractors and those companies providing building materials, products and components.
- Changes in design and construction in response to the sustainability agenda will increase, driven by central and local government policy and European legislation.
- The location of new developments must take account of the increased potential for coastal, riverine and urban flooding.
- Different strategies are required to deal with both the design of new buildings and structures and the management and maintenance of existing building stock.
- There will be increasing emphasis on the need for the cooling as well as the heating of buildings, especially in the southern part of the region.
- Practical technologies are required for the passive cooling of buildings (both existing

and new) in order to avoid further releases of greenhouse gases in energy-consuming cooling, ventilation and air-conditioning plant and equipment.

- Increased solar radiation should improve the performance of solar panels, photovoltaic cells etc. throughout the region and especially in the south. More information is required on the incidence of cloud cover and other climate features to understand the full impact.
- The reduction in demand for heating will reduce heating costs although the capital costs of heating installations will probably remain the same, in order to cope with continuing cold spell conditions.
- The impacts on site construction processes are not considered to be great. Generally site conditions will be improved (e.g. less days lost through frost) though there may be increased vulnerability during the construction process from winds, rainfall and storms, especially in exposed locations.

Traditional buildings in, for example France, may provide exemplars for design and construction details to cope with new climate. e.g. small windows, high-ceilings, external shutters, internal reflecting blinds.

- Increased use of existing technologies is required to reduce the consumption of mains potable water in buildings (both existing and new), especially in summer.
- Both existing and new buildings may be exposed to higher intensities of driving rain in winter, making certain types of construction vulnerable (e.g. cavity filled walls).
- There is considerable scope for linking adaptation strategies for the built environment in response to climate change to the growing understanding of sustainable building construction.
- A combination of sustainable construction and responses to climate change, particularly increased temperatures, could lead to a regional (or sub-regional) 21st century vernacular construction.
- There are potential lifestyle changes, particularly to do with the greater use of the external environment associated with buildings, both public and private.
- The construction industry is ill-informed about, and ill-prepared for, climate change impacts. Wide ranging education and training is required across the whole sector.
- There is considerable need to increase awareness of potential climate change and implications for the whole of the construction industry, particularly building design.

Building Stock is only replaced at about 1% per annum. So, as well as considering design strategies for new-build, it will be important to consider the refurbishment of existing buildings to accommodate climate changes.

Lowe 2001

- Finer grain data on some climate variables is necessary to determine appropriate responses. e.g. extremes of temperature, solar radiation, diurnal temperature changes.
- Standards and design criteria within existing industry practice guidelines will need modification. It will also be essential to shift sector use of meteorological data from historical to future based data.

There is already expertise in the design of sustainable buildings in the South West Region. This can be exploited to design new, regional buildings that are both sustainable and anticipate changes in climate.

STSD Conference 2002

- Commercial opportunities exist for developing regional expertise in passive solar heating, cooling, shading and other such environmental technologies.

Issues of particular regional concern

Some of the potential changes in climate need to be examined further in order to understand the differential impacts across the region.

- Specific locations within the region are potentially vulnerable to coastal and riverine flooding. *(See Coastal and Flooding Impact Domains.)*
- Specific locations within the region are vulnerable to extremes events of winds and storms.
- The geographical differences in temperatures across the region, leading to increased demand for cooling of buildings to achieve thermal comfort, especially in the more southerly locations.
- Reduced heating demand due to warmer winter temperatures. In the southern part of the region this will mean a reduced requirement for conventional space heating.

Adaptation is still not broadly understood in the construction industry. Building owners are unaware of possible impacts, particularly to structures built before stringent workmanship controls were in place.

Buro Happold 2002

- Increased solar radiation providing opportunity for solar gain to provide both heating in winter and cooling in summer. Again this will apply to the whole region but with greater opportunity in the south.
- Opportunities for exploiting external and semi-external environments.

The Way Forward

The expected lifespan of new and existing buildings means that the timescale for climate change scenarios is of direct relevance to the design, construction, maintenance and use of buildings.

Action needs to be applied immediately as buildings constructed now will be required to operate in conditions at least of the 2020's scenarios, and probably of the 2080's scenarios.

Design options are available to minimise climate impacts on new buildings. Design can minimise subsidence in clay soils, dampness from rain penetration, and weather damage to materials. These may incur additional capital costs at the outset, but are likely to be offset by consideration of lifetime costs.

Calculations suggest that in most cases there are unlikely to be cost-benefits in radical improvements to existing buildings. Regular maintenance to a good standard is the general guidance.

Good design can also help to reduce the need for increased air conditioning through the provision of good ventilation. Otherwise the increase in air-conditioning is expected to absorb the 12% - 19% energy-use savings that could be expected from the warmer winters. This will in turn add to global warming.

Changes to Building Regulations and other standards are required to address these issues.

The integration of information on Climate Change into design tools that support standards is a step that could be taken more quickly and easily than the amendment of the standards themselves. (E.g. BREVe, a software tool for calculating design windspeeds and loadings.)

Lowe 2001

There is an urgent need to develop passive designs and low-energy technologies for cooling, as well as more efficient air-conditioning equipment. (e.g. BRE/DEFRA market transformation initiative on air-conditioning).

Planning can help to avoid problems from flooding and coastal erosion.

In addition, the finance industry may take a stronger view about future-proofing building designs as pressures build on insurance companies to increase premiums or withdraw totally from insuring buildings in certain vulnerable locations.

Landowners, developers and sponsors of new buildings, particularly local authorities, can nominate standards of performance for new build that recognise potential changes in climate.

Sustainability

There is some evidence of regional enthusiasm for, and expertise in, the idea of sustainable building construction. (STSC Conference: Taunton June 2002). It is clear that adaptation of the built environment to climate change is unlikely to be pursued in its own right. However, there is considerable scope for linking adaptation responses to the wider sustainable construction agenda. (e.g. South West Future Foundations, SWRDA)

It would be useful to develop more distinct regional approaches to design and construction of buildings in the future. This is inconsistent however with the observed tendency to minimize or eliminate regional variation. The trend towards larger construction companies, encapsulated by 'Re-thinking Construction', tends to work against regionalisation of construction. The development of systems and approaches that allow and promote appropriate regionalisation despite these trends must be a matter of priority. (Lowe 2001).

As the built environment accounts for roughly 50% of greenhouse gas emissions in the UK it is important to seek further reductions in the use of energy generated from non-renewable sources. The continued implementation of energy saving measures and the use of renewable energy will both assist in this matter.

Knowledge levels

There is little evidence that the sector has made any use within the region of the latest scenarios published by UKCIP, although there now some studies underway nationally. Climate scientists, natural scientists and natural resource managers within the region have a grasp on the data and the issues. For others the phenomenon does not appear to justify research. The built environment domain is one where the climate scenarios can at least be used for modelling, for example thermal performance as part of a decision making and design process, as in the BRE tools for determining insulation, glazing etc.

Some professionals in the South West acknowledge the potential impacts of climate change on the built environment, but for most practitioners climate change means mitigation – reduction in energy usage and greenhouse gas emissions, not adaptation. A regional firm of architects with a high reputation for the design of sustainable buildings admitted that they had no formal policy on adaptation to climate change. Another firm of environmental engineers with an international reputation reported a tacit rather than explicit approach to adaptation issues.

Adaptation is still not broadly understood in the construction industry. Building owners are unaware of possible impacts, particularly to structures built before stringent workmanship controls were in place. (Buro Happold 2002.)

The potential hazards of flooding are acknowledged, and the statutory and advisory roles of the Environment Agency and Local Planning Authorities seem appropriate to deal with these issues.

Wessex Water Operations Centre building is interesting due to the number of strategies that the client was not prepared to commit to at construction stage, but allowed space for retro-fitting at a later stage. e.g. photovoltaics, cooling system.

Wessex Water

Building designers and consultants identified potential litigation as major concerns. It was unlikely that previously completed projects would be revisited, but new buildings must be designed to industry standards. We were advised therefore, that changes in standards that reflected potential changes in climate would be a highly effective mechanism for improving performance.

Initiating change

The following recommendations for arose from discussions within the sector:

- Change Building Regulations to reflect anticipated climate conditions, particularly with regard to increased summertime temperatures, grey water systems, and increased exposure to driving rain and wind damage from extreme events.
- Change professional and trade Codes and Standards to reflect anticipated climate conditions through appropriate lobbying of professional bodies, trade associations etc.
- Introduce future-based climate scenarios, rather than historic meteorological data as the basis for technical decision-making.
- Educate the construction industry including architects, surveyors, engineering and environmental consultants as well as contractors. Initially this may concentrate upon regional interpretation of the UKCIP02 scenarios, and then proceed to wider implications for the industry.
- Develop new forms of building contracting and procurement that requires developers to take responsibility for their products over a longer period of time.
- Develop strategies for future-proofing existing building stock, including the development of robust repair and refurbishment standards.
- The focus should be on the shift in emphasis from heating to cooling, particularly in urban locations, and in the south of the region.

- Encourage continuing dialogue between developers, designers, contractors, occupiers, financiers and insurers on all aspects of climate change, probably through the SWRDA, GOSW, professional bodies and trade associations.

Potential barriers

The need to adapt to potential climate change is not widely acknowledged in any part of the construction industry, whether this be clients, designers, or contractors.

It is suggested that there are two main reasons for this reluctance to engage with adaptation issues. These are to do with both the type of data available and the degree of uncertainty attached to the data.

While uncertainty is bound to reduce the level of practical response, straightforward ignorance is still a principal barrier. This ignorance probably results from the way in which climate data and scenarios are presented. It appears that, even in a sector that makes some use of quantitative predictive techniques, a more practical representation of climate is needed if the industry is to grasp the likely changes and their implications.

Despite this, some more sophisticated data is required within the industry if environmental engineers are to quantify the opportunities for passive collection and the challenges of sustainable cooling strategies.

A further potential barrier to change is the trend towards pre-fabrication, particularly of housing. This invites a national (or even international) approach to building design, rather than a regional, climate responsive approach.

Challenges and Opportunities of Key Climate Impacts in Built Environment Domain

Climate Impacts		Challenges + Opportunities
Increased Summer Temperature	C	Overheating within existing and new buildings.
	C	Building fabric exposed to thermal stress.
	O	Increased requirement for specialist expertise in technical aspects such as cooling, ventilation, passive solar design.
	O	Increased solar gain for passive water heating, photovoltaics etc.
	O	Prospect of new internal finishes (e.g. ceramic floor tiles in place of fitted carpets).
	O	Increased opportunities for outdoor activities relating to the built environment.
	O	Generally improved construction site conditions.
Reduced Summer Rainfall	C	Drying of substrata, especially in clay areas such as Bristol, Dorset, Gloucestershire leading to increased subsidence & associated insurance claims.
	C	Water supply problems both during construction and during building's use.
Increased Winter Temperature	O	Less requirement for space heating (fewer degree days).
		Possible increase in demand for canopy type structures externally.
Increased Winter Rainfall	C	Litigation risks for consultants and contractors, associated with both new designs and existing buildings.
	C	Some worsening of construction site conditions e.g. concrete, mortar etc.
	C	More robust designs required for rainwater disposal systems above and below ground.
	O	More water available, but will need capturing and storing, and require incentives from water companies to reduce consumption from mains supply.
Increased Sea Level and Tides	C	Restrictions on location of proposed developments.
	C	Requirement for flood defences to protect existing buildings.
Longer Growing Seasons and Reduced Frosts	C	Lawns and other amenity planting likely to require more maintenance.
	O	Less days lost through frost on construction sites.
Flooding Increased	C	Litigation risks for consultants and contractors, associated with both new designs and existing buildings.
	C	Higher specifications required for new drainage systems (especially urban)
	C	Improvements required to existing drainage systems (especially urban).
	C	Opportunity for introducing Sustainable Urban Drainage Systems (SUDS) in new developments.
Potentially Increased Winds and Storms	C	Walls and windows, especially cavity-filled walls vulnerable to driving rain penetration, especially in exposed locations.
	C	Structures and roofs vulnerable to damage in exposed locations.
	C	Buildings and infrastructure under construction vulnerable to extreme events, especially in exposed locations.

HERITAGE DOMAIN

Scope

The management, conservation and protection of the historical and natural heritage of the South West Region, including the designed landscape, parks, gardens, buildings, environmental & human archaeology and the natural landscape.

See Also

Rivers and Flooding, Water Resources, Coastal, Natural Environment, Built Environment, Tourism

Background

The South West region forms one of the UK's richest areas of natural and human heritage, containing for example 46% of England's Grade I listed buildings.

Percentage (%) of England's classified heritage found in the south west

	I	II*	II	Total
Historic Parks and Gardens	24	20	17	19
Listed Buildings	46			24
Scheduled Ancient Monuments				32
Conservation Areas				18
Protected Wrecks				41

The Heritage as discussed here (c.f. Natural Environment, specifically) is largely controlled, managed, and conserved though the aegis of the National Trust, English Heritage and Country Archaeological groups. National Parks, with their designated governing bodies and Areas of Outstanding National Beauty (AONBs) form important designations in the conservation and management of the landscape. Individual landowners (e.g. Duchy of Cornwall) and property owners also play an important part in this process.

Heritage in the region is particularly important in the context of tourism, and forms an important facet in the marketing of the region both site-specifically and as a whole.

Key Issues

- Deterioration of unearthed archaeology driven by drying out of uplands with enhanced heather growth and greater rooting densities
- Loss of archaeological remains and degradation of their palaeo-environmental context driven by accelerated oxidation arising from greater variability of water table in lowland wetlands (e.g. Somerset levels, Exe valley) as a result of shifts in rainfall and evaporation patterns
- Deterioration of unearthed archaeology arising from the potential ground-disturbance effects of agricultural changes (e.g. willow expansion, as bio-energy crop; exploitation of wetlands for crops requiring higher moisture, when free-draining valley sides become drier);
- Exposure and damage of buried archaeological remains (track-ways etc) in the inter-tidal zone caused by increased storminess and potential sea-level rise;
- Damage to protected wrecks as a result of increased storminess;
- Increased costs associated with maintenance of coastal structures (e.g. National Trust owned harbours) arsing from accelerated damage brought about by increasing storminess and sea-level rise.
- Increased management tensions and conflicts between conservation agencies and local communities brought about by implementation of 'managed retreat' or 'managed re-alignment' of coastal and riparian margins.
- Increased visitor pressures and increased revenue for historic buildings brought about by expansion of tourist season and increase in the number of short-break holidays predicted within a warmer climate;
- Potential increased insurance costs for listed buildings and National Trust properties arising from climatic damage
- Maintenance of historical planting schemes in gardens created in colder climate – e.g. increased grass cutting will raise maintenance costs.
- Potential increase in storm damage, light-degradation, rain damage, fungal and beetle damage to the exterior and interior of historic buildings;
- Changes to natural landscape contexts for heritage sites, National trust land, AONBs etc. as a result of climate driven vegetational shifts.

Issues associated with heritage and climate change can be broadly split into those pertaining to the 'natural' and those relating to the 'designed' landscape. In the context of designed landscape, a further sub-division can be made into archaeology (buried and above ground), historic

buildings and structures, and designed landscapes (parks, gardens etc). Each of these 'territories' is examined discretely.

Effects upon historical environment

Key issues concern the management of coastline and decisions on protection, managed re-alignment or retreat. Regional examples include Porlock Shingle Ridge (half National Trust owned)– breached in 1996 – where decisions were made to allow natural change. Freshwater marsh inland has now become brackish despite some pressure to re establish the shingle ridge.

There is often local pressure to preserve landscape, as this is what local people are familiar with. In other areas (e.g. Birling Gap E Sussex) the National Trust has allowed cottages to 'fall into sea' rather than attempting to protect them.

Designed landscapes

Significant park and garden acreage occurs in the South West. A large number of these landscapes have been created or laid out in the seventeenth and eighteenth centuries – a time period when Europe was at the height of the so called Little Ice Age. The potential impacts of climate change on these designed landscapes are various.

The historical shape and/or planting schemes that were designed for tolerance to colder climate may become unviable in the future. One of the most notable examples of a garden potentially at threat is the Late Seventeenth Century garden at Westbury Court, Gloucestershire on the banks of the Lower River Severn. Here repeated flooding over the last decade has created management problems particularly associated with the increased incidence of the water-borne pathogen *Phytophera* (related to potato blight) that has begun to attack the important and extensive Yew Hedge plant-scape. Westbury Court Garden is a site whose long-term viability has been directly questioned, with the threat being attributed particularly to climate change.

Other impacts have been on historical fruits such as the medlar. This was a popular Elizabethan fruit that was eaten after exposure to the first frosts in autumn. The lack of autumnal frosts in recent years has meant that these fruits are only edible after been deep frozen for six hours after picking. Both increased flooding and frost reduction are predicted in the UKCIP02 scenarios.

Climate change is also thought, already, to have influenced the management of some garden sites owned by the National Trust: Properties once closed for the entire winter are now closed for only 6 weeks. The South West, in particular, has witnessed such changes. These can be partially attributed to changing character in tourism-demand (e.g. the move to short-break holidays, and off-season breaks).

Nevertheless, the National Trust regards climate change as being one of the significant drivers in the longer opening season of garden properties. Many of the region's National Trust Gardens have a predominantly spring focus and warmer, drier springs have brought forward the first flowering (e.g. of camellias, flowering bulbs and rhododendron). Notable gardens with extended opening include the Cornish Trelissick and Glendergan gardens, both of which have started flowering earlier, potentially as a result of climate change.

Whilst this has greater cost implications for management it also increases income and is considered valuable for local employment by reducing its seasonality. The increasing short-break, off-peak trend in the region has also benefited the National Trust which is a considerable owner of holiday cottages. The occupancy of these has increased, again reducing the seasonality.

Water resources in heritage gardens may also become an issue, either through increased demands on irrigation to maintain historic planting, or through low-flows (or flood flows) diminishing or damaging water supply associated with formal water-gardens and pond systems. Water harvesting assessments may be needed to optimise such water gardens, e.g. as the Painswick Rococo gardens in Gloucestershire (McEwen and Hunt, 2002).

Additional threats associated with water features relate to ponds and lakes whose catchments are susceptible to overland flow and sediments erosion. Shifting agricultural practice and climate change may combine to accelerate sediment infilling of such features, leading to a dredging requirement. Dredging in such situations can lead to the loss of valuable palaeo-environmental data and should only be undertaken after sediments have been recovered for analysis. These sediments may hold valuable evidence that can be used to reconstruct environmental change (e.g. flooding histories) in specific garden catchments, which in turn can be used to investigate and monitor the impacts of climate change itself (valuable evidence was lost, for example when 300 years of sediment accumulation were dredged from the ponds at Westbury Court in the early 1970s, removing evidence of the flooding history of the River Severn).

Historic buildings, as with significant proportions of the building stock, are at risk from specific aspects of climate change related phenomena. Maintenance of historic buildings can range from the relatively recent structures (such as Castle Drogo, built between 1910 and 1930) through to decaying mining structures such as the Cornish tin mines and ruined buildings such as the 13th Centrury Hailes Abbey in Gloucestershire and Tintagel Castle in Cornwall.

Ruined sites pose particular problems as they are not readily protected from the weather. Shelter buildings are generally not deemed as allowable as they would have too great an impact on the settings of the protected structures (John Fidler, pers comm. 2002). In extant as well as with ruined buildings, the strong conservationist approach required ensures that climate change will remain a difficult issue. Replacement materials are required to be in sympathy with original materials, and internal changes in a building's air-movements can potentially lead to the ingress of fungal or faunal agents of decay. The chief agents of degradation are moisture ingress associated with timber decay, and the dissolution of calcareous materials and transport of salts in porous building stones (John Fidler, pers comm. 2002). Increasing temperatures are also known to increase the impacts of acid rainfall and other pollutants on building materials and artistic / sculptural works in building stones and stained glass. Storminess and increased winter rainfall predicted by the UKCIP2002 scenarios all pose threats to the maintenance of the historical buildings in the south west.

Additional temperature-related effects relate to biological decay. Whilst the immediate termite threat to British buildings has arisen through the accidental introduction of the subterranean termite *Reticulitermes lucifugus*, the northward movement of *R. santonensis* is occurring unaided and would adapt to warmer conditions in southern Britain quite readily. The northern penetration of the oak-beam-eating deathwatch beetle (*Xestofobium rufovillosum*) into Scotland may occur directly as a result of warmer conditions. However, in the south west the warmer temperatures may facilitate destruction of they egg-laying female beetles – heat triggers flight making the females more susceptible to integrated pest management based on light traps (John Fidler, pers comm. 2002).

The surface or exposed archaeological landscape

Increased storminess may lead to an accelerated rate of erosion. Other environmental factors include the marked increase in flood alleviation work undertaken by the Environment Agency due to increased risk of flooding. Some of these works are particularly damaging to the HE.

There are also increased problems to historic bridges caused by higher river levels and faster river flow. This is causing scouring of material around abutments and the loss of mortar.

The principal areas of extensive buried archaeology (i.e. that archaeology which is yet to be 'un-earthed' or examined for its palaeo-environmental and cultural / pre-historic evidence) lie in the extensive wetlands of the region. These include the upland peatlands on Dartmoor, Exmoor & Bodmin Moor, the lowland peatlands in the Somerset Levels & elsewhere, alluviated lowlands in Somerset, Avon & Devon, and coastal marshes in Devon, Gloucestershire & Somerset. Two threats are paramount in these sites: (i) the potential for changing water tables in the terrestrial peatlands leading to accelerated decomposition of organic remains (wood, leather, and fabric artefacts and structures; human and animal remains); and (ii) the erosion of coastal and near coastal deposits as a result of increasing sea-levels and storm-driven tidal surges.

The most effective preservation of archaeological and palaeo-environmental remains occurs when host (burying) sediments are continuously saturated below the local water table. Cyclical drying and wetting that is predicted to occur following the enhanced seasonality highlighted in the UKCIP2002 models is extremely likely to affect the preservation of buried evidence. The greater the oscillation of the water table, the greater will be the zone of oxygenation and leaching in the peats and soils. Thus wetter winters *and* drier summers re-enforce the problem. In drier (un-saturated) deposits archaeological preservation is generally poorer and more research is needed to confirm anecdotal evidence that environmental stratigraphy may be disrupted as a consequence of increased seasonal waterlogging.

The buried and surficial archaeology of upland peatlands is also vulnerable to root-disturbance, particularly by the invasive penetration of woody roots of heather species. Evidence of damage to archaeology is not uncommon in Dartmoor and Exmoor (Conservation Bulletin, 2002; Robert Van de Noort, pers. comm. 2002), particularly as a result of the spread of bracken, Bracken rhizomes favour well-drained ground often associated with buried upland archaeology and are able to exert both physical and chemical damage to the colonised area (Conservation Bulletin, 2002). Drying of upland peatlands are a result of the general shift to reduced annual precipitation (UKCIP2002 scenarios) is thought to favour heater and bracken growth therefore placing the archaeology under threat.

The Way Forward

Many of the national organisations, especially English Heritage and The National Trust have begun to consider climate change as a major issue and there is an increasing occurrence of climate change related policy statements arising from these organisations that testify to this. Staff in both organisations are involved in policy and research activities at national and international levels. Much of the research into the physical behaviour of building materials and historical structures has been undertaken by, or been done in association with, these organisations. As the South West region contains a significant proportion of the Nation's 'heritage' as defined in this Domain, this national process will have particular benefit to the South West.

The fabric of our heritage is prone to many pressures, of which climate change is but one, whilst climate change may indeed pose some

threat, for example, to Stonehenge it is the visitor pressures and transport facilities in the area that have been criticised as impacting most severely on the appreciation of heritage, both landscape and builtscape

To an extent it can be argued that the fabric of the buildings has the potential to withstand the assaults of predicted climate change (albeit with potential impact on 'purist' conservation principles) more so than the planted and 'wild' landscapes, woodlands, parks and gardens. In both cases however, it is clear that further investigations are required to evaluate the magnitude of challenges and their potential solutions. The principle organisations involved are, as highlighted above, already active in this process.

4 Recommendations

The public attitude to conservation of 'heritage' has the potential to be improved. This can be done hand in hand with the enhancement of the public understanding of science schemes, possibly through association with schemes such as COPUS (Commission on the Public Understanding of Science). Particular areas where public understanding has the potential to be improved relate to an appreciation of the 'innevitability' of change and the consequences of attempting to prevent it. The notion of 'managed retreat' in riparian and coastal areas of heritage interest is particularly appropriate to this approach.

There is some sense, that despite national initiatives in many organisations, there is an over-reliance on 'casual' consideration of climate change at a site-specific level. This is not to sugest that there are sites in which 'bad' or 'indifferent' practise is occurring. Rather it is to recommend that the national bodies may give stronger steers to regional- and site-based staff to ensure that climate change issues become a 'standard' component of site management and regional planning.

Challenges and Opportunities of Key Climate Impacts on Heritage Domain

Climate Impact		Challenges + Opportunities
Summer Temperature Increased	C	Increased potential for termite infestation
	C	Increased risk of reduced water supply to historic gardens and landscapes
	C	Increased risk of upland desiccation and consequent deterioration of buried archaeology
	C	Expansion of agriculture into the potentially drier areas that are now wetland, with damage to unearthed archaeology
	C	Potential for increased light – driven and temperature driven damage if historic fabrics and building's contents
	C/O	Change in visitor patterns to 'special interest' (e.g. Spring flowering) gardens
	C/O	Expansion of the visitor season due to warmer conditions and 'extension' of the summer
	O	Increased visitor numbers and improved income streams to specific sites
Winter Temperature Increased	C	Potential for greater survival of pests that have potential to damage structures and plants
	C	Potential for change to natural planting schemes and management practices
	C	Expansion of agriculture into the potentially drier areas that are now wetland, with damage to unearthed archaeology
	C	Potential for increased light–driven and temperature-driven damage to historic fabrics and building contents
	C/O	Change in visitor patterns to 'special interest' (e.g. Spring flowering) gardens
	C/O	Expansion of the visitor season due to warmer conditions and 'extension' of the summer
	O	Increased visitor numbers and improved income streams to specific sites
Summer Rainfall Reduced	C	Increased pressure on lowland (archeologically rich) wetlands for agriculture
	C	Potential for certain historic garden planting strategies becoming unsustainable
	C	Increased risk of desiccation of archeologically rich peatlands
Winter Rainfall Increased	C	Increased moisture penetration into historic buildings
	C	Potential impacts on historic planting schemes

HOUSING DOMAIN

Scope

The domestic environment in terms of lifestyle (indoors and outdoors), building maintenance and refurbishment, and the location, design, and construction of new dwellings. Technical aspects of housing construction are addressed in the section on the Built Environment Domain.

See also

Built Environment, Utilities, Heritage, Water Resources, Environmental Technologies.

Background

There were nearly 2 million dwellings in the region at the 1991 census. There is some variation of housing tenure when compared with averages for England. Owner Occupation is as high as 75% by comparison with 70% for the whole of England. Only 7% of public housing stock now remains with local authorities (English equivalent is 13%). Much has been transferred over recent years (the 1991 figure was 14%) to Registered Social Landlords (RSLs) who now own and manage 7% of stock within the region (2% in 1991). The private rented sector is relatively steady at 11% of the total stock, consolidated by recent 'buy to rent' investments and increasing employment mobility.

There is a wide variety of vernacular building traditions ranging from limestone in the north of the region, cob and thatch in the southeast, brickwork and clay in Devon and rough worked stone in Cornwall. Typical urban developments of 19th Century include (mainly brick) housing in settlements such as Swindon, Bristol, Cheltenham, Gloucester, as well as the coastal settlements of Poole, Bournemouth, Weymouth and Plymouth where property is more typically rendered.

Dwelling types are shown in the table below:

Dwelling Type	Percentage of region total (%)
Detached	30
Semi-Detached	27
Terraced	27
Purpose Built Flat	11
Converted Flat	5

Detached properties range from 43% of the local total in Dorset to 17% in the Bristol area. Flats in converted properties range from 8% in the Bristol area to 2% in Wiltshire.

Key Issues

The consideration of adaptation issues across the built environment must include the wider agendas facing the housing sector, some of which are included in the list of issues given:

- Projections for household numbers are 2.32 million in 2011 increasing to 2.52 million in 2021.
- The availability of land for housing development is a key issue for parts of the region. New legislation, funding and new planning regulation will all influence future developments.

The Housing Corporation relies on the Building Regulations to boost the standard of new dwellings and tends to concentrate more on creating sustainable communities through good design and high interior comfort plus community facilities (e.g. open space).

Housing Corporation

- The SWRDA is committed to providing 50% of new housing by 2010 on previously developed land and through the conversion of existing buildings.
- The demand for new housing continues to keep pace with general economic growth and increased household formation.
- Social housing will be a major focus particularly in the most deprived local authority areas and as part of a comprehensive regeneration strategy.
- Changes in lifestyle are anticipated as a result of climate change though it is not yet clear what form this might take.
- Pre-fabricated dwellings are being proposed as a way of speeding production and increasing quality.
- Different strategies are required to deal with a) the design of new housing and b) the management and maintenance of the existing housing stock.
- The impacts of some aspects of climate change (e.g. technical issues) will be common to all types of tenure. However, the responses will be managed very differently, particularly between owner-occupied properties and managed properties in both public and private sectors.

- There will be an increasing emphasis on the need for the cooling rather than the heating of residential buildings in the southern part of the region.
- The location of new housing developments must take account of increased potential for coastal, riverine and urban flooding.
- Those parts of the region where housing is founded on clay (including parts of Gloucestershire, Wiltshire, areas around Bristol and Bath, parts of Dorset and South Devon) are vulnerable to subsidence and ground movement from the drying out and shrinkage of clays in drought periods.

There will be increasing pressure on Registered Social Landlords to merge into larger units to spread the costs of all sorts of climate change impacts.

Those Registered Social Landlords (RSLs) with properties at sea level, near the coast, may potentially lose it. Insurance will cover the cost; if not we will seek mergers between RSLs to 'spread' the load financially or have to write off stock and the grants given to produce it.

Housing Corporation

- External space in the form of balconies, parks and gardens will be at a premium, especially in high-density schemes in urban areas.
- Practical, affordable technologies are required for the passive cooling of all housing in order to avoid further releases of greenhouse gases in energy-consuming cooling and ventilation equipment.
- The reduction in demand for heating may reduce heating costs and therefore current aspects of fuel poverty, but the need for cooling in summer may increase costs and create a new type of fuel poverty.
- Households are likely to increase their use of water for drinking and garden irrigation, pools etc. So, there will be a need to reduce consumption of mains potable water especially in summer, probably through the increasing use of water butts and grey water systems.
- Housing may be exposed to higher intensities of driving rain, particularly in exposed areas of Cornwall, North and South Devon and Dorset. Certain types of construction (e.g. cavity filled walls) are particularly vulnerable.
- There are potential lifestyle changes, particularly to do with the greater use of the external environment associated with all housing types.
- The housing sector is generally ill-informed about, and ill-prepared for, climate change impacts. Wide ranging education and training is required across the sector, for owner-occupiers, managers and developers of housing stock.
- The short-term nature of most housing investment, and the NHBC cover limited to a 10-year period, discourages long-term considerations in housing investment.

The Way Forward

There is little published material on the impact of climate change on housing except that concerning the technical issues of the building fabric. Clearly aspects such as flooding, exposure to winds, driving rain, heat stress etc. are important and are dealt with both in this section of the report, and in the section on the Built Environment.

Much greater understanding is required of the 'softer' aspects of housing, particularly lifestyle changes associated with changes in the weather.

Planning and design options are available to minimise climate impacts. These include:

- Ensuring that new developments avoid locations that are potentially vulnerable to coastal, riverine and urban flooding.
- Improving the technical specification of new housing to deal with extreme events of winds, storms and driving rain.
- Designing to improve cooling and ventilation in summer conditions and to reduce the need for increased air conditioning. The geographical differences across the region, will lead to increased demand for cooling in the more southerly locations (Dorset, Devon and Cornwall), and also in the urban centres (such as Swindon, Bristol, Plymouth) where the effect of urban heat-islands can uplift temperatures by a further 3^{o}C.

Heating/Cooling – enjoy 12% to 19% reduction in heating energy use……..use some of the gain to improve comfort and reduce damp.
Graves and Phillipson, 2000

- Exploiting external and semi-external environments to the full. This will be particularly important in urban environments generally and particularly in high-density housing where private open space is often at a premium.
- Creating adaptable dwellings that can respond more sensitively to changing climate conditions, requiring less costly alterations/additions for example.

Ventilation – raise temperature to dispel damp. Provide good natural ventilation where air pollution and security allow, especially in the southern part of the country. Consider mechanical ventilation only as a last resort.

Graves and Phillipson, 2000

Such initiatives may well incur additional capital costs but these are likely to be offset by consideration of lifetime costs. Planning can help to avoid problems from flooding and coastal erosion. Design can minimise subsidence in clay soils, dampness from rain penetration, and weather damage to materials.

Those responsible for RSLs have indicated that increased funds will be required from central government to improve the standards of both existing and new stock. A further response to resource problems will be to combine smaller RSLs into larger administrative units able to absorb the costs of particular schemes and achieve economies of scale.

The response of the insurance industry will be critical in both private and public sectors. There is some indication that insurers could withdraw from certain locations at high risk, as well as increasing premiums in vulnerable locations. The concept of 'future-proofing' building designs may be applied as a way of setting premiums.

Changes to Building Regulations and other standards may be an appropriate way of addressing some of these issues.

Knowledge levels

"Is this a wind-up? I don't do science."

Local Authority Housing Officer on receipt of Climate Change Impacts questionnaire.

Some housing professionals in the South West acknowledge the potential impacts of climate change on the built environment, but for most housing practitioners climate change is not on the agenda. Within this study it was difficult to elicit any response from many regional housing organisations, in both the public and private sectors. Many organisations could not identify appropriate personnel to deal with the topic.

Within the Housing Corporation the Senior Technical Officer for the region indicated that the HC had no explicit policies that addressed climate change issues (either adaptation or mitigation). The same was true for the Regional Operations Director of a major Housing Association who also reported being unaware of the concept of 'adaptation' before receiving the questionnaire.

No specific enquiries were made of owner-occupiers within this study, but other work suggests that many interested householders are aware of some of the potential impacts but unclear on how best to respond.

Recommendations

The following are recommendations for areas within which change can be initiated.

- Introduce future rather than historic meteorological data as the basis for technical decisions when revising codes and regulations relating to housing design and construction.
- Design new buildings using the following indicative strategies (BRE, 2000):
  - Design roofs in anticipation of 5-10% increase in wind loads.
  - Increase foundation depths by around 0.5m in susceptible clay soils.
  - Design for driving rain assuming higher levels of climatic exposure.
  - Avoid floodplains. Raise floor levels, and avoid underfloor wiring in vulnerable locations.
  - Plan for good ventilation.
  - Anticipate reduced heating load in winter, and design for passive cooling in summer.
- Educate the housing sector including housing developers, RSLs, local authorities, Housing Corporation, and designers. Initially this may concentrate upon regional interpretation of the UKCIP02 scenarios, and then proceed to implications for the sector.
- Educate owner-occupiers. Initially this may concentrate upon regional interpretation of

the UKCIP02 scenarios, and then proceed to adaptation responses.

- Develop new forms of housing development, procurement and financing which extends the investment period.
- Develop strategies for future-proofing existing building stock including the development of robust repair and refurbishment standards. The focus should be on the shift in emphasis from heating to cooling, particularly in urban locations, and in the south of the region.
- Undertake further research into lifestyle changes associated with climate change, and the implications for the socially excluded.
- There is a recognised need to understand more subtle characteristics of climate change e.g. sunshine hours, relative humidity, cloud cover, and pattern/magnitude of extreme events.
- It would be beneficial to modify standards and design criteria within existing industry practice guidelines, and to shift sector use of meteorological data from historical to future based data.

Potential barriers

One respondent identified a potential conflict between a sustainable construction and the creation of maintenance-free building fabric, presumably because a material which did not degenerate under any environmental conditions likely to be experienced in a changing climate would not be themselves organic in origin or remotely biodegradable.

The barriers to change with regard to existing properties vary according to the type of tenure.

Most properties in the South West are owner-occupied. It will be very difficult to achieve appropriate adaptation responses in this sector, as responses will be dependent on individual actions by individual households. Public awareness campaigns, particularly with regard to the avoidance of further energy consumption, will be important here.

Properties managed by local authorities, Registered Social landlords (RSLs) and large private landlords will benefit from strategic management and maintenance strategies. Adaptation responses will nonetheless not be forthcoming without appropriate funding from central government.

With regard to new-build there are five main barriers to change:

- Building Regulations and Codes do not sufficiently take account of climate change predictions in setting new performance standards.
- Professional and lay people have difficulty in responding to the degree of uncertainty associated with future climate scenarios.
- House buyers are reluctant to invest in anything other than the most conventional house designs.
- The move to centralised pre-fabrication of residential buildings may prevent the production of houses designed for local climate conditions.
- The general unavailability of building land forces housing development to what are perceived as difficult sites. In turn this makes development more complex, requiring more consultation which slows the process, and makes the resultant housing more expensive. All this makes it less likely that adaptation responses are given serious consideration.

Challenges and Opportunities of Key Climate Impacts in Housing Domain

Climate Impacts		Challenges and Opportunities
Increased Summer Temperature	C	Overheating of the interior environment of existing and new housing stock.
	C	Increase in certain types of household pests such as insects etc.
	C	Increased problems of keeping food free from bacterial infection.
	C	Heating costs down as less requirement for space heating.
	O	More outdoor socialising, barbecues etc.
	O	New types of food and possible changes in diet.
	O	New internal finishes (e.g. ceramic floor tiles).
	O	Increased opportunities for outdoor activities.
	O	Improved viability of solar water heating.
Reduced Summer Rainfall	C	Increased use of and demand for water: e.g. for irrigation of gardens, swimming pools, drinks etc.
	C	Less availability of potable water.
	C	Increased potential for subsidence & insurance claims due to drying out of substrata, esp. clays in areas such as Bristol, Dorset and Gloucestershire
	O	Greater and more consistent use of outdoor space.
Increased Winter	C	None identified.
Temperature	O	Heating costs reduced as less requirement for space heating.
Increased Winter Rainfall	C	Increased grant requirement for RSLs to deal with upgrading and maintenance.
	C	Improvements in rainwater disposal systems above & below ground will be needed.
	C	More foreign holidays to escape British winter.
	O	More water available but needs capturing and storing.
Increased Sea Level and Tides	C	Restrictions on location of proposed developments.
	C	Requirement for flood defences to protect existing buildings.
	C/ O	Relocation of housing stock associated with managed retreat.
Longer Growing Seasons and	C	Lawns & other amenity planting require more maintenance through increased growth and use.
Reduced Frosts	O	Less maintenance and associated costs arising from frost damage, thaws, etc.
Flooding Increased	C	Need to improve flood defences.
	C	Need to relocate vulnerable housing stock.
	C	Ensure no new housing development in vulnerable locations.
	C	Consider possibility of changed use for ground floors to less vulnerable activities (e.g. no electrical equipment).
	O	Opportunity for introducing SUDS in new developments.
Potentially Increased Winds and Storms	C	Walls and windows, especially cavity-filled walls vulnerable to driving rain penetration, especially in exposed locations.
	C	Structures & roofs vulnerable to damage in exposed locations.

PUBLIC HEALTH DOMAIN

Scope

Issues of health and well-being, including diseases, pests, vulnerable groups and positive opportunities.

See Also

Water Resources; Tourism and Leisure, Housing.

Background

The population of the South West is one of the lowest in the UK, although this level is expected to increase by nearly 11% from 1996 values by 2016. Households are likely to increase by almost 25% over the same period.

A large proportion of this population is elderly due to the attractions of retiring to the region, and large numbers of both the retired and working age community live in rural areas. Allowing for this age structure, the South West currently has the lowest mortality rate in the UK.

The region is greatly influenced by tourism – some parts of the region have a temporary summer population more than twice that of the rest of the year – which has its own influence on public health concerns.

Key Issues

- Potential for increase in radiation levels and skin cancer.

Incidences of skin cancer have increased in the last ten years even with increasing awareness.

Climate change is likely to continue this trend, particularly in the South West of the country.

Medical professional, Bath

The South West is particularly vulnerable to health impacts of climate change due to its high proportion of elderly people and pressure on local services dependent on tourism.

This makes the region open to perceptions of risk that might follow from climate-related health scares.

Public health officer, Exeter

- Maintenance of water quality and supply, essential for health and well-being, may be compromised if water companies etc. “fail to get it right”. Supply will be especially stretched if tourism does increase as a result of climate change.
- Psychological impact of flood events has been reported to be as damaging as the physical effects of flooding, particularly where domestic properties are concerned.
- Atmospheric conditions could favour an increase in urban pollution, while summer changes could alter the pattern and distribution of pollen and spores.

Water quality and reliability of supply is likely to be a significant factor where Public Health is concerned.

Public health officer, Exeter

- Mould growth, already a common concern in houses in the far south west of the region, is likely to become more widespread. Moulds are well recognised triggers for allergy sufferers and asthmatics.
- Very little regional research has been done in the area of climate change impacts on public health.

Issues of particular regional relevance

Climate change may affect the demography of the region via its influence on migration. The region is a popular choice for retirement and so has a large elderly population. Changes towards what is perceived to be better climate could increase the attractiveness of the region to migrants. However, since similar changes in climate are also anticipated in some of the major source areas of migrants (e.g. south east England) changes in relative attractiveness may be limited. It is also possible that increases in extreme weather associated with climate change could reduce the attractiveness of the region to potential migrants.

The water companies must be prepared for climate change to ensure that water quality does not decrease due to changes in climate, with potential consequent health impacts. There are many private water supplies in the region that also need to address climate change, but these may be difficult to regulate.

Strategies to reduce the potential health impacts should be addressed now, e.g. building design for optimal space cooling, and the planting of trees within urban areas to reduce the "urban heat-island" effects. It would be false economy to delay such activities until the health effects are being experienced on a regular basis.

The South West is likely to be the first region affected by increases in radiation, leading to a potential for skin cancer increase. This is enhanced by the region's having a generally good air quality, which allows greater radiation penetration. The likelihood of more summer visitors to the region also means that visitors to the region will transport this increase back to their home regions.

Notable risks

While it is easily understood that extreme weather events can lead to injuries and even deaths, it is also considered that they may lead to considerable long-term psychological impact. Such events and their aftermath could additionally burden the healthcare system. Following floods in Bristol in 1968 for example, 3,000 homes were flooded and there was one fatality, but there was also an increase of 53% in visits to the doctor during the year following the event.

The incidence of food poisoning in the United Kingdom has been rising in recent years for a variety of non-climatically related reasons. Superimposed on this general increase there is also a marked annual seasonal pattern of higher risk associated with periods of hot summer weather (e.g. salmonella peaks in the summer each year). Warmer summers are therefore likely to increase the incidence of food borne disease, all other things being equal.

Lyme disease is the only important vector-borne disease in the UK and is already prevalent in the South West region. It is not clear what effects, if any, climate change might have on the ticks and parasites that cause the disease. However, it does seem likely that a warmer climate would encourage changes in human behaviour (more outdoor leisure activities in tick-infested areas, lighter-weight clothing) that could increase risk.

Changes in rainfall patterns under climate change may affect surface water quality and the risk of microbiological contamination of public water supplies. Surface water is more likely to be contaminated than ground water.

The water-borne disease cryptosporidiosis has been associated with flooding following periods of dry weather. The South West already has a high incidence of cryptosporidiosis, which could be exacerbated by the predicted change to drier summers followed by milder, wetter winters.

An increased frequency of flooding associated with climate change could in theory also increase the contamination of estuarine and coastal waters with heavy metals. These metals are currently locked away in sediments, or even old mining spoil-heaps, but could be re-exposed by heavy rain or flood events. Warmer summers with higher near-shore water temperatures are likely to encourage more sea bathing and similar activities, which could increase population exposure to microbiological and other contaminants, including heavy metals.

The lack of large river systems in several areas of the region will increase pressure on existing water supply systems due to both high and low rainfall, with a corresponding risk of water quality deterioration. It should be noted however that water quality standards in the south west are high, and if regulation increases, increasing temperature should not cause any quality problems.

The region experiences high ozone episodes associated with stable anticyclonic conditions with high temperatures and strong sunlight, and these may be increased under climate change, although this is currently highly uncertain. Population exposure to ground level ozone and the associated respiratory health effects may therefore increase.

Heatwaves are associated with short-term increases in mortality and morbidity, primarily in the elderly, and those with chronic lung or heart disease. Climate change will increase the frequency of heatwaves in the region, although acclimatization will reduce some of the impacts

of increases in temperature. The direct effects of temperature on mortality occur at temperatures that are not necessarily extreme; for example, heat related mortality can be observed above 17^{o}C in London.

Skin cancer and other health impacts due to exposure to ultraviolet radiation are likely to be of increasing concern in the region. Warmer, sunnier summer weather is likely to encourage patterns of behaviour (e.g. more outdoor leisure and lighter clothing) that increase exposure to the sun.

Water quality and reliability of supply is likely to be a significant factor where Public Health is concerned.

Source unknown

Notable opportunities

The costs of adapting to climate change, i.e. reducing or preventing health impacts will be cost-effective because they are likely to have near-term health benefits as well, for example, improving disease monitoring and public health infrastructure.

Milder winters should reduce winter mortality rates.

Warmer summers should encourage the eating of healthier (salad type) foodstuffs and also increase participation in outdoor (physical) activities.

Health aspects of climate change may be sufficiently interesting to the general public that they are hooked into considering impacts where they might otherwise not have been. Every person, regardless of age or occupation, can understand the relevance of health matters, where they might perhaps feel that certain business or environmental impacts are "nothing to do with them".

The Way Forward

The drive towards more sustainable energy +

provision and use, including energy efficiency measures, will in many cases have a beneficial effect on public health.

The general aim of increasing awareness about sustainability issues may also encourage people's thoughts towards public health issues as they affect them in their personal lives.

Many of the believed anthropogenic causes of climate change are also related to the main causes of poor health in developed countries. A healthier and more sustainable lifestyle – for example less driving of fuel-powered cars and correspondingly more use of bicycles or walking will be encouraged by better weather, contribute to better health and reduce negative impacts on the environment.

Example of Good Practice

Isles of Scilly Health Centre have installed a ground sourced heat exchange unit for provision of both heating and cooling without an increase in greenhouse gas emissions.

Potential barriers

The difficulties to be overcome in the region are likely to be inertia due to a lack of funds and a tendency to believe that the South West, as part of an affluent Western society, is immune to situations and diseases more commonly associated with poorer developing parts of the world.

Knowledge and awareness

Public health workers are very well tuned to developments in their own field, but are less likely to attribute them to external influences. Those in positions to influence wide scale changes on a regional level may need further information before they are willing to act when the region is seen to have a generally good record for public health.

The Department of Health commissioned a UK national health impact assessment of climate change, which was produced in 2002, but as yet there has been no regional work carried out in the Health Sector. An integrated approach to monitoring impacts (health outcomes) and exposures (e.g. air pollution, water quality) is required to accurately gauge the true impact of climate change on health issues and this has not yet been achieved.

More research is also needed on heat related deaths and illness, and the role of temperature in food and water-borne disease transmission. Such research will require inter-sectoral collaboration; for example, between the water, health, academic sectors. Uncertainties exist on such matters as:

- How fast will people acclimatise to the warmer climate?
- How great is the risk of introduction of "new" diseases? (Currently not considered to be very great).
- How will adaptation measures in other sectors affect health, for example, increased use of insecticides in agriculture or home gardening? (Considered to have little regional relevance at this time).

Recommendations

Many health risks relating to climate change will be avoidable if appropriate changes in behaviour are encouraged. The biggest challenge and easiest way to protect and improve the health of those living in the region is to increase knowledge and understanding of what climate change will mean in terms of health impacts.

This process needs to start with the health sector itself, which requires increased access to and training in, the information available. Specific examples include recognition of weather-dependant diseases, such as those caused by *Giardia* cysts and *Cryptosporidium* oocysts, which may increase in streams following heavy rain events.

In addition to changes in diseases contracted locally, awareness of tropical diseases which could change distribution globally will be required by health workers in the region who treat people on their return from travel abroad.

Once local health scientists are better informed, they will be in a position to inform the general public – providing information and recommendations regarding specific risks for local environments (e.g. diseases in marshland areas) or “at risk” groups (e.g. heat stroke in the elderly).

They will need to establish and then advise on preventative measures available and response systems in place locally. There will be scope for involvement with LA21 initiatives across the region in many of these areas.

Challenges and Opportunities of Key Climate Impacts in Public Health Domain

Climate Impact		Challenges and Opportunities
Increased Summer Temperature	C	Risk of increased exposure to radiation; increased incidence of skin cancer.
	C	Increased risk of heat exhaustion and dehydration.
	C	Risk of heat stress in participants of summer sports.
	C	Risk of heat stroke especially among the elderly and children.
	C	Increased risk of food poisoning, including shellfish poisoning.
	C/ O	Need for more environmental health officers and laboratories to monitor abattoirs, food supplies etc. for potential food risks.
	O	Tendency towards eating healthier foods in warmer weather.
Reduced Summer	C	Risk of deterioration of water quality and supply.
Rainfall	O	More opportunities for outdoor activities, with associated health benefits.
Increased Winter Temperature	C	Increased pests and vermin surviving the winters – rats have increased 50% in recent times which may be partly climate related (C-CLIF 2001).
	C	Reduced winter die-off of bacteria and viruses.
	O	Less ill health due to living in what are currently cold, damp conditions.
	O	Less carbon monoxide poisoning due to a reduction in space heating requirements.
	O	Fewer deaths due to hypothermia.
Increased Winter Rainfall	C	Increased incidences of mould growth and associated health risks (asthma, allergies etc.), particularly in poorly heated/ventilated housing..
	O	None identified.
Increased Sea Level and Tides	C	Danger of being swept to sea by unexpected high tides and sea swells.
	O	None identified.
Longer Growing	C	None identified.
Seasons and	O	Less risk of accidental injury caused by slipping on ice etc.
Reduced Frosts	O	Fresh healthy and locally produced food available for a longer period.
Flooding Increased	C	Health risks associated with sewage system overloads.
	C	Risk to life and health through property flooding.
	C	Risk of long term psychological impacts on victims of flood events.
	O	None identified.
Potentially Increased Winds and Storms	C	Risk of personal injury due to falling or wind-propelled objects, or damage to infrastructure, electric cables etc.
	C	Limited risk of direct injury due to weather conditions.
	O	None identified.

TRANSPORT DOMAIN

Scope

Provision, management, maintenance and use of transport in, to and from the SW (road [incl. bus], rail, air, waterways); Includes supply, demand, investment and infrastructure strategies, sustainable transport strategies and promotion.

See also

Business; Tourism; Built Environment

Background

The south west region has a high-density network of A-, B- and unclassified roads, and two principal motorways: M4 and M5 (plus M32). The major trunk road and rail networks provide spinal routes to the Southwest peninsula from London and from the Midlands. The major North-South artery is the M5, which is paralleled by the A38. There are two major trunk road routes from East Devon towards Cornwall (A30; A38) but only one rail route. The regional airport with greatest passenger flow is Bristol, with lesser flows at Plymouth, Exeter, Bournemouth and also at Newquay, which recently has experienced a significant expansion of low-cost services to and from London.

The Scillies are connected by air mainly to Land's End (St Just) and to Penzance (heliport). The region has a very long coastline and has major freight ports at Portbury and Avonmouth, naval facilities at Devonport and Portland, major natural harbours at Falmouth (claimed to be the third largest in the world) and Poole, plus tourist and pleasure craft at many coastal resorts. Inland waterways operate principally for leisure/pleasure craft.

In terms of journeys made other than on foot, the private car overwhelmingly dominates. Cycling is a minority pursuit; rail use in the region is proportionately relatively low, except for inter-city travel between principal urban areas and to London. Local commuting by road greatly exceeds that by rail, even in the major conurbations; indeed within Britain, Bristol has one of the lowest rail-based commuting proportions (claimed by David Redgwell, Transport 2000, to be under 1%) for a city of its size. (This proportion might increase when the LRT scheme for Bristol is built.) Nevertheless, despite well-publicised difficulties over punctuality, rail passenger journeys are increasing, especially in Somerset/Avon/Gloucester — up 12.89% from 2000/1 to 2001/2 — and in Cornwall — an annual growth of 6.34% for the same period. The Exeter–Waterloo line has shown an overall growth in passenger journeys of 49% from 1994/5 to 2001/2.

The environmental effects of transport are explored in the Commission of the European Commission's White Paper *European Transport Policy for 2010: Time to decide*. This major policy consultation document is intended to provide the basis for a sustainable transport system and it counsels a significant shift in the balance of transport from road and internal European air flights towards rail, shipping and intermodal transport. A key driver therefore for the direction of future national transport policy may be this recent White Paper on transport policy, and this may then cascade into the regional transport strategy.

The context for the South West region is Regional Planning Guidance for the South West (RPG 10), which sets out the Regional Transport Strategy (RTS) for which the Southwest Regional Assembly has statutory responsibility. The RTS has 5 key objectives and provides ten transport policy guidelines, including reducing the need for travel (TRAN 1), and the maintenance of strategic Inter-urban and Inter-regional transport networks (TRAN 2).

The RTS derives largely from PPG 13 (Transport) and is soon to be revised. Its updates will be influenced by possible revisions to the Government's 10-year Transport Plan, which has been criticised recently by the House of Commons Transport Select Committee; future revisions to the Strategic Rail Authority's (SRA) 10-Year Plan, which presently offers very little for the south west region; the reports from various multi-modal studies; and the development of a South West regional public transport strategy.

Within the region the recommendations of the SWARMMS (London to South Wales and South West Area Multi-Modal Study) study of May 2002 — and indeed the TVMMS (Thames Valley Multi-Modal Study; continuing), which may suggest ways of unlocking capacity improvements for the west and south west — may be particularly influential, provided the South West Regional Assembly can then take the recommendations forward and lobby Central Government for public transport improvements. A possible forum for helping to identify priorities for the region may be the South West Public Transport Users' Forum (SWPTUF), which was established recently by the South West Regional Assembly.

Key Issues

Awareness

- Much of the transport sector in the South West has not yet significantly responded to the issue of climate change.

- In transport within the region, other issues have recently dominated the agenda, particularly how to develop the policy response to the various multi-modal studies being conducted (e.g., SWARMMS, which reported in May 2002).
- Climate change has nevertheless been invoked by the Strategic Rail Authority as one among several reasons for *not* extending electrification of the rail network to the West Country (see quote from SRA Chair).
- There is little evidence of awareness amongst transport operatives of the Commission for the European Union's White Paper on transport policy (except in so far as it directly impacts on their business).
- There is recognition in the European White Paper of relationships between transport use, emissions and climate change, and the need for mitigation, but there seems to be limited awareness in the industry of possible adaptation responses.
- Hence, climate change is not explicitly taken into account in the transport sector in terms of adaptation (other than perhaps in terms of dealing with the effects of flooding). There is some attempt to address mitigation through the reduction of carbon emissions.

Vulnerability

- Parts of the transport infrastructure of the south west are particularly vulnerable to flooding.
- Several towns and major cities within the region are susceptible to periodic flooding, the frequency of which could increase if winter precipitation levels and intensities increase, which would cause major disruption, especially to road-based transport within these towns and cities.
- During Autumn 2000, the South West peninsula was effectively cut off from the national rail network for several weeks by flooding at Cowley Bridge (River Exe), near Exeter, which washed away track embankment, and at Honiton tunnel. Recurrent severe flooding may sever the link in the future.
- For several winter months, the Tarka line (Exeter to Barnstaple) has been out of use, owing to flooding and consequent flood damage. The main (and only) rail line to west Devon and Cornwall is vulnerable to storm surges, high tides and to cliff instability near Dawlish. Main rail lines to and from the Midlands and the London-South Wales line (and diversionary route) have been disrupted by flooding especially in tunnels at Chipping Sodbury, Wickwar and Sapperton.

> **I am not convinced about the business case for electrification [of the Great Western main rail line] … [and] the environmental case is not as persuasive as it used to be, especially when you take into account power station emissions and then there's the climate change issue and the fact that electrification is susceptible to poor weather.**
>
> **I think the case for electrification has significantly weakened over the last few years.**
>
> Chairman, Strategic Rail Authority, quoted in RAIL, 438, June/July 2002.

Implications

- Climate scenarios indicate increased opportunities for travel to the south west (especially in summer), but the major transport mode currently is by road, primarily the private car. Motorway congestion in summer could be worse if tourism to the South West increases as a response to warmer summers.
- The rail network is underdeveloped and is vulnerable, especially to flooding, and there are no rail diversionary routes from the Midlands to the south west, or from Exeter to west Devon and Cornwall.
- The conflict between satisfying demand for travel and meeting carbon-reduction targets gives rise to considerable issues relating to traffic management, demand management, etc.

Adaptation responses

- Where transport planning does engage with the issue of climate change it seems to be concentrating more on mitigation (carbon reduction) topics, especially urban cycleways; and on safety issues such as traffic calming; rather than adaptation responses.
- Adaptation response to the threatened railway at Dawlish could be to build a new rail link inland, or to extend the Dartmoor railway from Meldon, via Okehampton and Tavistock, to Bere Alston and Plymouth, to provide an alternative and diversionary route.

Issues of particular regional relevance

Several towns in the region (e.g. Lynmouth; Bruton) have suffered from occasional flash

flooding, with road links temporarily severed. The A38 is particularly vulnerable to flooding at Tewkesbury and in the northern approaches to Gloucester. Climate change scenarios suggest road flooding could become more frequent in such areas.

The main (and only) railway to West Devon and Cornwall runs along the coast through Dawlish and is vulnerable to high tide spray, undercutting (recently combated by a major programme of concrete reinforcement commissioned by Railtrack), and cliff instability on the landward side, producing a recurrent risk of landslips occasioned by intense or prolonged rain. This rail link is increasingly vulnerable under climate scenarios of more intense precipitation, severe storms and higher sea levels. It is particularly vulnerable at times of high tides; indeed, in October 2002 new 'Voyager' services were suspended during 'exceptional' high tides, which in scenarios of higher sea level will tend towards the norm rather than the exception.

Climate warming might attract even more long-term residents to the South West. The region might also be perceived as an even more attractive area for retirement. These demographic changes will have impacts on transport needs.

Even amongst professionals, the notions of 'sustainability' and of 'climate-change mitigation' can be misrepresented. The recommendations of the SWARMMS study have been couched in terms of sustainability; its proposals reflect the major role that transport provision can play in this. However, the consequences of some of its recommendations may produce precisely the opposite effect from that intended.

For example, the South West Regional Assembly noted that SWARMMS, in recommending development of a second strategic road route to the south west, argued: "The A303 route through the Blackdown Hills is shorter [than the M5] and will minimise the use of fuel and production of greenhouse gases". The argument being that a shorter road route with free-flowing traffic, uses less fuel than a longer route that is congested at peak times.

However, this argument is of course spurious, as creation of an improved road link will result *overall* in increased traffic flows along both routes, which generate more greenhouse gas production! A 'do nothing' option would not relieve road congestion, and so would not improve fuel use. Significantly it would also deter any markedly increased road use, especially at peak periods (due to driver perception of congestion and increased journey times), and so would actually *save* on what would be increased greenhouse gas production (if the A303 be dualled) from increased volumes of road traffic.

"Despite increasing concerns on climate change, there's a lack of awareness on how the weather can affect business on a fundamental level… The transport sector is burying its head in the sand more than most — it's the least likely to agree that the British climate affects business revenues — and 96% think they spend enough accounting for the weather"

Stephen Lawrenson, Met Office Commercial Division Managing Director, quoted in Railway Strategies, Spring 2002.

As a transport authority, it is interesting to note that, in line with government policy, we are actively encouraging the use of sustainable modes of transport in order to meet, among other things, the target of reducing the production of greenhouse gases.
Some of the climate changes such as warmer, drier summers will aid this aim and encourage more use of sustainable modes, whilst other changes, e.g. increased rainfall and flooding, will discourage such action.

Transport Authority

Notable risks

- Specific locations along the transport infrastructure of the region are vulnerable to flooding; flooding is more disruptive to rail than road, owing to absence of adequate diversionary routes in the region.
- Weather extremes produce transport disruption (e.g., severe winds affect the two major road bridges over the Severn and closure to high-sided vehicles; trees brought down on rail lines).
- Repeated severance of only rail artery to the South West which could be caused by flooding (e.g. Cowley Bridge) or coastal erosion (Dawlish) or by conditions of higher tides; flooding of tunnels on main Midlands-Bristol rail route and London–South Wales lines.

Notable Opportunities

- Create strategic rail *diversionary* routes to combat flood/storm/other disruption, notably by dualling of Exeter–Salisbury route to the south west; dualling of Swindon–Kemble (to create a diversionary route via Gloucester to South Wales when tunnels flooded/closed on main Swindon to South Wales line); re-opening the Cheltenham–Honeybourne–Stratford line (as an alternative route from the South West to Birmingham).
- Potential to use climate change as a tool to help develop integrated transport and discourage people from needing to travel; this will help promote the sustainability agenda. Working from home could become a more feasible and accepted alternative to the travel-to-work lifestyle.
- Opportunity to encourage workplace Green travel plans, as way both of educating the public to curb increase in car use and to help achieve sustainability agenda of European White paper on transport.
- Gives greater reason to re-define the Cost-Benefit analysis of rail v. road to take greater account of (a) carbon emissions from transport; (b) the costs of not just the direct deaths (comparing road and rail accident rates) but also the indirect deaths (through respiratory ailments, caused largely by road traffic pollution); (c) the period over which capital costs can be recovered, as rail infrastructure is more expensive than road but has a longer life-span; (d) other environmental costs of transport.

The Way Forward

Within the transport sector, and perhaps more so than in any other sector other than energy supply, decisions made about developing mitigation responses to climate change also feature as adaptation responses (in terms of developing long-term sustainable transport systems).

It is not so easy therefore to separate mitigation responses from those concerned with adaptation. For example, modal shift might be built into planning as a direct result of the multi-modal studies. ARRB Transport Research has suggested this: "A very positive direction is to investigate the concept of a higher density development with better land-use mixes around railway nodes and along railway corridors" (Luk *et al*., 1998, p.1). This for example could be incorporated in the development of Clyst Hayes and development at nodes between Exeter and Salisbury, with investment in Salisbury–Exeter rail, rather than in upgrading the road capacity.

For modal shift to be encouraged on other transport corridors in the south west region, it would seem that multi-modal studies need to be given different frames of reference and working models (unlike, for example, the Bristol/Bath to South Coast Multi-Modal (*sic*) Study, which is largely road-based).

Local initiatives in rural areas, to improve Public Transport and to help encourage its use compared with the private car, may be funded through Rural Transport partnerships – a new scheme funded by the Countryside Agency.

The development of integrated transport is in its infancy in the South West, but some pilot schemes — such as the PlusBus scheme at Truro, the 'bus branchline' concept in Cornwall, integrated transport in the Fal Estuary, and bus-rail links in Gloucestershire — show the potential for these. Workplace Green Travel plans are becoming more widespread.

Currently, rail freight in the region is overwhelmingly dominated by transport of fossil fuels (with a large number of coal trains carrying imported coal from Portbury Docks). This raises the question as to whether this is a sustainable basis for the rail freight network in the longer term. Diversification, and expansion of other rail-freight activity, including wagon-loads, the use of freight multiple units, intermodal facilities and the provision of dedicated freight sidings and freight distribution yards may be more appropriate in the longer term.

One example is the site plan for development of a 25-hectare site near Swindon alongside the Honda car manufacturing plant, which includes provision for an intermodal terminal and rail-linked warehousing. Another is Cabot Park, a distribution park that has provision for rail-linked warehousing and an intermodal terminal, close to Bristol Port.

Sustainability issues

There seems to be a disjunction between the worthy 'sustainability' aspirations of the European White paper and of LTPs and the continuing national and regional increase in car ownership and car use. The abandonment of the Fuel Cost Escalator in the UK in response to fuel-price protests means that models of future motoring traffic growth (including road freight) may underestimate the growth in road use.

If environmental sustainability is to be achieved there is an even greater case (as argued by SUSTRANS and Transport 2000) for making cycling more possible and rail an affordable alternative to the private car in the south west. Education of the general public will be required, but this raises questions as to the ethics of social engineering on a large scale.

Knowledge levels

In a recent study conducted by the Meteorological Office, 20% of transport bosses said they do not take the weather into account, but feel that they should. The transport sector was the most likely of those questioned to fail to meet deadlines owing to weather-related problems.

Nevertheless, a recent (2000) appointment to Railtrack (Great Western Zone) has been made whose responsibility is (i) to analyse impacts of weather and climate on performance so causes are better understood and can either be mitigated or better predicted; (ii) brief the control centre on use of weather information and produce seasonal preparedness documents for winter, summer and autumn; (iii) attend a national weather group (with representatives from all zones) and feed back best practice on weather related issues to GW zone; (iv) provide advice on potential impacts of climate change for Railtrack staff at HQ in London and within GW zone.

Railtrack (successor: Network Rail) has recently set up a climate strategy group with an initial remit to look at the next 10 years. However, there is no group looking beyond this period (yet), none dealing with climate change in the train operating companies, nor in regional road-freight hauliers.

In this context it is not surprising that climate change issues do not yet figure highly amongst senior professionals in the transport industry. It does feature, however, as a driver for change in the European Union White paper, in LTPs etc., and in campaigning organizations such as SUSTRANS and Transport 2000.

The transport policy direction shown in the European White paper contrasts with continuing development of domestic air services to and from the region, which are (per passenger) very wasteful in terms of fuel, not a feature of 'green' transport and sit very uneasily with notions of 'sustainable development'.

Surface vehicles are a greater problem than aircraft in terms of pollution and thus climate change impact. [This ignores the *per capita* production of CO_2 from aircraft]

From a contributor in the air industry

The Highways Agency is aware of issues concerning increased frequency of intense rainfall events and of the need to develop the capability of the carriageway to cope with excess water. Within the South West region, the vulnerability of main rail lines to closure from flood or storm damage emphasises the need for adaptation responses; these should include the urgent development of alternative/diversionary rail routes, so as to ensure operational flexibility. This will facilitate modal shift from road to rail, as a main deterrent to rail travel and rail freight use is a perceived unreliability of services.

Within Great Western zone, some projects have taken climate change into account at the design stage so that schemes that will be around for decades in the future can be expected to withstand the changing weather patterns. One such example of this is Chipping Sodbury tunnel. This floods maybe once or twice during a typical winter. At present a scheme is being designed to pump the water to holding fields before being discharged to rivers when the levels have fallen. The rainfall amounts used in the design for the pumping capacity and other aspects took account of climate change.

Railtrack (Great Western Zone)

Awareness of climate change is subliminal in the transport sector. Few operators and fewer strategists have engaged with the issue. The transport sector is a major contributor to carbon dioxide emissions, and so is particularly relevant for mitigation measures. For example, highlighted in the SWARMMS study is the need to develop the rail infrastructure of the South West region (framed in the context of sustainable development), and there is also a need to eliminate rail bottlenecks to ensure that modal shift from road to rail is possible so that national rail passenger and freight growth

targets can be achieved (there are no agreed *regional* targets).

At present, the Strategic Rail Authority (SRA) seems unaware of potential adaptation responses to the climate change issue (except to see climate change as an excuse *not* to invest in electrification of the Great Western Main Line) and has not so far been able to capitalise on rail's 'greener' image in transport in the South West. Perhaps adaptation to climate change could form part of the 'business case' for developing the rail network in the South West, whereas the assumed axiomatic 'business case' for road investment should be counterbalanced by the environmental costs of increased carbon emissions that increased road capacity would produce.

There is clearly a need to consider predicted climate change when making long-term decisions about the provision and upgrading of transport infrastructure, vehicles and rolling stock. Ways to take this forward are suggested in a recent report by Wilson & Burtwell (2002).

The really serious changes for society rest with the NEED TO TRAVEL for work and recreation, BUT this moves quickly into the realms of social re-engineering and qualities of life arguments and exclusion for some sections of society. … research could extend to examine the impacts on climate to be derived from having a significant part of the population working from home.

Source unknown

Potential barriers

There is a dearth of finance available and at present a lack of political will to develop the rail network within the region significantly. Rail schemes have to pass stringent economic tests to show a return on investment, and the Strategic Rail Authority has in each instance to make out a strong "business case", which at present does not include taking account of climate change issues (except in a negative sense).

This contrasts with the effectiveness of the Highways Agency in finding access to finance for road schemes, the strength of the road user organisations, and in the assumed (almost axiomatic) business benefits that would flow from bypasses and other new road schemes. In the current Strategic Rail Authority 10-year plan, for example, there is no money to deliver the rail recommendations made in the SWARMMS study.

Significant numbers of the general public remain to be persuaded or are still unaware of the climate change issue and the role that transport can play in helping to mitigate or to adapt to anticipated changes.

As regards congestion charging and workplace levy charging in urban areas, there is little sign of many of these being introduced as yet. This is because the general feeling in local authorities is that the public remain hostile, and that public transport improvements need to come first, before the charges can be introduced; so any planning that assumes the money from charges will fund the *start* of public transport improvements is flawed.

There is an opportunity here to learn from the light rail (or combined light/heavy) schemes that have delivered passenger growth (e.g. Manchester and Tyne & Wear) and to analyse reasons for success, so that best practice can be introduced within the region (e.g. in Bristol).

Challenges and Opportunities of Key Climate Impacts in Transport Domain

Climate Impact		Challenges and Opportunities
Summer Temperature Increased	C	More visitors to the South West, so potentially increased road congestion and lack of rail capacity.
	C	Increased pollution from increased road traffic (leading to increased incidence of asthma and other respiratory problems, and so devaluing quality of life – one of the region's greatest assets).
	C	Rail expansion and danger of rail buckling, resulting in imposition of Temporary Speed Restrictions.
	O	Encourage use of sustainable transport – bus, rail, walking and cycling to alleviate congestion on roads and protect the environment.
	O	More opportunities to encourage tourism related to outdoor activities e.g. walking and cycling, public transport and circular walks, etc.
	O	Potential for publicity working with public transport operators, countryside access and tourism board.
	O	Opportunity to re-link Newquay to St Austell by rail, to provide direct regional rail link and so facilitate more tourism by rail within Cornwall, rather than by private car (Currently only 17% of rail traffic on Newquay line is local; information: Wessex Trains).
Winter Temperature Increased	C	Extension of tourist season in South West, especially to surfing resorts such as Newquay, increasing the period of congestion in the region.
	O	Less frost damage to roads from winter cold, so potentially less frequent need for road repairs.
	O	Fewer points failures on rail lines.
	O	Reduced frequency of use of rock salt for de-icing on roads, so savings from County budgets on salting works.
	O	Fewer ice/snow related road traffic accidents.
	O	Increased probability of meeting road accident reduction targets.
Flooding Increased	C	Flood risk to major roads in and between major cities, including Gloucester (A38); and in major towns including Tewkesbury.
	C	Flash-flood risk in Devon and Cornwall from high-intensity storms, disrupting travel.
	C	On roads, more surface water overload.
	C	Delays to public transport schedules and freight movements, owing to route flooding, bridge scour/damage.
	C	Perceived high risk of mainline rail connection to region being severed by flooding.
	C	Major issues of flooding at a number of vulnerable points on the rail network, including Cowley Bridge (R. Exe); the Tarka (Barnstaple) line; Sapperton and Chipping Sodbury tunnels; and just to the north of the south west region (disrupting the mainline between Cheltenham and Birmingham).
	O	For rail, opportunity to develop strategic alternative routes (e.g. dual the Salisbury-Exeter rail line; dual Swindon–Kemble; create new line Exeter to Plymouth, via Okehampton–Tavistock; reopen Honeybourne route Cheltenham–Birmingham) to provide robustness of communications when other lines are flooded and/or tunnels closed.
Summer Rainfall Reduced	C	Subsidence to roads (and rail), especially in clay areas.
	O	Risk of subsidence provides an opportunity to justify substantial embankment strengthening and capacity improvements, facilitating general benefit to rail services.

Climate Impact		Challenges and Opportunities
Winter Rainfall Increased	C	Fewer opportunities to encourage walking and cycling, thus encouraging more cars onto the roads
	C	Failure to meet targets for these sustainable modes of transport.
	C	Traffic moving to and between towns and cities vulnerable to floods.
	C	Major challenge to keep Tarka (Barnstaple) rail line open.
	O	Provide better bus shelters and rail-platform canopies.
	O	Lobby rail industry (Strategic Rail Authority; Train Operating Companies) and central government to ensure good rail links are maintained, and alternative rail routes are developed.
	O	Increase in air travel over rail travel to Devon and Cornwall, if improvements to airport capacity provided [Note: this in conflict with need to reduce greenhouse emissions, and against recommendations of European White paper]
Increased Sea Levels and Tides	C	Vulnerability of sole rail route to south-west peninsula at Dawlish at times of high tide; vulnerability exacerbated by rising sea-levels or storm surges; high tides exacerbate drainage problems further inland (e.g. north of Exeter)
	O	Construct alternative rail route Exeter-Plymouth, to ensure peninsula is not cut off from the rest of the national network, as happened in Autumn/Winter 2000-2001, and to encourage modal shift, road to rail.
	O	Flood risk reinforces the case to redouble whole of rail line Salisbury to Exeter, to provide alternative and diversionary route.
Longer Growing Season and Reduced Frosts	C	Encroachment of vegetation obscuring road signs, requiring more frequent maintenance and therefore increased costs.
	C	Increased weed growth on rail tracks requiring extra maintenance.
	C	Footpaths overgrown requiring increased maintenance or limiting use.
	O	Potential to increase the number of walking and cycling friendly routes.
	O	Walking and cycling become more attractive for commuters, every day activities, and tourism.
Potentially Increased Winds and Storms	C	More trees falling onto road and rail network, so higher budget and more operatives required to maintain and clear network.
	C	Increased risks to transport infrastructure.
	C	Less opportunity for helicopter and fixed wing planes to fly to the Isles of Scilly, so difficulty in keeping air link to Scillies open.
	C	Rail electrification may not be viable owing to increased risk of storm damage.
	C	Train operating companies required to run replacement bus services on already overcrowded roads if no alternative rail route is developed.
	O	Opportunity to encourage the construction of alternative and diversionary rail routes to and from South West.

UTILITIES DOMAIN

Scope

The provision and maintenance of utility supplies including considerations of supply and demand of energy (electricity, gas, oil, coal) and telecom services.

See Also

Water resources, Built environment, ICT.

Background

The south west, like the rest of the UK, is heavily dependant on fossil fuel for electricity, transport and heating needs. In 2001 the energy generation within the South West was estimated to be in the region of 3,950 MW, largely from nuclear power stations that are nearing the end of their lifespan. There is a new gas fired power station due to come on line by 2010.

There is a growing awareness in the region for a need to develop renewable energy resources, and in fact the region hosts the UK's first commercial wind farm, in North Cornwall. Cornwall in particular has been proactive in the field of renewables and produces over the national average for renewable energy, largely through wind power. The recent renewable energy audit for the south west suggests that the region can do much more in this area, and sets out ambitious targets for the next few decades.

Solid fuel and some gas supplies are transported through the region by road and rail. Large quantities are also imported through the region's ports. Considerations affecting these are dealt with under other sectors as being primarily concerns of transport and the marine sector.

The far south-western parts of the region rely heavily on electricity carried through an extensive cable network which bottlenecks at certain strategic points, such as Indian Queens in mid Cornwall.

Key Issues

- Space heating requirements will be reduced, but summer energy loads increased due to a greater demand for cooling (air conditioning).
- Increased use of renewable energy (RE) is possible, although changes in future wind, wave and solar conditions will influence planning considerations.
- Storm events may increasingly affect storm drainage and sewers, which are already highly susceptible to flooding, thus impacting on underground cables, pipes etc. for electricity, telecommunications and other utilities.
- Changing rainfall patterns may influence hydroelectric power output.
- Rising sea levels may increase the number of underground cable faults.
- Increased development of resource use efficiency measures is likely.
- Increased tourism and a growing population may increase pressure on supplies and require expansion of infrastructure.
- Existing infrastructure may be at increasing risk from storm events, sea level rise and coastal erosion.

Specific Climate Issues

The periferality of much of the extreme South West will make disruption to supply that much more time consuming to remedy. At the same time, many of the organisations involved with utilities provision are not based in those areas likely to be first affected by climate change, and are so not perhaps as "switched on" as might otherwise be the case.

Particular risks

- Damage to cabling both underground (flooding, subsidence) and above ground (flooding, extreme weather events).
- Reduction in heating demand may reduce markets in some instances.
- Large scale loss of power to the region through damage "upstream" of the region, caused by extreme events. In particular for the far south-western parts of the peninsular.

The Way Forward

There currently seems to be little real concern in these sectors, which will have to be addressed before progress can be made. That being accepted, there are a number of potential drivers that could bring the debate and eventually action, forward in the region.

- Energy – Government targets and financial incentives will encourage, or otherwise, the development of the renewables industry.
- Demand for affordable private air conditioning units will drive the market for this technology.

- Public pressure for continuity of supply both in energy and telecommunications will be a major factor in how these industries respond to the potential threats due to climate change.

Particular opportunities for the region

- Development of community renewable energy schemes connected to locally operated and connected grids would allow a sustainable use of power while protecting the region from disruption caused by situations occurring outside the region itself.
- Development of a market for air conditioning.
- Development of new equipment better able to withstand the predicted conditions.

Knowledge base

There appears to be very little involvement within the South West energy and telecommunications sectors as to the impacts and opportunities of climate change. This would suggest that there is a considerable need for an increase in information for this sector.

The CCIRG publication "*Review of the Potential Effects of Climate Change in the United Kingdom*" (1996) states that little research into physical impacts of climate change on the UK energy sector had been conducted at that time, and that furthermore there was little point in conducting such research until better, more regional projections of climate change became available. With the publication of the UKCIP02 scenarios, this might now become a more viable proposition. A study of the impacts of climate change on the electricity supply industry, funded by EPSRC (working with UKCIP) is due to begin in Spring 2003.

Challenges and Opportunities of Key Climate Impacts in Utilities Domain

Climate Impact		Challenges and Opportunities
Increased Summer Temperature	C	Capabilities of equipment used to transport electricity generally reduce with increased temperature. May need to invest in network improvements.
	C	Traditionally increased temperature relates to a reduction in electricity demand, which may be broken by increased use of air conditioning. This might require maintenance programmes to be rescheduled to cope with shifting demand/system capacity relationships.
	C	Cooling water in power stations less effective due to increased temperature.
	O	Potential for development of air conditioning business.
Reduced Summer Rainfall	C	Subsidence effects could damage underground cabling, pipe networks etc. (Not believed by TRANSCO to be a threat to gas infrastructure).
	C	Reduced water supply available for cooling water in power stations.
	O	Reduced rainfall may allow for easier and swifter summer maintenance work.
Increased Winter	C	Potential problem to power companies arising from increased demand for heating and therefore reduced sales..
Temperature	O	Reduced winter demand for electricity may reduce the need for investment in increased network capacity.
Increased Winter Rainfall	C	Access to land for fault repair may be impeded and maintenance programmes more difficult to carry out. There may be a need for increased 4-wheel drive/tracked vehicle capacity for access on soft ground.
Increased Sea Level and Tides	C	Coastal power stations and distribution network could be at risk from both sea level rise and increased tidal heights.
	C	Rising sea levels would increase the length of cabling under water and could increase the number of underground cable problems.
Longer Growing Seasons and	C	More tree trimming might be required to maintain clearance for overhead lines if tree growth starts earlier and continues for longer.
Reduced Frosts	O	Possible less risk of frost damage to underground infrastructure. (Limited due to frost precautions already taken.)
Flooding Increased	C	Electricity supply services have the capacity to be affected by river flooding, standing water and slope flooding and by drainage system overload.
	C	Substations may need isolating during extreme flood events. Extra attention is already applied to substation design if placed in a flooding prone area.
	C	Public may be at risk from overhead power lines if using boats on flooded land.
Potentially Increased Winds	C	Windborne debris can damage overhead equipment and cause power interruptions.
and Storms	C	Wind speeds over 100mph can cause direct damage to overhead equipment.
	C	Increased frequency of damage will require more frequent maintenance.
	C	Increased storm intensity may ultimately require a revision to equipment standards.

CHAPTER 8

BUSINESS SECTOR DOMAINS

LIKELY IMPACTS & POSSIBLE ADAPTATION RESPONSES

Introduction

This section considers those domains in the South West which fit broadly under the heading of 'the business sector'. Such headings are necessarily arbitrary but have proved useful in progressing and reporting on the study. Because of the wide range of commercial and industrial activity in the region the decision was made to limit the study to certain key sectors. Therefore this section focuses explicitly on the priority sectors which the SWRDA has identified as the main vehicle for economic development in the region. So, the section explores the following impact domains:

1. Advanced engineering
2. Biotechnology
3. Environmental technology
4. Financial services
5. Food and drink
6. Information Communication Technology (ICT)
7. Leisure and tourism
8. Marine engineering
9. Tele-marketing

(For details of the methodology adopted for researching and reporting on these domains please see Annex 2.)

This introductory section precedes the detailed consideration of each domain and considers some of the general issues relating to the entire business community. It is followed by a table of recommendations for the business sector and individual domains.

Business activity will be significantly affected by climate change, whether through direct impacts of future climate, such as increased flooding, or through new market opportunities presented in areas such as tourism or environmental technologies. In addition, activities within the business community by their very nature have an effect on all of society. Therefore, it is important that impacts and adaptation options for businesses are at the forefront of any climate change studies or policies. It is also evident however, that despite the potential for businesses to drive forward the climate change debate and both stimulate and develop solutions to the issue, there are very few business sectors, and even fewer individual businesses, for whom climate change adaptation is considered a serious issue.

Mitigating climate change, on the other hand, has become increasingly focussed on businesses through the fight to reduce greenhouse gas emissions and in particular through the introduction of the Climate Change Levy in April 2001 which levies a tax on the use of commercial, non-renewable energy. Unfortunately, many businesses view the imposition of these financial costs as simply an additional burden and do not appreciate the issues behind the legislation and the incentive to reduce greenhouse gas emissions.

More awareness raising is needed to ensure that businesses are at the forefront of climate change adaptation in the South West.

Business Profile of the South West

The business environment within the South West consists of 203,900 business establishments with the majority (85.4%) employing less than 10 people. (This is slightly higher than the national figure of 84.%). Just 1.3% of workplaces employ over 100 people in the South West, slightly less than nationally. Although medium and large workplaces (employing 25 or more people) are heavily outnumbered by small workplaces, the former provide the bulk of employment in the South West. Over three quarters of jobs in the South West are provided by medium and large workplaces.

Reflecting the small scale of many businesses, the region has one of the highest rates of business failure in the UK, with 4,514 businesses failing in 1997, equivalent to 2.5% of all business in the region. This is far in excess of the national average of 1.8%, despite the actual number of failures falling by almost 16% on the previous year. This suggests that there may be a need to improve business support and information services within the region on many issues, of which climate change may be one.

The region has a similar rate of new business formation, 40 registrations per ten thousand people in 1998, to that experienced across the U.K. as a whole. New businesses in the South West fare slightly better than average in terms of their longer term survival with 63.8% of businesses registered in 1995 surviving for three years compared with 61% nationally.

Due to its rural nature the South West has a particularly large concentration of businesses in the agriculture, forestry and fishing sector, accounting for almost 13% of all business establishments in the region.

The region also has a higher than average share of establishments in the mining, quarrying and energy sector reflecting the industrial strengths of the region. Other key sectors in the region include tourism, with the South West attracting more than

21m visitors each year, and information and communication technologies.

Those organisations and businesses directly involved in the protection and enhancement of the natural environment also play an important role with at least 1,376 jobs directly employed in this sector in the region contributing an estimated £26m to regional GDP (Source: RSPB Study). This reflects the growing importance being placed on enhanced environmental quality in creating conditions for inward investment and business growth, particularly for tourism but also in areas of film and media, and quality of life for residents.

The environment plays a significant part in the quality of life in the South West, in turn attracting people to live and work in the region. In a recent survey of company executives, 57% stated that overall quality of life was the most important personal factor for relocation to another city.

Research and Development (R&D) by businesses is greater in the region than the national average - but trails business R&D spending in the east and south east. Government R&D in the South West is slightly higher than the UK average, while R&D activity by higher education is slightly lower.

The South West has been successful in attracting inward investors, particularly in the east of the region, including Bristol and Swindon. These firms are concentrated in hi-tech, research, automotive, plastics and food processing clusters, and employ large numbers of people. Over 1,200 overseas-owned companies have located in the region, constituting 25% of the region's hi-tech manufacturing cluster which employs 50,000 people, and with a major presence in a number of other sectors including automotives, plastics, ICT and food processing.

Climate Change:

The Challenges and Opportunities for Businesses

Weather conditions already have significant impacts upon business activities, including disruption to supply lines, over- or under-stocking of goods, loss of work days for outdoor activities, infrastructure damage, overtime costs, financial penalties for late projects and health effects on staff.

A recent survey suggests that British businesses lose on average 11.54 days trading each year as a result of the climate (Met Office, 2001). The cumulative costs of these impacts are around £7.6 billion per year, or up to 10% of company profits. Despite the fact that 75% of businesses recognised the impacts of climate, 47% thought their business wasn't sensitive to the weather, and only 17% take climate into account when planning business activities.

A major barrier for the business sector generally is the difficulty in perceiving climate change as a current matter for attention, rather than a distant concern for beyond the 2020's. Businesses tend to plan only a few years ahead, and rarely recognise situations occurring today – e.g. reduced winter heating bills, higher insurance costs, increased flood risk etc. as being a symptom of climate change to which they are already exposed.

Future climate change scenarios suggest that significant business impacts will take place as a result of a number of climatic variables. Throughout all sectors generic impacts will include:

- Direct infrastructure impacts as a result of increased flooding, subsidence during dry weather, coastal erosion, windstorm impacts and water intrusion.
- Changes to resource usage, in particular increased energy demands for cooling in summer months, and reduction in winter heating demands.
- Changes to internal conditions within facilities, primarily hotter in both summer and winter, impacting upon production processes and worker health.
- Changes to external conditions for outdoor workers, primarily hotter summers and wetter winters.
- Health impacts as a result of higher internal and external temperatures, increased winter survival of diseases and other risks.
- Impacts upon supply lines, staff availability and business activities as a result of flooding, subsidence, and storm impacts on transport and communications facilities.
- Climate change impacts upon markets and customers on a regional, national and international scale.
- Changes to planning and building regulations as a result of perceived climate impacts and related government legislation.
- Changes to insurance costs and coverage, in particular in vulnerable geographic areas or economic sectors, such as operations within floodplains. Financial implications related to this may include changes to mergers and acquisitions, a lack of inward investment and an inability to develop or sell facilities.
- The potential for litigation against companies who provide services which are subsequently impacted upon by climate change. As a result businesses may become susceptible to legal challenges if their products and services do not allow for climate changes. This is an area that needs further investigation, and may well prove to be a driving force behind many businesses accommodating climate change in future projects.

Despite the potential risks and costs of these impacts, significant market opportunities exist for many business sectors to develop climate-proof products and services which reduce climate impacts and increase adaptability. In addition, opportunities exist within specific sectors such as flood defence technologies, tourism and environmental services to capitalise on both the positive and negative impacts of climate change. The expanding market for cleaner technologies and low carbon products means that many new opportunities exist within this field and many businesses may choose to diversify into these areas.

Despite these significant new market opportunities, both in the South West and globally, many businesses will be slow to react on their own. It is likely that government legislation, including changes to planning regulations, and financial penalties or incentives will be a major driving force behind business changes. It is likely that many forms of legislation will be in response to a demand to mitigate climate change and a recognised need to prevent catastrophic losses in vulnerable areas, such as along coastal regions.

However, the potential savings for business of considering the climate today and accommodating future changes means that corporate growth could be increased by considering climate and climate change as soon as possible.

Proposed actions for all businesses to accommodate climate change include the following:

1	Investigate potential climate change impacts on their business.
2	Create a management position with responsibility for climate change.
3	Report risks in annual reports.
4	Provide funding for climate change related activities in future budgets.
5	Appoint a climate change task force.
6	Develop and implement a climate change action plan.
7	Assess the effectiveness of the action plan and make further improvements.
8	Quantify greenhouse gas emissions and set reduction targets.
9	Communicate actions and findings to the public and shareholders.
10	Maintain links with stakeholders, researchers and the media.

Table 8.1

Proposed Actions for all Businesses

(Salt, 2001)

Recommendations for Business Domains

- Identify managerial responsibility within individual companies for addressing the impacts of climate change.
- Carry out simple risk assessment appropriate to scope of business based upon climate change scenarios.
- Risk assessment should include: health; supply lines; infrastructure; insurance; litigation, customer demand, etc.
- Specifically investigate the challenges and opportunities presented by climate change with regard to the market for goods and services provided by the company.
- Recognise that markets will be influenced by climate change impacts at a regional, national and global scale.
- In reviewing market threats and opportunities consider potential changes in lifestyle brought about by climate change.
- Monitor greenhouse emissions at company or site level and take steps to reduce them in order to reduce the potential for global warming.
- Identify appropriate policy frameworks within which to nest adaptation strategies.
- Co-ordinate the development of climate change strategies within each business sector in the region, possibly through Trade Associations, Professional Institutes, etc
- Explore commercial opportunities for **advanced engineering** in the development of 'flood-proof' infrastructure to accommodate higher storm surges and tides.
- Explore commercial opportunities for the development of new technologies in **renewable energy**.
- Undertake further research on climate change impacts on agriculture (e.g. drought conditions) and potential for **biotechnology** in adapting to new climatic conditions.
- Increase awareness of potential impacts of climate change in order to increase market opportunities for **environmental technology** sector.
- Encourage **insurance industry** to be more open in its deliberations on emerging policy with regard to climate change impacts.
- Encourage the **finance sector** to identify investment opportunities with regard to climate change mitigation including low-carbon technologies.
- Explore the potential for new local crops and produce as part of regional and sub-regional strategies for marketing local f**ood and drink** specialities. Use SWRDA sector development project as one vehicle for this work.
- Explore and monitor implications of global impacts on regional **tourism and leisure** activity.
- Provide co-ordinated strategy and support for disparate and often small businesses in the **tourism and leisure** industry. Use SWRDA sector development project as one vehicle for this work, in conjunction with Tourism South West and relevant trade associations.
- Try to spread visitor numbers throughout the year by extending tourist season to avoid further stresses on already stretched **infrastructure**

ADVANCED ENGINEERING AND AERONAUTICAL INDUSTRY DOMAIN

Scope

Commercial activities associated with advanced engineering, including aerospace engineering, medical devices and automotive vehicles and components.

See Also

Biotechnology, ICT, Environmental Technology, Coastal Erosion and Flood Defences, Built Environment, Utilities and Transport.

Background

This business sector is comprised of large multi-national companies who are major employers within specific geographic areas, as well as smaller regionally based components suppliers, expert consultants, and sales and distribution companies.

Businesses within this sector are clustered together in a number of pockets throughout the region, including; aeronautical engineering in Bristol, car production in Swindon, Helicopter production in Taunton, marine engineering in and around Plymouth, and medical related engineering throughout many areas.

As a result advanced engineering is an important employer and contributor to the regional economy, and in some areas has replaced more generalised engineering, in particular traditional defence based industries.

In addition this sector has attracted a large volume of inward investment into the region and developed the South West prestige overseas. As a result Advanced Engineering is a sector in which investment is being made by the SWRDA to further enhance the region's economic prowess and to ensure that new technologies and advances are competitive.

Key Issues

- Changes to manufacturing processes may be required to accommodate increased internal and external heat.
- Opportunities to develop engineering solutions to climate change impacts in many economic sectors and geographic regions.
- Changes to health risks as a result of climate change providing new opportunities for medical technologies.
- Impacts upon infrastructure, supply lines and customers.
- Increased costs as a result of restricted water supplies and changes to energy costs.
- Increased levels of down time as a result of loss of energy supplies and telecommunications during periods of extreme climate impacts.
- The introduction of global climate change mitigation legislation is likely to provide both challenges and opportunities to this sector through the development of low carbon technologies.
- Opportunities exist to develop on-site "climate proof" energy supplies using renewable energy technologies.

General Concerns for the Industry

This sector will incur similar infrastructure and transportation impacts as other business sectors. The result is an increased disruption to manufacturing processes through flooding of sites, rain intrusion into buildings, storm impacts, increased levels of subsidence during hot, dry, summers and impacts along coastal regions. Furthermore, transport links, particularly coastal installations such as ports and railway lines may be disrupted, as would electricity and telecommunications connections. Some impacts should, however, be offset by a reduction in cold weather effects, in particular a decline frost related impacts.

Repair and insurance costs are likely overall to increase and changes to planning guidelines to take account of climate change will affect plant expansion and other developments. Furthermore, the high dependency of this sector upon suppliers nationally, as well as the global markets it is involved in, results in it being very susceptible to climate impacts in other regions.

Components within manufacturing/engineering processes may be affected by changes in heating conditions and related requirements for increased coolants. Potential reductions in water supplies during dry summer periods may exacerbate this problem further. In addition increased heating moderation in offices and factories have related health impacts and affect worker productivity, thus requiring changes to building design and heating/ventilation processes.

The Way Forward

Despite the potential for considerable impacts in many operational areas, this sector has the potential to contribute significant engineering solutions to many of the climate impacts on a global scale. This may include the development of "flood proof" infrastructure, including engineered flood defences, and installations similar to the Thames Barrier to accommodate higher storm surges and tides.

In addition the development and increased use of renewable energy products within this sector and others will result in increased demand for technologies such as solar power, heat exchange technologies and tidal power installations. The use of on-site renewable energy will also reduce dependency upon vulnerable energy distribution infrastructure, and reduce energy costs related to fossil fuel combustion. The development of resource efficient products for global markets will provide a substantial opportunity for engineering companies, including such things as energy efficient vehicles.

New markets are likely to result from changes in demand for products related to climatic conditions on a global scale, such as increased demand for soft top cars and changes to health risks and related technology demands. Furthermore, demands for technologies which control or reduce greenhouse gas emissions within transportation and manufacturing process present a considerable short to medium term opportunity for businesses within this sector. This may include carbon dioxide fixing and disposal technologies.

Mitigating climate change is an important issue for this sector, as it remains dependent upon large-scale energy use and may produce high levels of greenhouse gases. As a result this sector may susceptible to government legislation, and may benefit from activities such as emissions trading schemes.

Mechanisms for Change

As with many economic sectors, advanced engineering will respond to a combination of customer demand, risk avoidance, costs, and government legislation. There is likely to be limited activities within many businesses to accommodate climate change impacts on a large scale. Drivers will include demands for technologies which have lower levels of greenhouse gas emissions. In addition increasing demands for flood defences and related engineering activities will be a significant driver on the product side of the business.

On the production side the primary drivers to consider climate change will be direct and perceived costs, in particular costs as a result of impacts such as flooding over a sustained period, and insurance costs. Linked into this will be changes in building and planning regulations which will dictate where and how facilities can be expanded.

The introduction of further government legislation and incentives to both mitigate and accommodate climate change will also act as one of the primary drivers for change in this business sector.

Barriers to Change

Traditional engineering and manufacturing has often been slow to respond to changes within environmental parameters. However, the new generation of engineering firms covered within this sector have developed into more flexible organisations than in the past. This is a consequence of the fluctuations within global business markets, but may prove to make them responsive to climate change.

Uncertainties within climate predictions coupled with the difficulties for businesses to accommodate climate change impacts pose a considerable barrier to change. In addition the cost of making changes to engineering plants and other facilities are considerable and unlikely to take place until higher knowledge levels are developed within the sector.

Perception of Adaptation Issues

There is little evidence to suggest that adaptation to climate change has been considered within this sector. However, the consideration of flood risks and planning changes is evident and this may prompt future adaptation considerations as the issue becomes more integrated within the business sector.

Challenges and Opportunities of Key Climate Impacts in Advanced Engineering and Aeronautical Industry Domain

Climate Impact		Challenge and Opportunity
Summertime Temperature Increased	C	Increased coolant costs for offices and manufacturing processes.
	C	Health effects upon staff working in offices and factories.
	C	Health effects on staff working outdoors.
	O	Change in market demand for products, e.g. Soft top cars.
	O	Increased use of solar power and heat exchange technology within the manufacturing process.
Wintertime Temperature Increased	C	The need to change current heating and ventilation systems within buildings to meet new building guidelines.
	O	Positive impacts upon energy costs and staff health.
	O	A reduction in cold weather impacts on supplies, manufacturing processes and infrastructure.
Flooding Increased	C	Direct infrastructure damage, and indirect impacts upon supplies and markets.
	C	Increased insurance costs and changes to planning regulations affecting infrastructure development.
	O	New products/markets for engineered flood defences and “flood proof” infrastructure.
Reduced Summer Rainfall	C	Restricted water supplies with association cost implications.
	C	Risk of subsidence in vulnerable areas.
	O	Increased use of solar power technologies in manufacturing.
	O	Opportunities for expanded work outside of buildings.
Increased Winter Rainfall	C	Impacts on infrastructure, in particular buildings and installations.
	C	Increased down-time and delays as a result of water intrusion.
	O	On-site water collection and storage operations.
	O	Increased water supplies during winter months.
Sea Levels and Tides Increased	C	Direct and indirect impacts on infrastructure, markets and supplies, in particular impacts on port facilities, and coastal installations.
	O	Engineering solutions to storm surges and tidal inundation.
	O	New engineering requirements for coastal infrastructure and ship design.
	O	The possibility to develop products for tidal power generation
Longer Growing Season and Reduced Frosts	C	None identified.
	O	A reduction in frost impacts.
Potentially Increased Winds and Storms	C	Increased direct and indirect impacts on infrastructure and supplies/ markets.
	C	Increased repair costs and insurance costs.
	C	Increased down-time through loss of energy supplies.
	O	The opportunity to develop on-site energy sources, such as wind turbines and other renewable energies.

BIOTECHNOLOGY DOMAIN

Scope

Commercial activities operating within the realm of biotechnologies; including medical techniques and equipment development, technologies derived from or responding to natural/ biological processes, and monitoring of biological indicators.

See Also

Agriculture; Health; Built Environment

Background

The SWRDA has identified over 100 companies within the region which fit into this description of the developing biotechnology sector. However, connected business sectors, including environmental technologies and agriculture which are well established in the region, are likely to be impacted in a similar way to this sector. In addition impacts within the ICT sector and other technology developers will have considerable impact upon what is in essence a very technologically dependent economic sector.

Many biotechnology companies are of a small scale and in some cases are recently established. The need for considerable resources and contact with leading scientific research has resulted in many spin-out companies from research establishments in the region. This is particularly true for a number of businesses operating out of the Tamar Science Park in Plymouth which have been set-up in conjunction with the University of Plymouth.

Biotechnology is one of the key sectors within the SWRDA development strategy for the region and has its own co-ordinator position.

Key Issues

Context

Recent issues surrounding the genetic modification of foods and other biotechnological developments have highlighted the challenges this sector faces. However, potential climate change impacts on a global scale will again highlight the need for drought or flood resistant crops and other biotechnological advances, thus providing opportunities for companies in the South West. The conflicting demands of public opinion and resource needs is an issue that is likely to expand further in the future as climate change becomes more of an established concern.

Main Issues

- Demand for climate resistant crops and biological processes will increase opportunities for market development.
- Health considerations, including increased solar radiation, heat effects and dehydration will provide potential market opportunities.
- Direct impacts upon business activities include dust and heat stress on operatives and equipment damage.
- Financial costs of insurance, resource use and investments will be affected by operations in this sector and beyond.
- The provision of advice and consultancy services to other business sectors will increase as climate change becomes a more substantive issue across the business world.

Impacts upon other business sectors and natural domains will present the biotechnology sector with considerable challenges and opportunities as more emphasis is put on resources to adapt to climate change impacts.

A primary example is the development of resistant crops to overcome increased drought and damp conditions. Species which resist increased pest numbers will increase in importance as well other modified natural processes.

The debate for GM work will re-open and many more people may see the benefits and moderate their opposition.

Biotechnology Company Adviser

Climate impacts upon health will be another priority area for development, including enhanced sun screening, such as sun blocks, and products to maintain hydration of humans during particularly hot periods.

Direct impacts upon operations within biotechnology companies will include health effects on staff working indoors and outdoors.

In our biotech work, opportunities would come from the physical effects such as flooding.

Biotechnology Company Manager

Instruments used in the field and in laboratories may require increased protection from higher temperatures and dustier conditions.

Other impacts include increased costs of natural resources and insurance costs, as well as global influences upon biotechnology activities as a result of climate change impacts in other areas.

The Way Forward

This sector has the potential to be at the forefront in developing solutions to climate change impacts. Therefore, the phenomenon itself will be a considerable driver as impacts become more apparent and research clarifies potential challenges. However, it will be the requirements of other business sectors for specialist advice and resources which will be the main drivers in developing climate change related activities in this sector.

> **Climate change is probably going to be a lot quicker than useful evolutionary changes. Biotechnology deals with living things, hence there will be a definable need to artificially adapt living things (foodstuffs, beneficial predators, livestock etc) to cope with any change. Society will reject most of these ideas due to the media's portrayal of any genetic modification as the stuff of science fiction.**
>
> Biotechnology Company.

Potential Barriers

The primary barriers to change are likely to be the challenges faced in developing genetically modified material and promoting acceptance of these throughout society, in particular within the U.K.

Scientific uncertainties within the field of climate change research will also pose a barrier to some companies who require this information, but do not have the resources to develop it themselves.

Therefore, this sector will be amongst the most responsive to climate change knowledge as it becomes more available.

Perceptions within the sector

Biotechnology businesses recognise the need to consider the environment as a vital resource and therefore acknowledge the need to adapt to climate change. However, the nature of the sector means that opportunities for modification of the environment to accommodate climate change exist.

Concern within the sector is on the acceptance of all adaptation strategies by the public. Opportunity will be provided but the solutions require significant funding which takes time and resources, even with public and government support.

Knowledge and information base

To date there has been little specific research or information dissemination on climate change within this sector specifically. Research into climate change impacts on agriculture with particular reference to drought conditions and other climatic phenomenon is relatively well developed and many of the issues raised there will be pertinent to businesses in this sector. In addition consideration of the health implications of climate change and response strategies which may include biotechnology will also benefit this sector - work on this is relatively advanced in many areas.

Challenges and Opportunities of Key Climate Impacts in Biotechnology Domain

Climate Impact		Challenges and Opportunities
Summer Temperature Increased	C	More focus on plants' genetic ability to resist extremes and possibly increased predator-attack, especially food-crops.
	C	Outside work; exposure to sun, dust, extreme heat and the subsequent unreliability of scientific instruments.
	C	Changes away from normal cooling methods towards air conditioning and other cooling methods, with associated increases in costs.
	O	The development of products and services to meet market needs (below)
	O	Develop new food supplements to cope with changes to peoples daily lives such as possible short-term dehydration.
	O	Develop crops and potentially livestock to resist heat stress
		Develop superior sun-block systems
	O	Develop preventative measures to deal with stronger sun and related enhanced ageing effects and skin cancers
Summer Rainfall	C	A restriction on water intensive activities.
Reduced	C	Changes to the cost of water and water abstraction.
	O	Develop drought- resistant crops.
	O	Opportunities for genetic modification of crops (e.g. Effects upon insects required for pollination)
Winter Temperature Increased	C	Change current heating and ventilation systems within buildings to accommodate warmer winters and to meet new building guidelines.
	O	A reduction in cold weather impacts on supplies, manufacturing processes and infrastructure.
	O	Positive impact upon energy costs and staff health.
	O	Opportunities for crops to be made more resistant to damp-related problems and resistant to certain pests which may proliferate under damper conditions.
Winter Rainfall Increased	C	Increased risk of flooding.
	C	Impacts on infrastructure, particularly buildings.
	C	Development of crops resistant to wet weather and related pests.
Sea Level and Tides Increased	C	Direct and indirect impacts on infrastructure, markets and supplies, in particular impacts on port facilities.
Longer Growing	C	Changes in demand for frost resistant crops.
Longer Growing Seasons and Reduced Frosts	C	Changes in demand for frost resistant crops
	O	The potential for multiple-cropping and the development of new species to accommodate the new growing conditions.
	O	Increased demand for consultative advice.
Flooding Increased	C	Direct infrastructure damage, and indirect impacts upon supplies and markets.
	C	Increased insurance costs and changes to planning regulations affecting infrastructure development.
	C	Impacts upon crops and monitoring equipment.
	O	Provision of specialist advice and research into causes and effects of crop damage and biological control of flooding.
Potentially Increased Winds and Storms	C	Increased direct and indirect impacts on infrastructure and supplies/ markets.
	C	Increased repair costs and insurance costs.

ENVIRONMENTAL TECHNOLOGIES DOMAIN

Scope

Commercial activities associated with environmental technologies, including environmental engineering, resource efficient products, renewable energy products, environmental monitoring equipment, low carbon technologies and related consultancies.

See Also

Water Resources, Built Environment, Biotechnology, ICT, Marine Engineering and Activities.

Background

The South West has a considerable, and growing, reputation for developing technologies that conserve and monitor the environment. The idea of the region as the "Green Peninsula" is often referred to and is well founded in its development of renewable energy in particular as well as many other specialist techniques and technologies.

The level of renewable energy development has grown considerably with over 70 companies in Cornwall alone involved directly with renewable energy development, such as wind power, wave power and thermal power.

In addition recent initiatives by the SWRDA to promote the development of environmental technologies have included the EnviroSkills SW project which aims to "provide an overall focus to support innovation in the Environmental Technology sector in the South West region, and as part of this, to help facilitate the SWRDA's engagement with the sector businesses". This project has included training needs analysis within the sector and a conference held in March 2002 which drew together businesses, training providers, policy makers and organisations to further develop the profile and training needs of this sector.

Subsequent initiatives to identify requirements within this sector and to further develop its resources are ongoing at present. The opportunities for this sector to develop over the short to medium term have been identified and are being developed as issues surrounding environmental protection and monitoring become more prevalent. The potential for the South West to be a leading force within this sector on a national and international scale is substantial.

Key Issues

This business sector will incur the same direct and indirect impacts upon its activities as other sectors, including flooding of premises, health effects on staff, and disruption to supply lines.

There are however, several issues specific to the environmental technologies sector, including:

- Significant opportunities exist for companies to develop techniques and technologies to monitor and mitigate the risks that climate change may bring - "climate proof" products and services.
- Renewable energy technologies provide opportunities for providing localised sustainable power generation options, reducing energy costs and the vulnerability of transporting power.
- Increased demand from other business sectors and organisations for consultancy services related to managing climate impacts.
- Increased sales of resource efficient technologies, pollution monitoring and other related equipment.
- Direct and indirect impacts upon infrastructure, business activities and supply lines.
- Increased resource costs, including fossil fuel based materials, and increased business costs.
- Increased need for climate impact and climate change consultancy.
- There is potential for expansion in the renewable energy, environmental consultant and related services sector as a result of the impacts of climate changes on other businesses and activities

"The mitigation option is where our business growth is!"

Renewable Energy Consultant.

"We have already had to move our server room to the second floor because of the flood risk. Our insurance company would only provide cover if we moved our servers."

Casella Cel Ltd.

The Way Forward

The need to continually monitor and attempt to manage the impacts of human activities on the environment has lead to a boom within the environmental technologies sector. The view that mankind can develop solutions to climate change in the form of "climate proof" and "clean" technologies has the potential to be a major driving force behind the development of environmental technologies.

The occurrence of the second "Earth Summit" in 2002 further highlighted environmental technology development issues as a response to climate change and more generalised sustainable development issues.

The importance of the natural environment within the South West region as a resource for tourism, energy generation and general economic development has long been recognised. Maintaining this natural environment is of vital importance to the socio-economic development of the region and in many cases this job will fall to businesses within the environmental technologies sector.

This sector is in a position to benefit from the need requirements of other businesses in terms of developing technologies and techniques to both mitigate and adapt to climate change. These include the ongoing development of renewable energies and low carbon technologies, as well as flood risk assessment tools, pollution monitoring technologies, and water supply management products.

Many of the products and services that the environmental technologies sector may develop to manage climate change are already being developed and applied in locations which are susceptible to climate extremes today, such as coastal areas susceptible to flooding. As a result these susceptible areas can be used as test beds for much of the products and services which may be required on a larger scale as a result of climate change.

When new products and services are being developed to manage, mitigate and monitor climate change, it is important that the impacts of climate change on these products and services themselves be considered. Impacts such as higher temperatures, wetter weather, and increased dust production may have significant detrimental effects on equipment and operators.

Potential increases in storminess and higher sea levels may also pose considerable problems to the development of shoreline or off-shore projects, such as off-shore wind farms or tidal barrages. As a result climate proofing of future products and services is essential.

Increases in business and insurance costs may affect future development of renewable energy projects and other infrastructure. However, the potential for this sector to develop climate proofing technologies, monitoring techniques and consultancy expertise related to climate change should result in it being at the forefront of producing low-risk developments.

Mechanisms for change

Many of the businesses involved in this sector within the region are conscious of climate change as an important issue and an important opportunity.

This being said, environmental technologies must react to customer demand. In terms of low-carbon technologies and resource efficient products this is already well established, and government initiatives to encourage their use are growing the sector further.

Climate change adaptation products and services are much less developed. However, existing monitoring and management techniques for flood defences and subsidence have created demands for products and services which can be applied to wider climatic impacts as and when these become more prevalent.

Barriers to change

The underlying barrier to climate change related development is the slow up-take in products and services by many business outside of this sector, i.e. the customers.

The size and financial status of many businesses in this sector mean that ideas may not be fully developed to the delivery point without outside financial input and an established market.

A significant barrier may therefore be the limited ability of smaller companies, which dominate this sector, to attract substantial investment from banks which have yet to consider climate change, or are reluctant to lend to smaller companies.

"We have adapted and are launching a range of low energy, long life ventilation products which go from domestic toilet ventilators right through to industrial roof fans. The company sees this as a market opportunity which local authorities, the education sector and the hospitality industry are keen to take up in response to Agenda 21, under the Government climate change programme. Despite this positive move towards sustainability the company has not had any encouragement from Government"

Vent Axia Company

Key Drivers

The primary driver within the sector will be demands from consumers who want products,

services and facilities that both mitigate and accommodate climate change.

Environmental management and sustainable development practices are becoming, and will continue to become, more important within all business sectors. This is a result of both public demand for sustainable services and government or European legislation to move towards more sustainable processes. In addition many business have seen environment consideration as a marketable product and therefore have altered their activities accordingly.

Smaller and newer businesses can be more responsive to the environment and within this sector they often have a personal desire to tackle climate change and environmental issues. With the number of smaller businesses found in the region, this bodes well for the future of this business sector in the South West.

Knowledge level within the sector

In addition to the recognised potential market opportunities in developing techniques and technologies to assist clients to adapt to climate change, environmental technologies companies themselves are frequently at the forefront of considering their role within the natural environment and potential impacts of climate on their practices. As a result they are advanced in developing sustainable business practices which will accommodate climate impacts.

The importance of the environment within the activities of this sector is paramount. As a result many of those working in this sector are highly knowledgeable about the issues involved and have contributed considerably to the development of knowledge on climate change related issues within the region.

However, as with many other sectors specific knowledge of climate change impacts and adaptation varies across the sector. The dissemination of climate change predictions and related knowledge in a relevant manner is an important factor in developing this knowledge base further. In addition the development of the most up to date and certain predictions of future climate is of importance to those businesses seeking to develop products and services to meet potential increases in demand and to assist in the financing of such developments.

In some cases businesses within this sector will actually be developing knowledge relevant to climate change impacts and adaptations. This knowledge is likely to be disseminated to other businesses through consultancy services.

Challenges and Opportunities of Key Climate Impacts in Environmental Technologies Domain

Climate Impact		Challenges and Opportunities
Summer Temperature Increased	C	Changes away from normal cooling methods towards air conditioning and other cooling methods, with associated increases in costs.
	C	Operational difficulties for equipment under higher temperatures.
	C	Health impacts on staff of higher temperatures and increased pollution, particularly in urban areas and within offices.
	O	The development of energy efficient cooling methods to prevent increased greenhouse gases as a result of air conditioning increases.
	O	The development of detection equipment for changes in pollutants and disease monitoring.
Summer Rainfall Reduced	C	Changes to supply and quality of water will impose restrictions on water intensive activities, and changes to the cost and abstraction of water.
	C	An increased demand for new water efficient technologies such as cistern dams, urinal controls, tap restrictors and monitoring equipment. Especially for intensive water users such as the agricultural, food and drink and manufacturing sectors.
	O	Increased demand for water treatment and "grey water" technologies to: a) maximise the use of reduced precipitation levels b) reduce loss through polluted water. c) combat increased levels of water pollution in higher temperatures.
Winter Temperature Increased	C	Change heating and ventilation systems within existing buildings to accommodate warmer winters and to meet new building guidelines.
	C	Reduced market for frost monitoring equipment.
	O	The opportunity to meet market needs for changes in heating and ventilation systems including heat recovery products.
	O	Positive impact upon energy costs and staff health.
Winter Rainfall Increased	C	Impacts on infrastructure, in particular buildings.
	C	Impacts on health through damp conditions, mould and disease.
	O	The potential for new products to accommodate more humid conditions.
	O	New markets in consultancy and monitoring equipment for processes susceptible to wet weather.
Sea Level and Tides Increased	C	Direct and indirect impacts on infrastructure, markets and supplies.
	O	Increased demand for services and equipment to monitor, mitigate and adapt to sea-level rise, coastal erosion and related impacts, including geo-engineering opportunities.
Longer Growing Seasons and Reduced Frosts	C	Impacts on energy crops and related products/ markets.
	O	New equipment / technologies in a more productive agricultural market.
	O	A reduction in frost damage to building, supply lines and other activities.
Flooding Increased	C	Increased insurance costs and changes to planning regulations affecting infrastructure development.
	C	Direct infrastructure damage, and indirect impacts upon supplies/markets.
	O	An increased need for environmental engineers and consultants to monitor flood risks and products to monitor and warn of flood risks.
	O	Expanding markets for post-flood recovery, such as de-humidifiers.
Potentially Increased Winds and Storms	C	Increased direct and indirect impacts on infrastructure and supplies/ markets leading to increased maintenance, repair and insurance costs.
	O	New markets related to “climate-proofing” buildings and infrastructure.

FINANCIAL SERVICES DOMAIN

Scope

Commercial activities operating within the financial services sector, including; banking, building societies and insurance providers.

See Also

Business, Public Health, Built Environment, Coastal Erosion and Flood Defence, Heritage, Transport, Utilities, and Leisure & Tourism.

Background

Financial services within the South West are primarily focused upon small to medium scale customer delivery points, be that through banks, building societies or insurance brokers. A relatively small number of banking and insurance institutions have larger offices in the region, and are predominantly based in Bristol, Gloucester, Swindon, and Exeter.

Financial services are one of the ten priority sectors of the SWRDA, and consequently are likely to be developed further in the future.

Leading financial organisations originating in the region include Bristol and West, Cheltenham and Gloucester (now part of Lloyds TSB Group) and Stroud & Swindon Building Society.

The influence of the City of London and global financial and insurance markets on this sector is substantial. This reflects the fact that financial services are substantially influenced by market forces far beyond regional boundaries.

Specialist financial services exist within the region, in particular ethical investments services and ethical/ green insurance services. This reflects the growing demand for these types of products in the region and beyond, as well as the importance that the environment plays within the economy of the region. Examples of this include NatureSave Policies Ltd. and The Ethical Investors Group.

When considering financial services it is important to consider the interrelationship between organisations and their customers. As financial companies are service providers, their liabilities and market opportunities will come about directly as a result of changes in the position of their customers, competitors and regulators. Therefore, within this sector direct impacts on financial services will be considered as well as indirect impacts upon customers and the market place.

Key Issues

- Global impacts of climate change, including floods and tropical cyclones, will have an impact on financial companies in the region, and subsequently upon their customers.
- Insurance companies are highly vulnerable to large losses as a result of changes in climatic variables, in particular changes to the severity and spatial or temporal distribution of windstorms, drought conditions, and coastal/ fluvial floods.
- Climate change introduces increased uncertainty into a market place which already has uncertainties attached.
- Warmer winters will result in a reduction in cold-weather related insurance claims.
- Banks and building societies will lose income as customers incur loses through climate impacts, such as disruption to supply chains.
- Properties in high risk areas, primarily flood plains and along unstable coasts, could lose value, become uninsurable or become un-saleable resulting in loses for lending institutions.
- Increased investment opportunities exist in climate change mitigation activities, including emissions trading activities, Renewable Obligations Certificates and low carbon technologies.
- There is likely to be declining investment in traditional fossil fuel based industries.
- Health impacts upon staff and those insured under health insurance schemes is significant.
- The full range of climate change impacts on all sectors will be felt by the banks, in particular short term impacts of extreme events.

The financial sector will be faced with a number of challenges and opportunities which primarily reflect the impacts of climate change on their customers and new markets for products and services.

> **"Recent history has shown that weather related losses can stress insurance companies to the point of impaired profitability, consumer price increases, withdrawal of coverage, and elevated demand for publicly funded compensation and relief."**
>
> IPCC, 2001

Insurance companies are likely to incur increased losses primarily as a result of the following impacts:

- Subsidence as a result of shrinkage of clay soils due to drying. This will primarily occur in the west and South West of the region

where Tertiary, Cretaceous and Jurassic clays are prevalent.

Currently £450 million is paid out annually in subsidence claims in the U.K. alone.

ERM, 2000

- Windstorms which damage infrastructure, particularly when accompanied by heavy rainfall, as may be the case for winters in the future.
- Flooding, both fluvial and coastal, has resulted in substantial losses in the past. Developments in floodplains exacerbates this issue. Currently, approximately 7 million people across the UK are at risk from river flooding alone, and this level is likely to increase as new developments take place (CII, 2001).
- Existing levels of claims for burst water pipes and other infrastructure damage resulting from freezing conditions may well decline as a result of warmer winters. However, if more winter holidays are taken and house are left unheated then pipe bursts may well occur (Palutikof, 1998).

Additional impacts upon insurance companies will include changes to claims for health and life insurance as a consequence of changing climatic conditions. In addition vehicle and travel insurance will be an increasing market, but losses in these categories may occur as a result of climate change, including increased car accidents in fine weather and outdoor activity accidents.

It is important to note that whilst for domestic insurance, claims reflect simply direct damage and loss, for commercial activities claims may also be made for lost income and business. This secondary factor means that businesses can make insurance claims for impacts upon their supply lines and other factors, as well as direct impacts upon the facilities they operate.

Recent insurance policies have allowed for payments to be made if non-physical impacts take place, such as events disrupted as a result of the climate (CII, 2001). This is both a response to businesses needs to avoid large losses, and an opportunity for insurance companies to expand their natural hazards service portfolio. Any increases in extreme events as a result of climate change may reduce companies' ability to maintain some of these services across the board, and/or increase premiums for businesses, which have a consequent effect on other financial services.

There is a significant correlation between summer rainfall and subsidence claims.

Palutikof, 1999

Financial services are very dependent upon levels of business activity in the region and as a result increased insurance losses and costs to businesses will affect the wider financial services sector through decreased loans and other services. In addition perceived risks of climate impacts in certain geographical areas or economic sectors may result in reduced investment in those areas. This is a particular concern for agricultural activities and in coastal regions (UKCCIRG, 1996). Therefore, financial services companies will incur differing levels of impact dependent upon their investment portfolio. The issue will also affect mergers and acquisitions policies as some companies are seen as winners and others losers. (ERM, 2000).

Lending risks as a result of climate change can be categorised as:

- Regulatory risks, including the introduction of legislation and financial instruments by governments or agencies.
- Short term risks as a result of rapid events such as storms.
- Long term risks as a result of long-term changes such as sea level rise.
- Reputational risks with banks making decisions and taking actions on investments.

It is likely that banking institutions will pass these risks on to insurers and re-insurers to minimise negative impacts.

Of particular concern is the level of inward investment into the region which plays a vital role in the region's economy. Any changes to investment levels will have consequences for all sectors in the South West. It is important to note that risk assessments and investment decisions will be influenced by global market conditions made by international companies.

Direct impacts upon business activities will be felt by the financial sector through impacts on working conditions, including office heating, health effects, and disruption to activities, particularly breakdown in communications which play a leading role in the fast moving financial markets (UKCCIRG, 1996).

Developments within the field of climate change mitigation and adaptation tools will result in changes in investments for financial institutions. Low carbon technologies and renewable energies will be an expanding market. In addition carbon trading schemes to reduce greenhouse gas levels are coming on stream and are becoming an important financial opportunity. In comparison, perceived "losers" in the low-carbon revolution will become less attractive as investment

opportunities, including fossil fuel based energy supplies, as new legislation and costs come on stream. However, the development and implementation of financial regulations and legislation will provide further opportunities for financial organisations specialising in such services.

The Way Forward

Recent extreme climatic events in the South West region, in particular the large-scale flooding in the winter of 2000 and the storms of the late 1980's and early 1990's, have resulted in increased insurance claims for natural hazards. Globally insured losses have increased over ten fold since the 1950's to approximately $40 billion per year in the 1990's (IPCC, 2001).

This reflects two principles evident within the insurance sector, and with consequent impacts upon all financial transactions. Insurance losses result primarily from extreme events affecting insured properties, and unlike most developed nations the U.K. currently offers insurance for flood risk as standard as well as other insured risks, such as subsidence and storm damage.

However, recent steps by insurance companies to reduce their risks in flood prone areas mean that some properties may soon become difficult to insure and therefore to sell. This will ultimately impact upon other financial services such as mortgage lending as well as influence planning considerations and government policy. In many European countries flood insurance is supported by the state, and this may need to be the case in the South West in the future.

Insured losses and impacts upon financial investments are influenced by wealth, property prices and other economic indicators within the region and beyond. Domestic Insurance claims are very dependent upon house prices and costs of contents as much as the level of impact themselves. Consequently, loss comparisons over medium to long time-scale involve more than just climate as a variable (Palutikof, 1999). In addition adverse market conditions and other non-climatic factors will influence insurance losses and financial investments, including economic down turns and international terrorism (IPCC, 2001).

However, standardised historical tends in insurance claims have shown increases during drought periods, related to subsidence, such as in 1989, and related to windstorms, flooding and cold weather (Palutikof, 1999). This historical data can be used as an indication of future impacts, although other factors need to be considered.

The financial sector in general focuses on short term changes and discounts long-term future costs, whilst remaining relatively quick to react to market changes.

Risk avoidance on investments and insurance decisions are the main drivers behind accommodating climate change. The potential for unsustainable loses is large and must be countered by either:

1. Changes to pricing, which is difficult to implement, may be uncompetitive and requires definitive information about future risks.
2. Risk transfer through such things as weather derivatives are a developing area to spread insurance risks.
3. Limiting the availability of insurance would reduce risks, but have considerable consequences for consumers.
4. Loss control activities through the utilisation of the industry's extensive resources.

(Parry, 2000)

Due to the global nature of the industry, drivers may well come from other parts of the globe who are more susceptible to climate change related losses. Therefore, drivers affecting climate change policies in the South West may originate from well beyond the region.

"This sector is a key agent of adaptation (e.g. through support of building codes, and to a lesser extent, land use planning) and financial services represent risk spreading mechanisms through which the costs of weather related events are distributed among other sectors and throughout society"

IPCC, 2001

Regulatory decisions by governments or international bodies will be drivers behind issues such as floodplain insurance, which in many countries is unavailable or provided by the state. In addition, changes to financial, and other related regulations associated with climate change will have consequent impacts upon financial services. These changes may take place on a national or international scale.

Potential barriers

Risk assessment models within the financial services sector are highly developed and require advanced data input. Of particular importance is a need for further information on extreme events and wind storms and models to track the interrelationships between climatic conditions and flooding/drought conditions.

Perception of Adaptation Issues

Adapting to climate impacts and avoiding risks is inherent to this sector. Therefore, accommodating climate change risks will become

a part of all investment and insurance considerations.

This sector is the driving force behind decisions made in many other sectors, in particular businesses, and due to the long term nature of investments in projects, such as dams and reservoirs, climate change adaptation is a major consideration. In effect this sector will substantially influence all other climate change adaptation policies on a global scale.

This sector, largely through insurance company activity, is responsible for promoting and funding a large amount of climate change related research. Dissemination of this knowledge has been facilitated through trade organisations such as the Chartered Insurance Institute, and interaction with risk assessment modellers. A survey by the CII found that 40% of insurers believed the home market would be influenced by climate change over the next 10 years. This shows an unprecedented level of concern for climate change impacts, with 89% of insurers questioned having at least a working knowledge of the issue (CII, 2001).

However, knowledge levels within smaller and South West based businesses in the field of adapting to climate change may need further development as the science develops further.

Further investigations into the impacts of climatic and other parameters as well as the vulnerability of certain activities and investments are required within this sector.

The large potential costs involved in climate change impacts means that this knowledge development work will be a focus of future climate impact studies and a driving force behind information development.

Challenges and Opportunities of Key Climate Impacts in Financial Services Domain

Climate Impacts		Challenges and Opportunities
Summer Temperature Increased	C	Increased disruption of businesses activities, such as crop losses, and related insurance claims.
	C	Increased health and life insurance claims due to strokes, heart attacks, food poisoning and heat stress.
	C	Direct impacts upon offices and working conditions.
	C	Increased leisure activities resulting in greater levels of accident claims.
	O	Greater opportunities for investment in solar based renewable energies.
	O	Increased demands for mortgages on holiday properties and tourism businesses in the region.
	O	Increased economic activity in the region due to increased tourism and businesses opportunities
Summer Rainfall Reduced	C	Increased insurance claims due to increased subsidence and land slides.
	C	Increased costs of fires, including wild fires, and related insurance claims.
	C	Agricultural losses and increased costs due to drought conditions and related insurance costs.
	C	Increased water costs for businesses, and related impacts upon financial performance and investments.
	O	Investment opportunities in "subsidence proofing" buildings.
	O	Investment opportunities and growth in water efficient technologies.
Increased Winter Temperature	C	Lower sales for energy companies affecting investments.
	O	A decline in claims for freezing pipes and related cold weather impacts.
	O	Expansion of winter tourism industry resulting in increased demand for financial services.
Increased Winter Rainfall	C	Increased business disruption and insurance claims, including building and property/stock damage.
Increased Sea Level and tides	C	Impacts upon coastal infrastructure resulting in investment losses and insurance claims.
	C	Increased marine and off-shore impacts and related investment / insurance losses.
	O	Investment opportunities in coastal defence technologies.
Longer Growing Seasons and Reduced Frosts	O	Reduced frost related insurance claims, eg crop losses, traffic accidents
	O	Increased economic activity and investment opportunities in agriculture
Increased Flooding	C	Higher costs of insurance claims and related impacts upon economic activity and investments, through damage and disruptions.
	C	Perceived risks of flooding in certain areas.
	C	Changes to flood risk cover for at risk properties.
	C	Impacts upon mortgages and property investments for at risk properties, and new developments on flood plains.
	O	Potential for development of flood specific insurance business.
Potentially Increased Winds and Storms	C	Increased insurance costs of windstorms, such as in the 1987 storm, impacts on transport, infrastructure and business activities.
	C	Investment impacts as a result of storm impacts upon businesses.
	O	New market investment opportunities in weather prediction, risk

assessment and impact protection markets.

FOOD AND DRINK DOMAIN

Scope

Commercial activities associated with the production, distribution and sale of food and drink.

See Also

Marine Fisheries, Agriculture, Health, Water Resources

Background

The comparatively high levels of agricultural and fishing activity within the South West has led to the establishment of a significant food and drink processing and packaging industry within the region. In addition the large number of visitors to the region and the global reputation of local produce, such as Cornish Pasties, has resulted in companies trading in food and drinks within the region and exporting further afield.

This sector is one of the SWRDA's priority sectors with a dedicated sector co-ordinator. A recent survey of companies involved in food and drink report on over 3000 different establishments in the region. Activities undertaken included mail order, farm shops, hamper providers, delicatessens and farmers' markets as well as packagers and producers of a range of food and drink.

Key Issues

- Cooling methods need to be enhanced to avoid damage to produce and reduce bacterial build-up.
- Potential increases in food poisoning need to be accommodated to avoid increased legal challenges and business losses.
- Changes to food and drink consumption patterns, including ice creams and cold drinks.
- Increased visitor numbers will result in a larger regional market for food and drink, in particular local specialities.
- Changes to crop and animal production as a result of changed climatic parameters, including changes to fish spawning and heat stress on animals.
- New product opportunities as a result of changes to traditional crops and species, such as increased wine production.
- Marketing opportunities exist for locally produced food and drink which is seen as safer and more environmentally friendly as it limits transportation - "food miles".

Context

Recent issues surrounding food safety and animal health have lead to local demand for sustainable food production on a local scale. As a result niche markets have developed, most prominent among these being organic produce.

Changes to consumer tastes and the availability of fresh produce from all around the globe have resulted in changes to markets for food and drink. Warmer weather is likely to enhance this situation within the region and encourage a move away from some traditional produce.

It is important to note that issues such as over-fishing and other non-climatic variables could be more influential in affecting supplies of produce than climate change itself, although climate change will place an additional burden on many stretched resources.

The cultural changes which will take place as a result of warmer summers and winters may have the greatest influence upon customer demands, which underpin this industrial sector. New and expanding products like ice cream and wine will offset changes away from some traditional produce. Furthermore, the increased influx of visitors to the region, in particular those from overseas who may be looking for a warmer region which is not as hot as other areas, will result in changes to food and drink demands. However, visitor demand for local specialities may also see a rise in this area of the sector.

Changes to the supply of natural ingredients for products, such as changes to fish species and crops, will fundamentally alter the costs involved in their production and ultimately availability of raw materials. New species will lead to new market opportunities in some produce.

Processing techniques and manufacturing processes will be affected by increases temperatures in particular which result in increased coolant demands. Reductions in summer water supply will place strain on drink producers in particular.

Health risks to workers within the sector as well as consumers are a significant challenge to this sector. In particular is the need to prevent increased food poisoning as a result of higher temperatures and related bacterial growth. Potential legal consequences of this could be considerable.

The Way Forward

Changes in consumer demands towards new and/or sustainable, locally produced products will be a considerable driver. In addition concern about specific species and production processes by consumers will result in moves away from some products and encourage changes to new products.

Policies and activities to accommodate climate change are unlikely to be developed on their own,

but will be accommodated within the need to develop sustainable activities and reduce greenhouse gas emissions.

The provision of locally produced and/or organic foods will result in changes towards more sustainable manufacturing processes which may be a driving force to adapt to climate change. In addition locally produced produce will reduce transport related greenhouse gas emissions.

Best Practice in the Industry

The Bath Breakfast where all the food on your plate is produced within a short distance of Bath, has acted as a considerably successful marketing tool and highlighted locally produced initiatives.

Initiatives to increase environmental protection and encourage sustainable farming and fishing practices will also have consequences for food and drink manufacture and reduce the vulnerability of suppliers to climate change.

A significant driver towards adapting to climate change will be financial and insurance costs which will impact upon business expansion and site development. Additional regulatory and financial instruments as a result of government action will influence this business sector.

Potential Barriers

Few, if any, businesses within this sector have considered this issue to a great degree. This lack of knowledge and the long-term uncertain nature of the issue which could act as major barrier to change.

In addition the small scale of many businesses involved in food and drink production and distribution means that resources and planning horizons do not accommodate issues such as climate change.

Perception of Adaptation Issues

Businesses in this sector recognise the need to consider the environment as a vital resource. In addition they recognise the value of increased visitor numbers and the restrictions of an over-stretched transport infrastructure on their business activities.

However, policies to adapt to climate change specifically are seen as the primary responsibility of government and regional agencies, and are often considered to be beyond the resources of businesses themselves.

To date there has been little research or information dissemination within this sector. Research into climate change impacts on agriculture and fisheries is comparatively well developed and many of the issues raised there will be pertinent to businesses in this sector.

Challenges and Opportunities of Key Climate Impacts in Food and Drink Domain

Climate Impacts		Challenges and Opportunities
Increased Summer Temperature	C	Changes away from normal cooling methods towards air conditioning and other cooling methods, with associated increases in costs.
	C	Increased bacterial build-up in foods leading to higher rates of food poisoning and related litigation matters.
	C	Health impacts upon staff who work both inside and outside.
	C	Transport of fresh produce may become difficult or more costly due to extra refrigeration requirements.
	C	Loss of traditional species of animal and crops.
	C	Some traditional food types may become less popular in warmer weather (e.g. Cornish pasties).
	O	The potential to develop tourist market as visitors to the region increase.
	O	New techniques and processes in response to changes in conditions and markets.
	O	The availability of new crops and species within the region, thus reducing import costs and developing new products, eg wine production.
	O	Increased consumption of warm weather food and drinks, such as ice cream, leading to new markets.
Reduced Summer Rainfall	C	Changes to the cost of water and supply levels, particularly important in drink manufacturing.
	C	Difficulty in storage of short shelf life fish in higher ambient temperature resulting in increased operating costs.
	O	Increased levels of tourism and so expanding markets within the region.
	O	Dietary changes to lighter meal consumption such as fish.
Increased Winter Temperature	C	The need to change current heating and ventilation systems in buildings to accommodate warmer winters and meet new building guidelines.
	O	Changes in food consumption patterns resulting in changes to demand for certain products and new/ expanding markets for other products.
	O	A reduction in cold weather impacts on supplies, manufacturing processes and infrastructure.
	O	Positive impact upon energy costs and staff health.
Increased Winter Rainfall	C	Impacts on infrastructure, in particular buildings, and transportation.
	O	Increased visitor numbers to indoor based food and drink attractions.
Increased Sea Level and tides	C	Direct and indirect impacts on infrastructure, markets and supplies, in particular impacts on port facilities.
Longer Growing Seasons and Reduced Frosts	C	Greater input into longer crop production cycle, offset by higher returns.
	O	Potential for more crops to be supplied and less crop loss in the winter.
	O	Potential for new crops and associated industries – e.g. wine production could become a large South West concern.
Flooding Increased	C	Direct infrastructure damage, and indirect impacts upon supplies and markets.
	C	Increased insurance costs and changes to planning regulations affecting infrastructure development.
Potentially Increased Winds and Storms	C	Increased direct and indirect impacts on infrastructure and supplies/markets a major factor in continuity of supply during winter months when most successful fishing opportunities are available.
	C	Increased repair costs and insurance costs.

INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) DOMAIN

Scope

Commercial activities with the design, manufacture, distribution and support for hardware and software aspects of computers, telephones and related peripheral equipment.

See Also

Advanced Engineering, Environmental Technology, Built Environment, Utilities and Transport.

Baseline

This sector has seen massive expansion in recent years and has developed into a significant new area of economic development within the South West. Large international companies, such as Telewest Broadband, have located within the region and have lead to further development of smaller companies dealing with such things as web design, software development and equipment production.

Despite recent changes within this sector with the end of the dot.com and mobile phone boom, the skills and facilities which have developed within the region means that this sector remains an important contributor to the region's economy, and will further expand as technologies develop.

Key Issues

- Changes to health risks to workers inside, in particular those using electronic equipment.
- Impacts upon infrastructure, in particular communications masts and overhead cables.
- Potential increased energy costs due to carbon taxation methods and infrastructure damage.
- Increased levels of down time as a result of loss of energy supplies and telecommunications during periods of extreme climate impacts.
-
- Technologies associated with mitigating and adapting to climate change, for example monitoring building temperatures and flood risks, will be an increased market.
- On-line technologies will reduce the vulnerability of activities to climate impacts upon transportation links, such as coastal railways.
- Global climate modelling and risk modelling requires ongoing development in software and computer technologies.

The ICT sector has the potential to provide many of the technologies and solutions which will help to predict, accommodate and develop under a changing climate. This includes the software and technologies needed to run the global circulation models which produce the UKCIP02 scenarios as well as communication systems which reduce reliability upon transportation links which may be at risk from climate impacts. In addition there is scope for software and technologies to monitor flood levels, manage crops, and control temperatures in buildings.

The sector will be vulnerable to climate impacts through infrastructure damage. In particular threats to communications masts and overhead wires as well as other facilities such as manufacturing plants in coastal regions.

Changes to working and leisure time activities, including increased home working, and developments of on-line working and leisure facilities, will result from changes to the climate as well as other pressures. A proposal for an interactive website which provides tourist attraction details dependent upon weather conditions has been put forward, and signifies the importance of this sector in providing solutions to changes in other sectors.

A further important role for this sector, which may also be a niche market for some companies, is in the education and delivery of information to the public and other businesses on climate change. This could be in the form of visualised climate change scenarios and risk assessments for individual business activities.

The Way Forward

As with many economic sectors, ICT will respond to a combination of customer demand, risk avoidance, increasing costs, and government legislation. However, ICT is a very innovative sector of the economy and is in a position to benefit from impacts in other sectors.

Threats to infrastructure, and in particular planning regulations and insurance costs for structures such as telecom masts will force businesses to consider future climatic conditions when planning new developments. However, other planning issues such as the health effects of communication infrastructure will continue to play a large role in planning considerations.

Key drivers will include demands for technologies which predict and monitor climate impacts, and risk assessments in many sectors from agriculture to flood controls.

Changes in energy supply costs, and possible disruption to supplies as a result of climate impacts, will be of significant importance to this energy dependent sector. Government legislation and incentives to reduce dependency upon fossil fuel energy supplies may result in opportunities for on-site renewable energy supplies and energy efficient practices and technologies.

Potential Barriers

While uncertainties within the climate change debate pose a considerable barrier to change, it is the inertia within other industrial sectors who are the customers of ICT businesses that pose the largest barrier. The ICT sector itself is relatively responsive to new markets and economic changes and as a result will change when a market becomes significantly developed. Current economic conditions within the sector and other influences on this sector may result in limited change in the short term.

Knowledge Base

Little research has been done within this sector, and as a result knowledge levels and engagement with businesses has been limited. It is unlikely that adaptation strategies have begun or that the issue is seen to be of importance to many of the businesses in this sector. Considerations of economic stability and future expansion are priorities in the short–term. Climate change does not figure within the timeframes used or in the long-term planning for the majority of businesses.

Challenges and Opportunities from Key Climate Impacts in Information and Communication Technologies Domain

Climate Impacts		Challenges and Opportunities
Summer Temperature Increased	C	Increased need for cooling equipment and buildings with consequent increases in costs.
	C	Health impacts upon staff who work inside and with electronic equipment.
	O	The development of technology and software to monitor building temperature and other software needs.
Winter Temperature Increased	C	The need to change current heating and ventilation systems within buildings to accommodate warmer winters and to meet new building guidelines.
	O	Beneficial impacts on supplies, manufacturing processes and infrastructure.
	O	Positive impact upon energy costs and staff health.
Flooding Increased	C	Infrastructure damage, and impacts upon supplies and markets.
	C	Increased insurance costs and changes to planning regulations affecting infrastructure development.
	O	New technologies/ software to monitor and manage flood risk areas.
Summer Rainfall Reduced	C	Non-identified.
	O	Potential for on-line data on water management.
	O	New technologies/ software to regulate water supply.
Increased Winter Rainfall	C	Impacts on infrastructure, in particular buildings and cabling.
	O	Non-identified.
Increased Sea Levels and Tides	C	Direct and indirect impacts on infrastructure, markets and supplies, in particular impacts on port facilities.
	O	New technologies/ software and on-line data to monitor sea-level rise
	O	Impacts on transport infrastructure could result in more activities being undertaken interactively and to avoid excessive travel.
Longer Growing Season and Reduced Frosts	C	Non-identified.
	O	New technologies/ software in crop monitoring and management.
Potentially Increased Winds and Storms	C	Increased direct/indirect impacts on infrastructure and supplies/ markets.
	C	Impacts upon overhead cables and communication infrastructure.
	C	Increased repair costs and insurance costs.
	O	A reduction in travel resulting in more electronic communications.

TOURISM AND LEISURE DOMAIN

Scope

The provision of tourism accommodation, attractions, activities, food and drink retail outlets (including urban, rural and coastal) and recreational, leisure and sports facilities.

See Also

Rivers, Forestry, Agriculture, Fisheries, Coastal, Heritage, Transport, Built Environment, Health, Food and Drink.

Background

Tourism plays a vital role within the South West's economy, with over 20 million visitors in 2000, spending over £3.6 billion within the region. In addition a total of 131.5 million day trips were taken to the region in 1998. The value to the economy of the South West can be estimated to be in the region of £5,000 per household in Devon and Cornwall. Tourism supports about 225,000 jobs within 11,000 businesses in the South West. Within the region there is approximately 10,000 establishments with accommodation for over 600,000 visitors, 80% of whom travel to the region by car.

Climate is a primary motivating factor that is taken into account, particularly in relation to longer holidays, when deciding location and timing.

Acacia Report, 2000.

This level of visitors makes the South West the most popular destination for domestic tourists, with 16% of domestic tourist trips in England being to the South West. The region attracts a lower number of international visitors, accommodating 8% of the visitors to England.

Within the region there are five specific experiences which visitors come to enjoy:

- Cities and Spa Towns
- Coasts
- Resorts
- The Countryside
- National Parks and Open Spaces

Of these 75% of visitors are attracted by the culture and environment of the region. There is also a series of niche markets, which include health tourism and spiritual tourism.

Environment based tourist attractions are becoming increasingly popular within the region and include the very successful Eden Project and attractions such as the Gaia Energy Centre. The managed use of the environment as a tourist attraction highlights its value to the region.

69% of links golf clubs say their course is facing serious threat from erosion and/or flooding in the next 50 years.

CII, 2001

Key Issues

- Any increase in tourism must be managed to avoid damage to the South West's most valuable asset – the environment.
- Sea level rise and flooding threatening coastal and riverside installations.
- Health implications of increased heat stress, food poisoning and UV exposure.
- Increased pressures on services and utilities due to greater visitor numbers and climate impacts on infrastructure.
- Increased visitor and climate related pressures on natural environment attractions.
- Potential to exacerbate current peaks in demand in an industry already heavily influenced by seasonality.
- Opportunities for diversification, new markets and job creation.
- A longer, more reliable summer season and a warmer winter, thus extending the tourist season.
- Increased opportunities for outdoor recreation and warm weather services.

The region needs to develop the infrastructure to allow for greater outdoor activities... everything from cafe terraces to showers on beaches.

SW Tourism

- Opportunities for increased prestige and marketing based upon "green" tourism.
- An increase in extreme weather, including increased heat-waves, in other tourism markets, such as the Mediterranean, resulting in less overseas travel and an increase in domestic tourism.

An opportunity to market "storm tourism" - short breaks to experience nature at the extreme.

Malcolm Bell, SW Tourism

We see the greatest issue to be the lack of public engagement in the theme of adaptation. This fails to provide the right climate of support that would give politicians the will to address the necessary changes to e.g. investments in infrastructure, overseas aid etc.

Eden Project

- Increased travel costs as airline fuel is incorporated within a carbon taxation scheme could increase visitors from within the UK, whilst also discourage overseas visitors. Additional increases in domestic travel costs could similarly reduce long distance travel within the UK.

Climate change impacts and adaptation strategies within the tourism and leisure sector need to be built into the existing primary issues which exist in this sector, in particular:

- The wider debate on sustainable development and how tourism can be developed in a sustainable nature.
- Increased efficient use of resources and environmental considerations - therefore developing "green tourism".
- Increasing public transport services and reducing the dependency of visitors on the car.
- Developing tourist and leisure services to provide a higher level of service for customers.
- Undergoing a cultural change to develop more Mediterranean style services and facilities to attract overseas visitors and meet the higher expectations of domestic visitors.
- Overall a desire to increase quality and value for money throughout the sector in the region.
- The recent crises in the farming industry and declines in traditional rural activities mean that tourism now underpins many rural economies in the region. However, the increased purchase of holiday homes in rural areas has lead to higher property prices and associated problems for residents.
- Taxation on fuel and energy is an issue which affects both the development of leisure facilities and the costs incurred by visitors for travel.

Managing Development

Tourism and the use of leisure facilities is set to benefit from climate change as the climate becomes warmer and drier in the summer and warmer in the winter. Consequently, the tourist season should extend beyond its traditional boundaries and develop further in the winter months.

In addition the use of outdoor leisure facilities, including sports grounds, gardens and natural parks, and beaches will increase as temperatures become warmer. This provides an expanding market for leisure based holidays, which already account for 25% of U.K. holiday expenditure (CII, 2001), such as golfing and fishing holidays in the region which will provide higher income from visitors.

Since 1974 there has been a clear relationship between July temperatures and the number of domestic holiday trips.

Agnew,1999

Whilst this increase in visitor numbers has the potential to rapidly develop the sector, it is essential that this is done in a managed way. The region's facilities are currently very stretched during the tourist season, in particular the transport infrastructure and popular visitor destinations. It is therefore essential to manage adaptation to climate change by trying to increase the quality of the service provided to customers and thus increase visitor spend rather than just the numbers of visitors.

Benefits and disadvantages of growth

Increasing visitor numbers during the winter months and in particular the "shoulder months" is a substantial opportunity as the climate becomes warmer. This effectively allows visitor facilities to remain open for a longer season, and in some cases year round. This will have an additional benefit to the region as it will secure jobs in the sector and also mean that tourist specific services remain in operation for longer periods thus benefiting local residents who are often left with limited services during the "off season".

Visitor numbers to the region are likely to increase from both within the U.K. and overseas as tourist destinations in other areas become less desirable as a result of uncomfortable temperatures and other climate change impacts in the region.

Higher visitor numbers will have a positive effect on local economies, in particular in rural areas. Tourism will increasingly become the primary income stream for many in rural regions.

A likely increase in holiday homes will continue to push up house prices in rural areas and may affect living standards for local residents who cannot afford higher prices.

Accommodating climate impacts on infrastructure and facilities is viewed as being essential to ensure that costs are kept down and that the

opportunity for all year round tourism is not reduced by storm impacts.

Adaptation is of particular importance to ensure that the buying and selling of properties, which could be greatly influenced by insurance, financial costs, and planning regulations, does not hinder economic development.

The Way Forward

The need for sustainability

Policies and activities to accommodate climate change are unlikely to be developed on their own, but will be accommodated within the need to develop sustainable tourism activities and enhance the region's environmental resources.

The recognised need to manage the region's infrastructure to accommodate increasing visitor numbers will also act as a mechanisms for change. The SWRDA and South West Tourism are both committed to developing sustainable practices within the tourism industry.

The development of outdoor activities and leisure services is a response to public demand for activity based holidays and the "cafe culture" experienced overseas. New developments such as the Falmouth Marina and increased activities like beach volleyball in Weymouth will move the industry towards developing outdoor services and consequently accommodating new opportunities which climate change may present.

Additional drivers to change will be developing "Eco-tourism" activities which market the natural environment and "green" practices to attract visitors. In Scotland environmental tourism activities have increased occupancy rates by 20%, and the South West is aiming for a similar increase.

Similarly the recognised value of the region's environment to its tourist industry will be a driver in protecting areas against climate change impacts, where economically possible. The National Trust predicts that 75% of visitors come to the region because of its conserved landscapes, and are advanced in assessing responses to climate change. Similarly the recently created World Heritage Coastline further emphasises the unique attraction of the environment and ensures that its protection is at the forefront of future policies. Indeed the English Tourism Council report that 75% of visitors would be prepared to pay more to protect the environment.

The ability to market the region as a warmer sunnier place will be the main climate related mechanism for change. It was the Victorians who first discovered the mild winters on the English Riviera and who subsequently developed many of the region's tourist centres. By promoting outdoor activities and regionally distinctive attractions there is great potential to develop a further revolution in visitors and services in the region. Marketing new quality facilities will help to attract visitors who may otherwise go overseas and who want breaks outside of the summer season.

Potential barriers

The tourism sector is at the forefront in considering climate change within its future, as a direct result of the potential benefits that a warmer, sunnier season would provide. South West Tourism are very active in issues related to sustainable development under which climate change is of significant importance. However, individual practitioners themselves are limited in their understanding and ability to consider climate change.

This is a result of a lack of understanding of the issue, uncertainties surrounding the science of climate change, and the lack of clear messages from the media and policy makers on adapting to the opportunities and impacts. This reflects to a degree the unbalanced nature of many media stories regarding the issue which fail to put across the coherent message being developed by national and international bodies, such as IPCC and UKCIP, and gives excessive credence to contradictory, often unsupported, claims.

The underlying barrier to climate change related development is the financial status of many of the businesses. This is a result of the fact that most businesses involved in tourism in the region are small or even micro businesses with limited resources. It is very difficult to engage with a disparate industry such as tourism, when many businesses are of a size where they might not consider their own impacts and contributions to be significant on a regional level.

In addition the influence of other issues upon the market place means that the tourism sector is vulnerable to many changes and is in a limited position to address climate change. This was highlighted by the recent Foot and Mouth Disease epidemic which severely damaged the industry in the region.

Knowledge levels

Businesses and organisations in the region recognise the need to consider the environment as a vital resource for tourism and leisure. Over 80% of businesses in southeast Cornwall were concerned about the state of the environment and its relationship on their business, yet only 29.4% of these businesses considered their own impact on the environment (Vernon, 2001).

The belief that climate change, and the environment in general, is an issue beyond individual's or business's scope had been reflected in discussions with service providers. Consequently, adaptation to climate change is likely to be re-active rather than proactive. This is also a result of the financial considerations of the industry and the fact that in common with other sectors, many tourism businesses plan on 2 to 5

year time horizons which do not fit with projected climate change scenarios.

The impacts on tourism (both global and domestic) will be wide ranging, diverse and interrelated. To date there has not been much research on tourism (at a global and local scale) and climate change. The effects, therefore, of these changes are hard to quantify.

Dr David Viner, Climatic Research Unit

A difficulty in securing funds to finance adaptation initiatives as a result of the uncertainties in the projections has also been identified as a major issue for those who wish to be pro-active.

Where adaptation has been considered, issues identified have focused primarily on reducing direct climate impacts and accommodating increased visitor numbers and related stresses, as well as developing higher quality facilities for outdoor activities.

To date there has been little research or information dissemination on the links between tourism (on a global or local scale) and climate change. Furthermore, there is no evidence that climate scenarios have been used by individual organisations. This reflects the fact that very few leisure and tourism businesses or organisations have considered climate change beyond the implementation of the Climate Change Levy, which has not had as substantial an impact as in other business sectors.

The knowledge base on environmental and sustainable development issues is more extensive and understood within the sector, but consideration of the issues by businesses needs further consideration. Effective sustainable practices need to be put in place to prevent superficial "green" activities being marketed. Transportation and energy efficiency are of particular importance, with many tourists visiting attractions by car, and these are dependent upon regional changes as well as individual business practices.

Example of Best Practice

In South Hams there is a "Green Tourism Business Scheme Award" for businesses improving the efficient use of natural resources and protecting the environment.

C-CLIF held a workshop on climate change and Tourism on the 30th October 2001. This was attended by over 40 businesses and organisations. Information from the presentation and discussions at this workshop have been used in this section.

Principal Drivers

The primary driver within the sector will be demands from consumers who want services and facilities that accommodate changes in the climate as well as increased expectations of quality services and environmental preservation.

Environmentally friendly and sustainable activities will become increasingly important within the region to satisfy customer demand, as will be the development of a "cafe society" that allows for similar activities as in overseas resorts.

The fact that so many businesses have limited resources means that direct economic benefits of considering climate change will act as a key driver for adaptation. This could be in the form of government incentives, and established, low-risk, business practices to benefit from climate change.

There is likely to be a small group of businesses who will make the first steps in this issue, and a trickle-down effect once benefits have been recognised. There is a need here for trade organisations to provide assistance in reducing risks on financial investments.

A further driver will be individual consideration of the climate change issue and the environment as a whole. Studies suggest that newer businesses as well as individuals with personal experiences of sustainable practices and overseas cultures will make some businesses adapt quicker.

Personal desire to tackle climate change and environmental issues will also make businesses more innovative and willing to consider adaptation (Vernon,2001). This indicates that getting the climate change message across in a forceful and coherent manner will be a further key driver, and therefore places the onus on scientists, agencies, the media and NGO's to do this.

The South West should unlock its unrealised potential by developing its infrastructure to accommodate more visitors and marketing its regional distinctiveness and natural environment... the region needs to be proactive not re-active and market its green credentials.

The English Riviera Tourist Board.

Challenges and Opportunities of Key Climate Impacts in Tourism and Leisure Domain

Climate Impacts		Challenges and Opportunities
Increased Summer Temperature	C	Need to adapt to increased heat in visitor facilities e.g. hotels.
	C	Visitor health impacts, including heat stress, heart attacks and strokes.
	C	Requirement for more outdoor activities and facilities, including water parks, with associated increases in resource demands, including water resources.
	C	Higher temperatures resulting in lower urban air quality.
	C	Effects on coastal water quality, including increases in algal blooms, jelly fish numbers and beach management.
	C	An increase in warm water algal blooms resulting in water discolouration, thus affecting water based activities.
	C	Possible increased cases of food poisoning as higher temperatures result in higher levels of bacteria.
	C	Increased demand for water supplies and irrigation with drought conditions becoming more frequent.
	O	Increased visitor numbers as summers become more reliable.
	O	Increased use of sporting facilities and visitors to sports events, in particular water sports.
	O	Market opportunities as Mediterranean destinations become too hot.
	O	Greater demand for outdoor facilities, sporting facilities and warm weather goods and services e.g. Beach volleyball in Weymouth.
	O	Higher sea surface temperatures could extend the sea and inland water bathing and recreation season and range of activities e.g. more surfers at Newquay.
Reduced Summer Rainfall	C	Potential limitation of water supplies and related costs.
	C	Drought effects on natural tourist attractions such as gardens.
	C	Lower flow levels in rivers may increase pollutant levels and thus reduce their attractiveness to visitors and creating potential health problems.
	O	Less rainy days increasing outdoor and water based activities.
	O	Less rain for outdoor events e.g. Glastonbury Festival, sports events.
	O	Summers perceived to be more reliable, thus attracting more visitors.
Increased Winter Temperature	C	The need to change heating and ventilation systems to accommodate warmer winters.
	C	Increased pests and vermin who survive the winters, having a negative impact on tourist perceptions as well as health.
	O	Increased winter visitor numbers and spend leading to a more year round tourist season and "winter sun" holidays.
	O	Increased use of outdoor recreation and sporting facilities.
	O	Lower energy costs for facilities as a result of lower heating demands.
	O	Positive health effects on visitors and staff.
	O	Marketing opportunities of warmer winters.
Increased Winter Rainfall	C	Infrastructure damage through increased intense precipitation.
	C	The saturation of grounds (e.g. sports facilities) resulting in increased

		drainage impacts, management costs, and reduced usage.
	C	Reduction in visitors to outdoor attractions on rainy days e.g. football matches.
Climate Impacts		**Challenges and Opportunities**
Increased Sea Level and Tides	C	Infrastructure damage, in particular coastal attractions, such as golf courses.
	C	Impacts upon transport infrastructure, such as ports and coastal transport links e.g. Dawlish Warren.
	C	The squeezing of beaches and coastal habits as well as increased coastal erosion around visitor sites such as along the Jurassic Coast.
	C	Increased pressure on coastal management and water quality resulting in increased costs.
Longer Growing Seasons and	O	Lower costs in maintaining grounds and sports facilities, including under pitch heating.
Reduced Frosts	O	Reduced frost related accidents.
	O	A reduction in frost impacts on infrastructure.
	O	Changes to species within landscaping schemes in e.g. Caravan Parks.
	O	A longer visitor season for garden based attractions.
Flooding Increased	C	Direct flooding of accommodation and other infrastructure.
	C	Effects on insurance costs and planning regulations.
	C	Flooding results in bad publicity for areas thus deterring visitors.
	C	Water-logged gardens and sports facilities.
Potentially Increased Winds and Storms	C	Impacts upon infrastructure and transport links.
	C	Roofs and other structures vulnerable to structural damage all vulnerable in exposed locations
	C	Damage to caravan sites and other vulnerable installations.
	C	Increased pressure on indoor attractions.
	O	Greater storminess brings more fossils out of the rocks at places such as Lyme Regis, Charmouth.

MARINE ENGINEERING AND MARINE ACTIVITIES DOMAIN

Scope

Commercial activities operating within the marine environment, including offshore, nearshore and coastal activities.

See Also

Advanced Engineering, ICT, Environmental Technology, Coastal Erosion and Flood Defences, Built Environment, Utilities, Transport.

Background

Traditionally this sector has been dominated by large-scale ship building or refitting. This still continues in a very much smaller scale, including the development of naval ships in Devonport Dockyard. However, this business sector is now comprised primarily of small and medium sized companies operating in a number of areas across the region.

Specific activities of note include the development of leisure craft, such as yachts, which is an expanding market. In addition offshore infrastructure development, with particular focus on renewable energies, is a new and expanding market for companies in the region.

The South West has a traditional maritime base, and its decline over recent decades has prompted considerable investment by the SWRDA amongst others. This includes subsidies, training schemes and support for new technologies within the sector to build up its competitiveness in the region.

As a result marine engineering remains an important employer and contributor to the regional economy, although it is primarily in smaller scale niche markets.

Key Issues

- Changes to manufacturing processes may be required to accommodate increased internal and external heat.
- Opportunities to develop engineering solutions to climate change impacts in coastal zones.
- Changes to health risks to workers using inside and outside facilities.
- There are likely to be acute impacts upon infrastructure, particularly coastal based facilities and supply lines, and also on customers.
- Increased costs as a result of restricted water supplies and changes to energy costs.
- Increased levels of down time as a result of loss of energy supplies and telecommunications during periods of extreme climate impacts.
- Opportunities to design new coastal and offshore technologies to accommodate changes in sea levels and storm surges. This may include flood defence products and offshore installations.
- Opportunities exist to develop offshore and coastal based renewable energies, such as off-shore wind power and tidal barrages.
- Increased outdoor leisure activities will increase demand for watercraft and other marine services, including local ferry services.
- Global impacts upon the marine sector will have considerable impacts upon regional activities as a result of the global nature of the industry.

This sector will incur similar infrastructure and transportation impacts as other business sectors. In particular, it will be highly susceptible to impacts in coastal zones and within the marine environment. Furthermore, as with other sectors, transport links, particularly coastal installations such as ports and railway lines may be disrupted, as would electricity and telecommunications connections. However, a reduction in cold weather impacts, in particular a decline frost related impacts, will be beneficial to many winter activities.

Changes to planning guidelines, particularly in coastal regions, and potential increases in insurance costs in high risk areas will affect plant expansion and other developments. Climate impacts in other parts of the globe will have important consequences for many suppliers and customers as well as competitors of regional firms.

Components within engineering processes may be affected by changes in heating conditions and related requirements for increased coolants, with potential reductions in summer rainfall exacerbating this problem. In addition increased heating moderation in offices and factories have related health impacts and affect worker productivity, thus requiring changes to building design and heating/ventilation processes.

This sector has potential to benefit from changes in demand for watercraft and water based activities, including increased visitors year round and increased use of the marine environment throughout the region. Engineering solutions to many of the climate impacts on a global scale present opportunities through flood defence development, water quality evaluation technologies and consultancies involved in marine preservation or management.

Coastal and offshore renewable energy development has huge potential for the region. Recent developments in offshore wind farms, tidal barrages and wave power devices mean that the scope for marine based power generation within

the natural environment of the South West and overseas could lead to expansion into these areas.

Recent trials in wave energy devices in Plymouth have highlighted the potential for producing secure, renewable and localised energy supplies which both mitigate climate change and limit the effects of climate impacts on the National Grid**.**

The Way Forward

As with many economic sectors, marine engineering will respond to a combination of customer demand, risk avoidance, increasing costs, and government legislation. The ongoing threat of coastal erosion and related changes to planning regulations and insurance costs, as well as the dependence upon the marine environment, may result in this sector being more responsive to the need to adapt than other sectors.

Key drivers will include demands for technologies which accommodate climate impacts at the coast. Linked to this will be direct and perceived costs as a result of impacts such as sustained flooding and changes to insurance costs. Linked into this will be changes in building and planning regulations which will dictate where and how coastal and offshore facilities can be expanded.

New markets for marine based tourism and transportation activities will develop as more visitors come to the region. Increased demand for renewable energy, including increased government spending, will provoke businesses to consider this issue further and invest in this sector.

The introduction of further government legislation and incentives to both mitigate and accommodate climate change will also act as one of the primary drivers for change in this business and other sectors.

Potential Barriers

The small scale of many businesses involved in this sector means that it is often difficult to consider climate change on a medium to short term.

Uncertainties within the climate change debate pose a considerable barrier to change. In addition the cost of making changes to plants and other facilities are considerable and unlikely to take place until higher knowledge levels are developed within the sector.

Knowledge Base

Little research has been done within this sector, and as a result knowledge levels and engagement with business has been limited. It is unlikely that adaptation strategies in all but the larger businesses, such as The Association of British Ports, have begun. Considerations of economic stability and future expansion are priorities on the short time scale; climate change does not figure within this timing or planning for the majority of businesses.

However, the consideration of flood risks and planning changes is evident and this may prompt future adaptation considerations as the issue becomes more integrated within the business sector.

Opportunities within renewable energy has been acknowledged by many businesses, which may well lead on to looking at the wider issue of climate change and adaptation as more knowledge dissemination takes place and methods of integrating climate change into business planning horizons becomes more evident.

Challenges and Opportunities of Key Climate Impacts IN Marine Engineering and Marine Activities Domain

Climate Impacts		Challenges and Opportunities
Increased Summer Temperature	C	Increased cooling costs for offices, manufacturing processes and installations.
	C	Health effects upon staff, both in offices etc. and outdoors.
	O	Increased tourism and water-use providing new markets.
	O	Increased use of solar power and off-shore wind energy installations.
Increased Winter Temperature	C	The need to change current heating and ventilation systems within buildings, installations and craft to accommodate warmer winters and to meet new building guidelines.
	O	A reduction in cold weather impacts on supplies, manufacturing processes and infrastructure.
	O	Positive impact upon energy costs and staff health.
Flooding Increased	C	Direct infrastructure damage, indirect impacts upon supplies and markets.
	C	Increased insurance costs and changes to planning regulations affecting infrastructure development.
	O	New products/markets for engineered flood defences and “flood proof” infrastructure.
Increased Summer Rainfall	C	Restricted water supplies with associated cost implications.
	O	Increased use of solar power technologies in manufacturing
	O	Opportunities for expanded work outdoors.
Increased Winter Rainfall	C	Impacts on infrastructure, in particular buildings and installations.
	C	Increased downtime and delays as a result of water intrusion.
	O	On-site water collection and storage operations.
	O	Increased water supplies during winter months.
Increased Sea Levels and Tides	C	Direct and indirect impacts on infrastructure, markets and supplies, in particular impacts on port facilities, off-shore and coastal installations.
	O	New engineering requirements for coastal infrastructure and ship design.
	O	Engineering solutions to storm surges and tidal inundation,
	O	The possibility to develop products for tidal power generation.
Longer Growing Season and Reduced Frosts	C	None identified.
	O	A reduction in frost impacts on manufacturing and facilities.
Potentially Increased Winds and Storms	C	Increased direct and indirect impacts on infrastructure and supplies/markets.
	C	Increased down-time through loss of energy supplies.
	C	Increased repair costs and insurance costs.
	O	The opportunity to expand off-shore wind farms, such as the proposed site in the Severn Estuary.

TELEMARKETING DOMAIN

Scope

Commercial activities associated with telephone based sales, promotion and marketing through the use of call-centres and similar facilities.

See Also

ICT, Leisure and Tourism, Financial Services.

Background

This sector has seen massive expansion in recent years and has developed into a significant new area of economic development within the region. In many areas call centres and related activities have replaced some of the more traditional economic activity.

Tele-marketing companies tend to be relatively high users of labour and telecommunications equipment. In addition the products they market are very much dependent upon wealth levels within society and business activity in the region and beyond. Therefore, this sector will be very dependent upon activities in other business sectors.

This sector will be partly responsible for marketing the products and services to mitigate and adapt climate change, including climate proof goods and services and insurance products.

Industry Source

Key Points

- Changes to health risks to workers inside call centres, in particular those working with computer equipment.
- Impacts upon communication infrastructure, which is the main form of product delivery.
- Increased levels of down time as a result of loss of energy supplies and telecommunications during periods of extreme climate events.
- Opportunities to develop new markets within other business sectors as a result of climate change, including enhanced tourism opportunities.
- Increased opportunities to market government initiatives to mitigate and accommodate climate change through telemarketing activities.

This sector will be subject to much the same impacts as business in general, including infrastructure damage, increased insurance costs and planning considerations. In addition changes to energy costs as a result of climate impacts on power generation and price rises to mitigate climate change may have a particular impact upon this reasonably energy dependent sector.

Climate impacts upon communication structures, such as telephone masts, have the potential to disrupt telemarketing activities. These impacts may take place within the region or on a global scale as many telemarketing activities operate beyond the regional level.

The potential to market some of the goods and services that other business sectors may provide in order to respond to climate change are significant. This may include flood control technologies, new outdoor tourist activities, and insurance services for risk prone areas. As more goods and services are developed, this sector will be tasked with marketing these to customers in the region and beyond.

Telemarketing may also be employed to promote government or commercial initiatives to reduce greenhouse gas emissions or adapt to climate change impacts, such as flooding. This could be an important role for this sector.

The Way Forward

As with many economic sectors, telemarketing, will respond to a combination of customer demand, risk avoidance, increasing costs, and government legislation. However, telemarketing is very responsive to changes within businesses and is in a position to benefit from changes in marketing and products in other sectors.

Key drivers will include demands for marketing schemes for new technologies which, for example, predict and monitor climate impacts, and provide risk assessments to other business sectors.

Changes in energy supply costs, and possible disruption to supplies and communications services as a result of climate impacts, will be of significant importance to this communication intensive sector. Opportunities for on-site renewable energy supplies and energy efficient practices and technologies exist to overcome some of these challenges, as do satellite based communications equipment which is less susceptible to climate impacts.

Potential barriers

Uncertainties within the climate change debate pose a considerable barrier to change. However, it is the lack of engagement with this issue within the sector which poses the main barrier to incorporating climate change into the business practices of this sector. Similar levels of under-engagement within the customers of tele-marketing businesses means that this sector is only likely to respond once other sectors have products and services they want marketing.

Knowledge levels

No research has been done within this sector on climate change impacts or adaptation response, and as a result knowledge levels and engagement with businesses has been limited. It is unlikely that adaptation strategies have been considered or that the issue is of importance to many of the businesses in this sector.

A few exceptions may exist within businesses who operate in flood risk areas; however, it is likely that these businesses will relocate rather than attempt to adapt as relocation is relatively easy given a lack of heavy plant infrastructure.

As with other sectors, considerations of economic stability and future expansion are priorities on the short time scale, climate change does not figure within this timing or planning for the majority of businesses.

Challenges and Opportunities of Key Climate Impacts in Telemarketing Domain

Climate Impacts		Challenges and Opportunities
Increased Summer Temperature	C	Increased need for cooling of equipment and buildings and associated increases in costs.
	C	Health impacts upon staff who work inside, particularly with electronic equipment.
	O	Increased marketing of warm weather activities and services.
Increased Winter Temperature	C	The need to change current heating and ventilation systems within buildings and to meet new building guidelines.
	O	Positive impact upon energy costs and staff health.
Flooding Increased	C	Direct infrastructure damage, and indirect impacts upon supplies and markets.
	C	Increased insurance costs and changes to planning regulations affecting infrastructure development.
	O	Marketing of new technologies to monitor and manage flood risk areas.
Summer Rainfall Decreased	C	None identified.
	O	Marketing of water management technologies and initiatives
Winter Rainfall Increased	C	Impacts on infrastructure, in particular buildings and cabling.
	O	None identified.
Increased Sea Levels and Tides	C	Direct and indirect impacts on infrastructure, markets and suppliers.
	O	None identified.
Longer Growing Season and Reduced Frosts	C	Non-identified.
	O	Marketing opportunities for new crops and produce to customers, such as new wines and foods.
Potentially Increased Winds and Storms	C	Increased direct and indirect impacts on infrastructure and supplies/markets.
	C	Damage to overhead cables and communication infrastructure and signals.
	C	Increased repair costs and insurance costs.
	O	Marketing opportunities for storm-proof goods and services and insurance services.

CHAPTER 9

LOCAL AUTHORITIES DOMAIN

Scope

The wide range of functions and responsibilities undertaken by local authorities. Consideration is made of County, Unitary and District Councils, but not of Parish and Town Councils. Despite the importance of this domain, time has permitted only a limited enquiry in this area.

See Also

All other Impact Domains.

Baseline

Local government within the region is organised through 6 County Councils, with 36 District Councils and 9 Unitary Councils.

The prospect of an increasing role for regional governance is increased following the release of the recent White Paper *Your Region, Your Choice: Revitalising the English Regions* (*May 2002)*

At present such changes are unlikely to be imposed upon regions, but will probably follow local referendums. Nevertheless, within the time frame of anticipated climate change such changes seem likely.

The majority of the proposals suggest an enhanced role for elected regional assemblies but there is also a strong implication for changes at County and District levels. A growth in the number of Unitary authorities, and a reduction in the number of County Councils, seems the most likely outcome of such changes.

Other Drivers of Change

Local Authorities operate under increasing influence from central government. This applies to over-arching concepts of governance, such as 'Best Value', and also to specific targets to be achieved in discrete policy areas, such as 'Law and Order'.

The full impact of Cabinet government in local councils is yet to be realised, but it will change the relationship between councillors and officers, and probably give increasing influence to senior elected members.

Local authorities therefore experience increased pressure on limited resources with the growing perception that they are asked to achieve increasingly more with increasingly less.

One of the requirements recently imposed on local authorities is the creation of Local Strategic Partnerships (LSPs) for the purposes of developing Community Strategies (or Community Plans). LSPs are non-statutory, non-executive organisations which bring together at a local level the different parts of the public sector as well as the private, business, community and voluntary sectors, so that different initiatives and services support each other and work together. These partnerships will become increasingly important mechanisms through which local authorities will develop and implement policy.

Key Issues

The wide range of activities for which local authorities are responsible means that climate change, both adaptation and mitigation, impacts on many different areas. Local Authorities need to identify those areas that are vulnerable to climate change as a matter of priority in order to develop appropriate responses.

Strategic responses on climate change are being carried out by many local authorities but generally the focus is on mitigation rather than adaptation.

Local Authorities are encouraged to sign up to the Nottingham Declaration on Climate Change. Again, there is only limited reference to adaptation issues within the text of the Nottingham Declaration, despite the fact that the declaration represents the key initiative on climate change for the public sector.

Many of the climate change adaptation issues that face local government are similar for all authorities. Certainly, neighbouring authorities are likely to experience similar changes in climate. There will be considerable benefit through co-operation between councils, both at County and District levels.

It is unlikely that adaptation to climate change will achieve sufficient priority in competing council agendas to become a major policy driver in its own right. Therefore, it will be important to find appropriate policy frameworks within which adaptation issues can be nested.

The potential hazards of flooding are acknowledged, and the statutory and advisory roles of the Environment Agency and Local Planning Authorities seem appropriate to deal with these issues.

Local Authorities have an important role in emergency planning, both in preparing and co-ordinating local arrangements. Responding to extreme weather events will now become an important part of such planning.

Building designers, engineers and surveyors, and their consultants identified potential litigation as major concerns. It was unlikely that projects that were already completed would be re-visited, but new projects will need to be designed to new, future-proof standards. We were advised

therefore, that changes in performance standards, codes etc. that reflected potential changes in climate would be a highly effective mechanism for improving performance.

As well as considering the more obvious and statutory functions of councils, Local Authorities should also be encouraged to consider potential lifestyle changes that might be influenced by changes in the weather. For example, the greater use of the external environment in parks, pavement cafes, cycling and other leisure activities, may require significant changes to present planning policies.

We need both to adapt to the effects of climate change to protect our communities and to act creatively NOW to cut the greenhouse gas emissions that cause climate change. In addition to providing a challenge, climate change offers an opportunity to address issues like fuel poverty, which have dogged our communities for a long time.

Community Leadership and Climate Change 2001

Discussion

The Structure of Local Governance

Although local councils operate at county, unitary or district levels the main findings of this study do not distinguish between the different functions of different types of council. Nevertheless, we did encounter some significant differences between authorities, but this reflected geographic location rather than authority type.

Workshops conducted in the south-western part of the region revealed a strong sense of isolation and remoteness from the corridors of power and influence in Whitehall. For example, it was suggested that, despite extensive lobbying, central government did not appreciate the strategic importance of road and rail links into Devon and Cornwall, and their increasing vulnerability due to climate change. Such political concerns are beyond the scope of this study but they should be taken into account in considering adaptation responses from the South West region.

Diverse Roles

The publication 'Community Leadership and Climate Change' identifies three principal roles for local authorities in relation to climate change. These are:

- LAs as service providers
- LAs as corporate managers
- LAs as community leaders

As service providers local authorities are responsible for a range of functions which include the following:

Development Planning/Land Use Planning
Transport (GTPs)
Develop Control
Housing (both as landlord and enabler)
Building Control
Engineering including drainage
Roads maintenance, snowploughs, salt, etc.
Conservation of buildings, parks, trees etc
Economic Development
Social and Economic Regeneration
Education
Culture, Libraries etc
Tourism and leisure
Urban Design and the Street Scene
Environmental Health and Pest Control
Waste Management
Emergency Planning

As corporate managers councils have responsibility for all of the functions that fall upon any large organisation. These include:

Buildings and other Estate Management
Health and Safety
Vehicles
Procurement
Personnel Management
Risk Assessment and Management
Environmental Management
Potential Litigation

As community leaders councils are called upon to be proactive with regard to the following, both in a leadership role, and as examples of good practice.

Strategic Vision for community
Social, Economic & Environmental well-being
Economic Development
Community Planning
Regeneration
Sustainability Strategy for community
Climate Change Strategy for community
Nottingham Declaration on Climate Change

Links to Sustainability

There is some evidence of regional enthusiasm for sustainable development amongst local authorities, driven by a mixture of central government edict and local enthusiasm. This is likely to increase as Community Strategies are developed and further commitments are made to the Nottingham Declaration. The sustainability agenda seems the most likely policy framework through which to pursue adaptation to climate change. A few authorities (e.g. Devon County Council, Cheltenham Borough Council) are now pursuing specific climate change strategies which deal with both mitigation and adaptation agendas.

Data availability and understanding

There appears to be little published literature that specifically addresses the role of local government in the advent of climate change. A useful initiative has been carried out by a partnership between the Department for the Environment, Food and Rural Affairs, (DEFRA), the Local Government Association (LGA), the Improvement & Development Agency (I&DeA) and the Society of Local Authority Chief Executives (SOLACE). Amongst other outputs they have published a short manual on "*Guidance for Local Authorities*".

Generally the evidence is of some general awareness of sustainability issues amongst those with environmental responsibilities (such as LA 21 officers). For others, even those with technical responsibility, the phenomenon has only just registered. In fact the workshops that were run as part of this study proved to very useful in catalysing understanding and awareness of potential impacts.

Some local government officers in the South West acknowledge the issue of climate change, but for most practitioners climate change means mitigation; reduction in energy usage and greenhouse gas emissions, not adaptation. There is little evidence that local authorities have made any use of the latest scenarios published by UKCIP. Again, this was a beneficial outcome from some of the workshops.

On the other hand we have evidence that lay people seem to have a good grasp of some of the predicted changes in climate and some of the significant impacts.

As part of the process of developing its Climate Change Strategy, Cheltenham Borough Council recently carried out a survey across the local community. This revealed high levels of awareness not just of the potential causes of climate change, but also some of the likely impacts. Such understanding was not just replayed headlines from the tabloid press, but was soundly based on knowledge of the locality and the complex inter-relationships between the natural environment, human society systems, and the weather.

So, if lay people seem to have a good basic grasp of the issues, why is it that local government officers and members seem reluctant to engage with adaptation issues? There appear to be three main reasons for this;

- the type of data available.
- the degree of uncertainty attached to the data.
- adaptation to climate change is nowhere near the top of the political agenda.

This is an aspect which warrants further research, as our increased technical and scientific understanding is of little value without the prospect of this understanding being incorporated into all organisations, but particularly those in the public sector.

Data

It appears that, even in a sector which takes its strategic responsibilities seriously, the presentation of climate change scenarios represents a barrier to understanding and consequent action. Even where quantitative data are available, most officers and members find it difficult to relate the numbers on climate data to their own experience.

On the other hand, some more sophisticated data is required for technical purposes, if environmental engineers (amongst others) are to bring some quantification to bear on technical issues, such in the built environment, for example.

Uncertainty

There are many aspects of uncertainty in the latest UKCIP02 scenarios. These are explicitly acknowledged in the Scientific Report, and dealt with very thoroughly. In fact one significant feature of the latest scenarios is that of increasing certainty and confidence in the models. Nevertheless, there continue to be misgivings about the reliability of the data and the willingness to make investment decisions on what is perceived as dubious data.

It is this aspect that represents the biggest challenge. Perhaps it is only the empirical evidence of the changing climate over the next few years that will persuade those with responsibility to make tough (spending) decisions. Is it the newly empowered elected members or the technical officers who will wield the greatest power, and be the best target for persuasion?

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

A clause from the Nottingham Declaration on Climate Change

Political Priorities

The tenure of locally elected authorities is even shorter than that that of national government. This is intrinsically at odds with the long-term nature of climate change.

The world of local government is increasingly driven by edicts from the centre; targets, outputs and disparate but circumscribed agendas. Unless

such targets include those associated with climate change, we are unlikely to see real action in the immediate future, except perhaps in those areas vulnerable to major flooding. Whilst local government is a political phenomenon, the politics are increasingly those of the centre, of Whitehall and Westminster, and not at local level.

The Way Forward

Recommendations for Change

The following are recommendations for areas within which change can be initiated by local authorities:

- Sign up to the Nottingham Declaration.
- Identify key adaptation issues for each authority.
- Support the national initiatives on climate change already begun by the Local Government Association (LGA), the Improvement & Development Agency (I&DeA) and the Society of Local Authority Chief Executives (SOLACE).
- Encourage officers in relevant departments to pursue further climate change understanding through networks of professional bodies, local government officers, Local Government Association etc.
- Encourage sub-regional groupings of County, District and Unitary authorities to share best practice in both technical and managerial aspects of adaptation. It may be appropriate for a regional organisation such as the Regional Assembly to orchestrate this process.
- Undertake a more detailed exploration of the UKCIP02 scenarios and their implications for sub-regional locations. This might include the presentation of climate scenarios in ways that relate more directly to people's experience of the weather. The outcomes of such work can be disseminated by local authorities to the wider community.
- Explore the most effective policy framework within which adaptation responses might sit. In particular, investigate the suitability of Local Strategic Partnerships and Community Strategies as appropriate vehicles.
- Local plans need to take account of climate change impacts – for example in zoning areas suitable for particular purposes, and in policies designed to protect biodiversity.

CHAPTER 10

CROSS-SECTORAL DOMAINS

Introduction

This chapter explores the complex inter-relationships between different responses to climate change across different sectors. It does not use the standard format for individual domain reports, but is more descriptive and discursive in style.

The reports on individual domains concentrate on those issues most pertinent to their particular sector. Even in these individual reports there is a recognition of the way that impacts interact across different domains, particularly where adaptation strategies for one domain clearly have implications for another domain. Nevertheless, it was recognised that the Scoping Study should acknowledge cross-sectoral aspects of impacts and adaptation responses. It was seen as important to examine potential adaptation responses across domains. In discussion with the project steering group three contrasting localities were chosen in which to investigate such responses. These were:

- an urban setting (the city of Bristol);
- a rural setting (the Tamar Valley on the borders of Devon and Cornwall);
- a coastal setting (the coastline of Dorset).

All three localities had the advantage of having an inter-agency or cross-departmental body that could address issues such as climate change. The city of Bristol has a Sustainable City team with responsibility for the cross-cutting agenda of sustainable development. Part of the Tamar Valley is an Area of Outstanding Natural Beauty, which has a partnership committee to assist in its strategic management. The Dorset Coastal Forum was set up to promote the sustainable management of the Dorset Coast.

Workshops were held in each of the localities. We are grateful to all those who gave their time to the workshops, which involved the participation of managers and decision-makers who had some experience of considering problems across sectors. We have used selected examples from each setting to examine how potential adaptation responses might impact across different sectors.

Urban Context: Public Open Space

The adaptation of public spaces in urban areas such as Bristol to new climatic conditions illustrates the interconnected nature of planning and design. In the warmer and sunnier conditions anticipated in the UKCIP02 scenarios, shade in public space will become increasingly necessary and hence planned and designed for. One such case is school play areas. Local Education Authorities and school governing bodies have begun to put into their specifications for new schools the requirement of shaded external areas. Existing school layouts will have to be modified. The costs of these will need to be included in LEA and school budgets. National government, with concerns over increasing skin cancer and the consequent NHS bill, will legislate for such provision for those LEAs and schools who have not done so already.

Shade will be required in other public places in urban settings, for example, on streets. If one were to map the distribution of trees in Bristol today the relatively treeless areas would be in inner city areas such as St. Paul's and outer city, former local-authority housing estates, such as Knowle and Hartcliffe. This raises social deprivation and resource allocation issues.

Technical issues arise in inner city areas where narrow roads and pavements are restrictions on straightforward tree planting. New street and traffic layouts may be needed, which would require extra investment. In new developments it will be easier to incorporate sensible planting arrangements. In private developments local authorities will be able to specify in planning requirements that appropriate species of trees will be planted at appropriate densities and locations.

Shade will also be important in city centre areas in response to changing lifestyles. It is anticipated that outdoor living and street-activity will become a greater feature of life in the South West than at present. In future, Bristol may have to think of itself more like continental Europe with pavement cafes open until late at night. Tree-lined streets such as the Promenade in Cheltenham may become more evident in South West towns along with increased pedestrianisation. On the other hand it may be that new forms of shelter are also required to protect pedestrians (and possibly cyclists) from extreme rainfall events. Can shelter from both sun and rain be achieved through similar types of structures? and will these be predominantly natural? (ie. trees or other vegetation) or man-made structures? or both?

Planners will need to anticipate trends towards increased outdoor living ahead of changes in consumer behaviour. Such opportunities will bring their own problems such as law and order, changes in local bye-laws on the use of the pavement, and problems of noise disturbance at unsocial hours outside domestic windows left open to increase cooling and ventilation.

The choice of appropriate tree species to provide shade must be made in the prospect of milder, wetter winters, but warmer, drier summers. It will have to be considered whether the existing species of planes and limes will thrive in the new conditions. If not, tolerant species will need to be identified, cultivated and planted. The effect on the urban landscape of such new species will have to be considered, and it is possible that the decision will be made to continue with existing species, and accept a more demanding management regime (such as more intensive irrigation).

Tree planting strategies will also affect building foundations, especially in the new climatic conditions. Species with too high a water demand will cause subsidence. Indeed such existing tree species close to existing buildings may have to be removed. More trees *per se* will also mean more blocked drains and root damage to other features of the built environment. Nevertheless, trees will have secondary benefits in terms of absorbing pollution.

The fear of litigation may also be a spur for some institutions in adapting their environments to cope with new climatic conditions. It is possible that schools may encounter legal claims through failure to protect schoolchildren from the excesses of sunshine and heat, whilst local authorities may receive claims when existing and newly planted trees increase the damage to foundations. Bristol clays are particularly vulnerable in this respect.

Tree planting on the scale envisioned to provide adequate shade may create public places with an entirely different townscape, especially if non-native species are required. The planning of such schemes might use public meetings and exhibitions to explain the need for these changes and use the opportunity to raise awareness of climate change and the need for adaptation.

Although in the urban scenarios outlined above there is no single issue which demands priority attention, in combination they demonstrate the cross-cutting nature of adaptation responses to climate change.

Coastal Context: New Fish Species

The second example comes from the coastal setting. Rises in sea temperature are already being noticed along Britain's coastline. As one fisherman pointed out '*…….we are losing the seasons: last year sea temperatures didn't drop below 10 degrees.*' Such changes are already creating a myriad of effects: ecological, economic and environmental. The knowledge of these effects does not just rest with experts and scientists. It is those who derive their livelihood from the sea and coastal waters who provide an important source of knowledge concerning changes to marine ecosystems and to the local coastal economies. Moreover, local people's knowledge is often not just restricted to their locality. Because they are linked into a wider network of knowledge through their trade and industry contacts those fishing the coastal waters of Britain have not only an extensive knowledge of British waters but are linked to marine fishing people all over the world.

The complexity of change in coastal ecosystems and the economic effects that follow from this can be illustrated by changes in fish stocks off the South West coast. For example, with warmer sea temperatures, Manila clams are now well established in the waters of Poole Harbour. The clams have thrived to the point where they are now actively displacing other species, including the economically important mussel population, through competition for limited food stocks. Fishermen have had to shift their business from mussels to Manila clams. The Manila clam is only one of a number of new species that is displacing fish stocks well recognised on British dinner tables. Sea bass is replacing cod in our coastal waters, but not yet in our fish and chip shops.

Poole itself has benefited economically from such changes. The new types of shellfish that are being caught all round the British coasts are transported by lorry from various fishing ports to Poole. There may not yet be the demand in Britain for these new species, but in Spain there is a ready demand, particularly to supply the Friday meal tables in this Catholic country. So the lorries with their fish consignments are then shipped from Poole to Bilbao and distributed to fish suppliers, mainly in Southern Spain. This is a new opportunity that climate change has already created.

However, there are negative consequences from these new trading patterns. The previous fishing industry based on traditional species like cod, plaice and mussels was more environmentally friendly with regard to transport. That trade was based on boats coming into port and the catches being distributed throughout Britain by train and lorry. Now the transport is primarily based on land with fleets of lorries travelling in greater numbers and longer distances. CO_2 emissions are therefore much higher in aggregate. Indeed such has been the impact on previous modes of fish transport, that the rail spur in Poole Harbour is threatened with closure, and luxury apartments are being proposed to replace the existing harbour-side rail depot. Presumably the housing development is more attractive with the prospect of a balmier climate in coastal Dorset. If the railhead closure goes ahead then it will mean that even more lorries serve the needs of the port with a further increase in CO_2 emissions.

There are two other aspects to the tale of the Manila clams. First, scientists when initially asked about the presence of the clams in Poole Harbour advised the local fishermen that there was nothing to worry about as the waters were too cold for the clams to thrive. Clearly this advice was ill-founded: in fact the clams have flourished. With changing climate, experts may get it wrong again so making ordinary people sceptical of expert opinion, including views on climate change itself.

Second, the experience of new species moving into Poole Harbour and the surrounding coasts has made some local people wary of new species *per se.* We were told that the experience of the clams would make those responsible for the management of fishing around Poole Harbour hostile to the import of any new species. However, if we are to plan properly to ameliorate the consequences of climate change and to seize the opportunities, then we will probably need to be pro-active in the introduction of new species. We will certainly need decision-making fora where the benefits of such an approach can be debated, and institutions where appropriate action can then be taken. Ecological Luddism can be partly avoided by harnessing the knowledge of local people and allowing them to share their understanding of the complex interactions between man and nature.

Rural Context: River Catchments

The third example is from a catchment basin, in this case the Tamar Valley. With a future rainfall regime which is wetter in winter and the prospect of more extreme weather events, higher run-off and more flash floods will occur. In the upper reaches of the Tamar catchment high run-off is already being experienced because of the lack of wooded areas and the intensity of stocking. With wetter and more extreme conditions higher failure rates of man-made and natural slopes are likely to occur. This will affect both the productivity of the land and disruption to the existing poor road system. In what is already an economically marginal area this will cause problems for farmers and certainly discourage tourists, a source of income for many in the area. With climate change it is likely that more spring crops will be grown in the catchment area, thus exposing the land for longer periods. Higher run-off and higher sediment load will result.

Reservoirs could be constructed to deal with higher run-off levels but at the moment South West Water has no plans for further construction of reservoirs. Afforestation, for example with oaks, is another possible solution to reduce higher runoff, but such planting will take a long time to mature to the point where it significantly reduces run-off. Therefore, it seems likely that other forms of riverine flood defence will need to be constructed in the lower reaches of the catchment.

The Tamar Valley was an important mining area in the 19th century. Mining debris is still strewn throughout the catchment but is stabilised to the present rainfall regime. The predicted increase in rainfall quantity and intensity will mobilise tips leading to slope stability failures. The spoil heaps of the South West have never received the attention that tips in South Wales have enjoyed since the Aberfan disaster in 1966. The present condition of the Cornish tips is uncertain and hence with even small changes in rainfall patterns slope failures are unpredictable.

These tips also contain highly toxic material such as arsenic. Toxic pollution of water supplies is likely to follow remobilisation of such material. During the period of mining and the immediate aftermath of the cessation of mining, quantities of similar material did move from the mining debris tips through the catchment to be deposited on the mudflats of the Tamar estuary. This will also be remobilised if run-off is sufficient to expose the toxic deposits. The problem will be exacerbated by increasing sea level and possibly increased storminess, which will raise the river level in the lower part of the catchment.

Increased sediment load from upstream and changing sea conditions will increase the need for dredging in the Tamar estuary. The increased sediment load will also have an effect on freshwater fish stocks in the Tamar. Salmon is the most important of these fish to be affected because of the part it plays in the local fishing and tourism economies.

Conservation Philosophies and Strategies

There is one cross-sectoral adaptive response that was noted in all the workshops. This was a wish to hold onto precious, local natural features in spite of the changes in climate and which we termed the "Canute syndrome". This view was not universal, but there were instances where species, habitats and landscapes were regarded as too important to lose, particularly when they related to some sense of our identity as British or English.

For example, the Tamar Valley has important market gardening businesses, especially for strawberries. Due to its importance to the local economy it was suggested that genetically modified strawberries could be introduced to allow the industry to continue under the new climatic conditions. So genetic modification could make sure that we had Tamar Valley strawberries and cream, making genetic modification an agent of conservation rather than its usual image as an agent of undesirable change.

Some would want to preserve particular landscapes that are judged as important to our heritage. Landscape gardens such as those in the National Trust properties in the Tamar Valley could be one such English landscape. Under the changed climate what price would we be prepared to pay to keep these three hundred-year-old features? Would this be done through genetically modified species or irrigation? Landscape preservation on a much larger scale would need to be considered in the case of AONBs. Their very name tells us that they are places of outstanding natural beauty but what if nature changes? Do we preserve them as they are, or allow them to evolve with climate change? If we chose the former course, the countryside of the South West could come to be made up in part of islands of conservation. The cost implications of such strategies will need to be assessed. The economies of these localities are based mainly on tourism from people who visit just to see these beautiful landscapes. If attitudes do not change, the tourists will go away and the local economy devastated, but if they are preserved there may be significant cost to the rest of us.

One of the aspects the Tamar case illustrated is the need both to think in a holistic way; in this case about the whole catchment, and at times to abandon empiricist thinking in favour of intuitive modes of reasoning. For example the increased dredging in the Tamar estuary has been happening for sometime but it has been difficult to track definitely the source(s) of the increased sediment load. So nothing has been done about it as no one can be held responsible for it.

Management through Partnerships

The complexity and diversity of the issues outlined above highlight the need for debates within inter-agency bodies to ensure that cross-sectoral issues such as these are recognised, understood and addressed. All of the groups that participated in the cross-sectoral workshops were part of some multi-agency partnership, either formal or informal, which

provided the context within which such issues could be addressed.

The Dorset Coastal Forum was established in 1995 to look at the long-term strategic issues facing the Dorset coast. The overriding aim of the Forum is to promote a sustainable approach to the management, use and development of Dorset's coastal zone, which will ensure that its inherent natural and cultural qualities are maintained and enhanced for the benefit of future generations.

The Dorset Coast Strategy has now been prepared on behalf of the Dorset Coastal Forum. It sets out a future for the coast, covering the coastline and inshore seas from Lyme Regis to Christchurch. As the first part of the strategy, 15 topic papers on activities along the Dorset coast were produced. The purpose of these documents was to encourage dialogue and consultation with Forum members and other interested parties, in order to produce a strategy based on consensus. The Forum is now involved in the process of implementing the actions contained within the Strategy.

Bristol City has a unit dedicated to Sustainable Development within its Department of Environment, Transport and Leisure. This new unit encompasses a range of services and facilities from the CREATE Centre to the Ecohome, from environmental quality to pollution control, and looks at Local Agenda 21 and its impact on Bristol's environment. The City Council is also the lead partner in the recently created Local Strategic Partnership which includes other agencies dealing with issues such as health (the Primary Care Trust), and crime and disorder (the local constabulary).

Many of the participants in the Tamar Valley workshop were part of another network in the form of the Tamar Valley AONB Partnership. This is a group of organisations working together to conserve and enhance the AONB. Members of the partnership include:

District Councils, County Councils, Country Land and Business Association, Countryside Agency, representatives of Parish and Town Councils, Rail Partnership, Wildlife Trust, Rivers Trust, Estuary Consultative Committee, English Heritage, DEFRA, NFU,

The partnership comprises two bodies: a Partnership Committee of bodies with a major AONB-wide interest; and an Advisory Forum to ensure widespread community involvement.

Together they seek to:

- Promote the AONB and the Management Plan to all constituent organisations and others.
- Co-ordinate work towards the vision for the AONB via the implementation of the Management Plan.
- Review and monitor progress of the Plan and its objectives.
- Consider, debate and recommend courses of action on the main issues relating to the AONB.
- Accommodate new requirements due to changes in AONB legislation.

This may seem an obviously sensible arrangement that needs no reporting, but, despite the fact that partnerships are increasingly popular in many initiatives, they have yet to be developed with a specific climate change agenda as part of its remit. Such partnerships may well be appropriate to address the cross-sectoral complexity of adaptation to climate change.

The Tennessee Valley Authority in the USA provides an example of holistic thinking that may provide the model for inter-agency institutions that could plan and design for the new climate of the South West. As the history of the TVA explains:

> *'Right from the start, TVA established a unique problem-solving approach to fulfilling its mission-integrated resource management. Each issue TVA faced—whether it was power production, navigation, flood control, malaria prevention, reforestation, or erosion control—was studied in its broadest context. TVA weighed each issue in relation to the others. From this beginning, TVA has held fast to its strategy of integrated solutions, even as the issues changed over the years*.'

CHAPTER 11

SUMMARY OF FINDINGS

Introduction

The Scoping Study set out to understand the potential impacts of climate change upon the South West Region of the United Kingdom, to explore the current understanding of adaptation to climate change across the region, and to consider possible responses. The principal aims of the Scoping Study were to:

- Provide an **overview of the best current information on the predicted climate scenarios at global and UK scales, and particularly at regional scale.** Specifically to report on the latest UKCIP climate scenarios for the South West region for the 2020's, the 2050's, and the 2080's. This reportage was to be based upon an understanding of historic and contemporary climate change data for the South West region.

- **Report on the levels of awareness of climate change issues across the region and within different sectors and domains.**

- Identify the main domains (and their key stakeholders) in the South West Region which will be most affected by climate, **in order to identify the main problems and opportunities associated with the impacts of climate change**, **and report on how stakeholders expect to adapt to potential changes in climate.**

- **Identify areas for further action and research in response to this understanding of the type and extent of potential impacts and appropriate adaptation responses.**

A brief summary of findings in response to these aims is reported in this chapter. Recommendations for further action are reported in Chapter 12 and Priorities for Future Research in Chapter 13.

Climate Data for the SW Region

The quality of climate data, both of historic climate, and modelled futures continues to improve. The UKCIP02 scenarios, upon which this study is based, are able to claim greater certainty in many aspects of the modelled climate, and are also more explicit about areas of uncertainty.

In putting together the questionnaire for this study we tried to present scenarios in a simple way that would be accessible to all. Simple scenarios were presented for single climate variables (such as average summer temperature and winter rainfall). As well as crude numbers (e.g. ºC) an attempt was made to characterise the climate scenario by reference to other places that experienced similar climate, or recent events in the UK climate that were similar. Despite this many respondents were put off by the apparent complexity of the scenarios and did not complete the questionnaire. This suggests that even this simplified data is perceived to be too complex.

Paradoxically, we also encountered the problem of some data being over simplified. So, a simple characterisation of average summer temperatures was not sufficient evidence on which to base judgements about passive heating and cooling strategies for buildings, or even the impact on coastal tourism. For even simple technical decisions on such matters to be well informed further information is needed. Data on aspects such as solar radiation, hours of sunshine, sea temperature, extreme events, cloud cover and relative humidity all also required. Whilst most of these data are available amongst the 15 climate variables reported on the UKCIP website, very few of our respondents had accessed this information. The depth of information, academic style and use of specialist terminology tends to discourage all but those well versed in the subject matter from pursuing the information they require.

The study has also revealed the fact that in speculating about future climates it is not sufficient to explore just a single variable. We have found that understanding is enhanced by describing scenarios on a seasonal basis. For example, summers can be described as drier, and warmer with similar frequencies of winds and storms, but possibly higher intensities.

Although the study was explicitly based on UKCIP02 scenarios we have found both lay and professional alternatives presented, particularly with regard to the reversal of the Gulf Stream and consequential cooling. Some detailed data are presented in graphic form in Chapter 5. The probability curves for individual climate variables have proved to be a very useful way of exploring the individual climate variables in more detail.

Awareness of Climate Change

The response of stakeholders to the subject of climate change has been mixed. Some respondents, particularly those with responsibility for the management of the natural environment, were well aware of the phenomenon. Other respondents were not only ignorant but did not seem to consider it relevant to their areas of responsibility.

It is difficult to explain this with any great confidence but two reasons suggest themselves above others:

- the apparent complexity of data;

- the fact that adaptation to climate change is not generally considered a priority.

The apparent complexity of data has already been discussed above. The study also revealed that adaptation to climate change is not generally a priority whether in the public, private or voluntary sectors. Organisations, and therefore their staff, are increasingly driven by targets, measurable outputs and missions. This means that unless adaptation to climate change is specifically on the agenda of a company, local authority or voluntary organisation, work in this area is unlikely to be regarded with any importance.

Almost all of our respondents reported that there were no policies on adapting to climate change within their organisation. It was clear that in most instances there was no-one with formal responsibility for climate change adaptation. This last fact in itself probably explains the poor response generally received to the questionnaire.

Within the different sectors that formed the focus of the study the best informed were those dealing explicitly with the natural environment. Those organisations providing water to the region, or with responsibility for nature conservation or flood defences seemed to have the fullest understanding of the potential impacts and had given some thought to adaptation responses.

Those dealing with other aspects of infrastructure and society varied in their level of awareness and understanding. It was surprising to find that those who were acknowledged experts in sustainable construction and sustainable development, with considerable expertise and experience in reducing greenhouse gases, nevertheless admitted to very little understanding of adaptation issues in their professional roles.

Business domains were again varied in their appreciation of the issues, but generally there was a low level of awareness of the issue.

Overall, there was the impression that individuals did know something about the main features of climate change scenarios for the region, but only in a personal capacity. Somehow this was not being translated into a professional application. In general, the impacts were seen as threats or challenges. It was only after extended discussion and further thought that opportunities were identified.

Impact Domains
Impacts and Adaptation Responses

Natural Environment Domains

The natural environment is probably the most conspicuous and visible receptor for the impacts of weather. In both public and professional realms it is the natural environment that first comes to mind in considering the impacts of climate change, for example through coastal and river flooding, water supply and demand, natural habitats, and potential changes in agricultural crops.

With the exception of the more linear stretches of protected coastline and some river-valley woodlands, many of the region's protected sites for nature conservation are pockets of semi-natural habitat in a sea of agricultural or occasionally urban landscape.

The South West has a Regional Biodiversity Action Plan unlike most other regions, but its practitioners in nature conservation are hampered by various perceptual, institutional and practical barriers to planning for biodiversity in the wider countryside (Watts, 2001).

With regard to **biodiversity** in the region it is clear that changes are already taking place. The range and variety of species will not just be affected by how we manage protected and designated areas but how integrated land-use and management strategies can be developed. Difficult choices are required from those with management responsibility. We have encountered many conservation specialists who have difficulty in accepting the potential impacts of climate change and seek (Canute like) to hold onto protected species and habitats in the face of significant changes in climate. Even during the course of the study we have observed a change in this attitude, and a much clearer recognition of the inevitability of climate change and the need for more radical responses.

The effects of climate change on **agriculture** are now broadly understood. These include an extended growing season, the potential for new crops, an increased requirement for water for summer irrigation, a potential loss of competitive advantage compared with other locations, and reduced die-off of pests and diseases due to warmer winters. Some of these changes are already occurring but within the farming community generally there is not much awareness or concern. At present there are more pressing issues on the agricultural agenda, including BSE, the aftermath of Foot and Mouth Disease, the implications of the Curry Report and changes to the Common Agricultural Policy.

Existing, established **woodland trees** generally are likely to survive changes in climate but new planting may require consideration of different species or different nursery regimes.

The main impacts **on the coast** will be to do with coastal erosion and the reduced depth of beaches arising from increased sea levels and storm surges. Difficult decisions are required from those with responsibility for the management of coastal defences. Abandon; manage retreat; or defend robustly are the main options in the vulnerable locations. Again an integrated approach is required.

The impact on **marine fisheries** is similar to that in agriculture. The marine harvest is already changing but there are again more pressing issues than

climate change. Traditional species such as cod are migrating north, whilst new, more exotic species are now present in southern waters. The other items on the fisherman's agenda include the recent pronouncements on EU quotas, and the need to renegotiate the Common Fisheries Policy. These have tended to pre-empt consideration of climate change impacts, despite the empirical evidence that change is already happening.

The main impacts associated with **rivers and other watercourses** concern **flooding** in its various forms. The recent experience of riverine flooding is still in the public consciousness and the planning system is now exerting further control on potential development in floodplains. Periods of intense rainfall also lead to problems associated with excessive run-off from the land, and flash flooding in both town and country, largely associated with insufficient capacity in existing drainage systems. Insurance companies are taking an increased interest in the financial consequences of flooding, and through premium pricing or new policy exclusions are likely to determine policy in this area.

Issues of both supply and demand of **water resources** are affected by increased rainfall in winter but reduced rainfall in summer. As usual storage across the seasons becomes the main problem, particularly when extended periods of summer drought will increase demand for domestic and agricultural irrigation as well as for commercial and industrial use. The quality of water is also of concern as riverflows reduce and pollutant concentrations therefore increase. Nevertheless, the water companies in the region appear to have a clear understanding of the main issues and appropriate adaptation strategies.

Society and Infrastructure Domains

The study has revealed three main issues across the domains of society and infrastructure:

- aspects relating to physical infrastructure;
- aspects relating to lifestyle;
- issues relating to the management of change.

The physical infrastructure of buildings, bridges, power transmission lines, transport infrastructure (roads, rail, air) and heritage (both natural and built) are vulnerable to most aspects of climate change. The lead-time and investment periods for infrastructure are such as to justify serious consideration of long term changes in the weather. Whilst changes in average conditions (e.g. increased rainfall in winter) will have some effect, it is changes in extreme conditions that are likely to have the greatest impact. For example, although the UKCIP02 scenarios do not suggest any significant overall changes in windiness and storms, the likelihood of extreme wind and storm events could increase, and it is these that will cause physical damage. So the main physical impacts will include flooding (riverine, coastal and urban) and possible wind damage.

Climate change will affect energy demand in the South West with reduced heating requirements in the winter probably offset by increased demand for cooling in the summer. Of particular importance to the region is the potential opportunity for further development of renewable sources of energy: biomass, vegetable oils, solar, hydroelectric, wind and wave power are all areas upon which climate change will impact. It is widely recognised that more work is required in this area, to understand better the subtle impacts of the different climate variables.

Lifestyle changes are significant in two ways. Lifestyle will influence climate change (through patterns of energy usage, transport etc.) and be influenced by it (through choices in holiday patterns and destinations, increased *al fresco* eating etc.). Such changes are elusive and there is little literature on the subject. Nevertheless we can look to examples of societies and cultures which operate in the type of climates that we anticipate, as some sort of indication of the way that society in the South West may develop.

In this report we have identified some possible lifestyle impacts such as: increased use of bicycles and walking as modes of transport; increased use of external spaces in urban areas with a consequent impact on the street scene (pavement cafes, night life etc.). Increases in outdoor physical recreation can be anticipated, with potential improvements in general health, but this may increase exposure to radiation and associated cancer risks. More research is required to track possible lifestyle changes and their wider implications.

The management of change has philosophical and political implications, as well as economic ones, in considering how best to respond to potential climate impacts. Generally decisions will be more easily made in the public sector, particularly at the large scale, if climate change attains sufficient priority. Some aspects of the private sector can be controlled by legislation, regulation, fiscal policy etc. Perhaps the most elusive challenge will be influencing individuals and householders to adapt to the changing climate in ways that do not make the situation even worse, through increased emissions.

Any adaptation responses will need to be managed in a way that does not exacerbate the global warming phenomenon. This report identifies several instances where potential adaptation strategies are in conflict with aspirations to reduce greenhouse gases and consequent global warming. This is particularly true in the transport domain, where new strategies still fail to acknowledge global warming implications. Also in the built environment there is the potential need for increased cooling in summer. Conventional responses would install fans, air-conditioning or similar cooling devices, all of which will increase energy consumption, and therefore increase global warming.

The greatest managerial challenge is to find the most appropriate policy context within which to incorporate strategies for adapting to climate change. Within large organisations the range of potential impacts is considerable so responsibility for adaptation does not just belong to a single department or unit. Issues range from building maintenance and insurance, to new market opportunities. Managers must ensure that policies and responsibilities are designed to reflect the full portfolio of concerns.

Business Domains

Future climate change scenarios suggest that significant business impacts will occur from several different climate variables. Across all business sectors generic impacts will include:

- Direct infrastructure impacts as a result of increased flooding, subsidence during dry weather, coastal erosion, possible windstorm impacts, and sea/ground-water intrusion.

- Changes in resource usage, particularly increased energy demands for cooling in summer, and reduction in winter heating demands.

- Changes to internal conditions within commercial and industrial premises, primarily hotter in the summer and winter, impacting upon production processes and workers' health.

- Health impacts as a result of higher internal and external temperatures, increased winter survival of diseases and other associated risks (eg food poisoning).

- Impacts upon supply lines and business activities as a result of flooding, subsidence, and storm impacts on transport and communications facilities.

- Climate change impacts upon markets and customers on a regional, national and international scale.

- Changes to planning and building regulations as a result of perceived climate impacts and related government legislation.

- Changes to insurance costs and coverage, in particular in vulnerable geographic areas or economic sectors, such as operations within floodplains. Financial implications related to this may include mergers and acquisitions, a lack of inward investment and an inability to develop or sell facilities.

Despite the potential risks and costs of these impacts, significant market opportunities exist for many business sectors to develop climate-proof products and services which reduce climate impacts and increase adaptability. Opportunities also exist within specific sectors such as flood defence technologies, tourism and environmental services to capitalise on both the positive and negative impacts of climate change. The expanding market for cleaner technologies and low carbon products means that many new opportunities exist within this field and many businesses may choose to diversify into these areas. Such opportunities exist at both national and international scales.

A final consideration is the potential for litigation against companies who provide services which are subsequently impacted upon by climate change. As a result businesses may become susceptible to legal challenges if their products and services do not allow for climate changes. This is an area that needs further investigation, and may well prove to be a driving force behind many businesses accommodating climate change into future projects.

Further research to identify the probabilities of climate change impacts and to allow businesses to accommodate climate change into business planning and activities is required and should be at the forefront of research activities. Businesses themselves need to take a leading role in developing further knowledge on impacts, changing markets and adaptation responses.

Local Authority Domains

Local government within the region is currently organised through 6 County Councils, with 36 District Councils and 9 Unitary Councils. Structural changes now seem likely. These may include an enhanced role for elected regional assemblies, a growth in the number of Unitary Authorities, and a reduction in the number of County Councils.

The publication 'Community Leadership and Climate Change' identifies three principal roles for local authorities in relation to climate change. These are:

- LAs as service providers
- LAs as corporate managers
- LAs as community leaders

This wide range of activities for which local authorities are responsible means that climate change, both adaptation and mitigation, impacts on many different areas. Local Authorities need to identify those areas that are vulnerable to climate change as a matter of priority in order to develop appropriate responses. As well as considering the more obvious and statutory functions of councils, Local Authorities should also be encouraged to consider potential lifestyle changes that might be influenced by changes in the weather.

Strategic responses on climate change are being carried out by many local authorities but generally the focus is on mitigation rather than adaptation. Local Authorities are encouraged to sign up to the Nottingham Declaration on Climate Change. Again, there is only limited reference to adaptation issues within the text of the Nottingham Declaration,

despite the fact that it represents the key initiative on climate change for the public sector.

Many of the climate change adaptation issues that face local government are similar for all authorities. Certainly, neighbouring authorities are likely to experience similar changes in climate. There will be considerable benefit through co-operation between councils, both at County and District levels.

It is unlikely that adaptation to climate change will achieve sufficient priority in competing council agendas to become a major policy driver in its own right. Therefore, it will be important to find appropriate policy frameworks within which adaptation issues can be nested. One of the requirements recently imposed on local authorities is the creation of Local Strategic Partnerships (LSPs) for the purposes of developing Community Strategies (or Community Plans). It may be that this is an appropriate policy framework through which to manage climate change adaptation.

Local Authorities have an important role in emergency planning, both in preparing and co-ordinating local arrangements. Responding to extreme weather events will now become an important part of such planning.

Generally the evidence is of some general awareness of sustainability issues amongst those with environmental responsibilities (such as LA 21 officers). For others, even those with technical responsibility, the phenomenon has only just registered.

The world of local government is increasingly driven by edicts from the centre: targets, outputs and disparate but circumscribed agendas. Unless such targets include those associated with climate change, we are unlikely to see real action in the immediate future, except perhaps in those areas vulnerable to major flooding.

Cross-sectoral Domains

Because the various impact domains that have been investigated are difficult to separate from each other, it was seen as important to examine potential adaptation responses across domains.

Decisions taken in one domain (e.g. agriculture) may have major repercussions in others (e.g. biodiversity; floods). Decisions taken on upland land-use in a catchment can have major implications downstream, and this is exemplified particularly during and immediately after prolonged or high-intensity rainfall events. The role that forestry might play in intercepting precipitation and mitigating surface run-off, and the role that a more sensitive agriculture can play in providing refuges and corridors for species, are examples of cross-sectoral and multi-disciplinary issues in the South West.

Some examples from one of three localities which were studied for cross-sectoral issues illustrate how potential adaptation responses might impact across different sectors.

The complexity of change in coastal ecosystems and the economic effects that follow from this can be illustrated by changes in fish stocks off the South West coast. As a result of warmer sea temperatures, Manila clams are now well established in the waters of Poole Harbour. The clams have thrived to the point where they are now actively displacing other species, including the economically important mussel population, through competition for limited food stocks. Fishermen have had to shift their business from mussels to Manila clams.

Poole itself has benefited economically from such changes. The new types of shellfish that are being caught all round the British coasts are transported by lorry from various fishing ports to Poole. In Spain there is a ready demand, particularly to supply the Friday meal tables in this Catholic country. So the lorries with their fish consignments are then shipped from Poole to Bilbao and distributed to fish suppliers, mainly in Southern Spain. This is a new opportunity that climate change has already created.

However, there are negative consequences from these new trading patterns. The previous fishing industry based on traditional species such as cod, plaice and mussels was more environmentally friendly with regard to transport. Catches were based on boats coming into port and the fish being distributed throughout Britain by train and lorry. Now the transport is primarily based on land with fleets of lorries travelling in greater numbers and longer distances. Total CO_2 emissions are therefore much higher. Indeed such has been the impact on previous modes of fish transport, that the rail spur in Poole Harbour is threatened with closure. If the railhead closure goes ahead then it will mean that more lorries serve the needs of the port with a further increase in CO_2 emissions.

The complexity and diversity of the issues outlined above highlight the need for at least discussion, and possibly partnerships, between relevant agencies, to ensure that cross-sectoral issues such as these are recognised, understood and addressed.

All of the groups that participated in the cross-sectoral workshops were part of some multi-agency partnership, either formal or informal, which provided the context within which such issues could be addressed.

These may seem to be obvious and sensible arrangements that need no reporting, but, despite the fact that partnerships are increasingly popular in many initiatives, they have yet to be developed to include climate change adaptation. Such partnerships may well be appropriate to address the cross-sectoral complexity of adaptation to climate change.

CHAPTER 12

RECOMMENDATIONS

Introduction

The SWCCIP is committed to taking forward the issues identified in its Scoping Study. The Partnership will work to ensure that consideration of climate change is built into strategic plans for the region. It has endorsed the following recommendations and proposed actions. These are reported as a set of overall recommendations, followed by a set of recommendations for each of the clusters of domains.

These recommendations are also included at the beginning of each cluster to which they relate. (Natural Environment: Chapter 6; Society and Infrastructure: Chapter 7; Business: Chapter 8; Local Authorities: Chapter 9).

Overall Recommendations

- **Review the role of the South West Climate Change Impacts Partnership to take forward regional work on climate change.**
- **Ensure that the main findings and recommendations of the Scoping Study are incorporated into current and future strategies and frameworks within the region.**
- **Ensure that the South West Climate Change Impacts Partnership continues to have an overall understanding of South West regional work on climate change impacts and adaptation, and to act as a focal point for that information.**
- **Encourage all organisations to identify appropriate policy frameworks within which to incorporate adaptation strategies.**
- **Increase awareness of the need for climate change adaptation across all sectors. Most stakeholders are ill-informed about, and ill-prepared for, dealing with the potential impacts of climate change.**
- **Ensure that simple messages are conveyed to the media because conflicting messages can create confusion on the direction and magnitude of climate change.**
- **Identify and take forward specific projects for action:**
- **Review regional and sub-regional arrangements for emergency planning in anticipation of extreme weather events.**
- **Co-ordinate the development of climate change strategies within local authorities.**
- **Co-ordinate the development of climate change strategies within sectors in the region.**
- **Identify those issues at a regional level where central government action is required.**
- **Undertake further research within selected sectors to better understand the significance of local impacts.**

Recommendations for Natural Environment Domains

- Encourage the implementation of the South West Biodiversity Action Plan incorporating the findings of the Scoping Study.
- Monitor the quantity, frequency and impacts of run-off from agricultural land and uplands generally.
- Make full use of the principles established in the MONARCH and REGIS studies in their potential application in the South West.
- Avoid preconceived and fixated views on what should be found living in specific locations, and alongside what other species, in the face of natural, uncontrollable changes in climate and habitat.
- Encourage site visits for all relevant sectors to those mainland European locations which currently experience climates similar to those anticipated for different parts of the South West region.
- Make use of historical and archaeological evidence, as well as contemporary evidence, in considering likely impacts of climate change on the natural environment.
- Undertake further research in order to improve the quality of data with regard to extreme events and probability, particularly with regard to coastal storms.
- Quantify need for increased summertime irrigation for South West **agriculture and horticulture.**
- Undertake continual monitoring of climate change impacts to increase awareness in **agricultural** sector.
- Review the potential loss of competitive advantage for South West **agriculture.**
- Develop policy responses to address **biodiversity** issues by considering integrated land-use management (including integrated marine and coastal management).
- Review potential species loss, opportunities for range expansion, and climatic effects on landscapes in assessing impacts on regional **biodiversity.**
- Encourage further research into, and monitoring of, the erosion of **coasts** and beaches.
- Rationalise the current split in responsibilities for **flood and coastal defence** and work towards more integrated management.
- Assess the risk of remobilisation of toxic substances in **riverine/estuarine** sediments.
- Renegotiate Common **Fisheries** Policy in the light of species loss and relocation.
- Monitor the impacts of changing water quality/quantity in **rivers** on habitat and biodiversity.
- Create a searchable database of hydrological data on water quality/quantity data in **rivers** in the South West region to be available to stakeholders including general public.
- Increase control on future development within **flood risk** areas, including increased status for the Environment Agency in the review of planning applications.
- Manage abstraction licences for **water supply** faced with increased demand for irrigation and industrial usage.
- Review impact of longer droughts and modelled 4% rise in household water demand by 2021 on regional **water supply**.
- Review capacity of **sewerage and drainage infrastructure** in the prospect of flash floods, flooding of sewer networks, and rising sea levels.
- Manage increased turbidity, nitrates concentration and *cryptosporidium* content in **groundwater** during wetter winters.

Recommendations for Society and Infrastructure Domains

- Review regional infrastructure for transport and utilities to identify further areas of vulnerability to climate change over a long time scale.

- Review opportunities for increased production of renewable energy as a result of potential climate change: e.g. wind, water turbine; solar; biomass; wave; tide; biofuels.

- Undertake further research into lifestyle changes associated with climate change, including implications for the socially excluded.

- Change relevant codes and standards to reflect anticipated climate conditions, particularly with regard to increased summertime temperatures, grey water systems, and increased exposure to driving rain and wind from extreme events.

- Invest in research into offshore **renewable energy** sources - wind, wave energy, and reassess the environmental and economic effects of the Severn Barrage.

- Design **new buildings** to anticipate reduced heating load in winter and passive cooling in summer.

- Investigate passive or low-energy techniques for increasing ventilation rates and cooling for **existing buildings** in higher summertime temperatures.

- Increase awareness amongst those with responsibility for developing and managing **housing** stock: (including housing developers, Registered Social Landlords, local authorities, Housing Corporation, designers, and owner-occupiers).

- Include adaptation to climate change within regional strategies for **sustainable construction.**

- Review potential impacts of extreme events (storms, floods, high temperatures, etc.) on **transport infrastructure** (road, rail, air, shipping), undertake appropriate risk assessment, and review enhanced specifications of maintenance regimes for **transport infrastructure** (road, rail, air, shipping).

- Encourage pedestrian and cycling modes of **transport** where improved climate conditions permit.

- Undertake feasibility studies for alternative and diversionary routes for strategic **rail and road routes** threatened by climate change impacts and extreme events, and lobby at national level as appropriate.

Recommendations for Business Domains

- Identify managerial responsibility within individual companies for addressing the impacts of climate change.
- Carry out simple risk assessment appropriate to the scope of a business based upon climate change scenarios. Such risk assessment should include: health; supply lines; infrastructure; insurance; litigation, customer demand, etc.
- Specifically investigate the challenges and opportunities presented by climate change with regard to the market for goods and services provided by the company.
- Recognise that markets will be influenced by climate change impacts at regional, national and global scales.
- In reviewing market threats and opportunities consider potential changes in lifestyle brought about by climate change.
- Monitor greenhouse emissions at company or site level and take steps to reduce them in order to reduce the potential for global warming.
- Identify appropriate policy frameworks within which to nest adaptation strategies.
- Co-ordinate the development of climate change strategies within each business sector in the region, possibly through Trade Associations, Professional Institutes, etc.
- Explore commercial opportunities for **advanced engineering** in the development of 'flood-proof' infrastructure to accommodate higher storm surges and tides.
- Explore commercial opportunities for the development of new technologies in **renewable energy**.
- Undertake further research on climate change impacts on agriculture (e.g. drought conditions) and potential for **biotechnology** in adapting to new climatic conditions.
- Increase awareness of potential impacts of climate change in order to increase market opportunities for **environmental technology** sector.
- Encourage **insurance industry** to be more open in its deliberations on emerging policy with regard to climate change impacts.
- Encourage **finance sector** to identify investment opportunities with regard to climate change mitigation including low-carbon technologies.
- Explore the potential for new local crops and produce as part of regional and sub-regional strategies for marketing local **food and drink** specialities. Use SWRDA sector development project as one vehicle for this work.
- Explore and monitor implications of global impacts on regional **tourism and leisure** activity.
- Provide co-ordinated strategy and support for the disparate and often small businesses in the **tourism and leisure** industry. Use SWRDA sector development project as one vehicle for this work, in conjunction with Tourism South West and relevant trade associations.
- Try to spread visitor numbers throughout the year by extending tourist season to avoid further stresses on already stretched **infrastructure.**

Recommendations for Local Authority Domains

- Identify key adaptation issues for each authority.

- Support the national initiatives on climate change already begun by the Local Government Association (LGA), the Improvement & Development Agency (I&DeA) and the Society of Local Authority Chief Executives (SOLACE), including signing up to the Nottingham Declaration.

- Encourage officers in relevant departments to pursue further climate change understanding through networks of professional bodies, local government officers, and the Local Government Association.

- Encourage sub-regional groupings of County, District and Unitary authorities to share best practice in both technical and managerial aspects of adaptation. It may be appropriate for a regional organisation such as the Regional Assembly to orchestrate this process.

- Undertake a more detailed exploration of the UKCIP02 scenarios and their implications for sub-regional locations. This might include the presentation of climate scenarios in ways that relate more directly to people's experience of the weather. The outcomes of such work can be disseminated by local authorities to the wider community.

- Explore the most effective policy framework within which adaptation responses might sit. In particular, investigate the suitability of Local Strategic Partnerships and Community Strategies as appropriate vehicles.

- Local plans need to take account of climate change impacts – for example in zoning areas suitable for particular purposes, and in policies designed to protect biodiversity.

- Consider the implications for their local communities of potential lifestyle changes resulting from climate change.

CHAPTER 13

PRIORITIES FOR FUTURE RESEARCH

Introduction

The following areas have been highlighted for further research:

Climate Science

Undertake further research in order to improve the quality of climate scenarios data.

1. Specifically with regard to extreme events and probability, and particularly with regard to coastal storms. It is recognised that this a difficult area for climate science but this is an aspect of the data that is important to many domains.

2. Make the data currently published on the UKCIP website available in a more user-friendly format for use at a sub-regional scale.

Both of the above may form part of both national and regional studies.

Natural Environment Domains

Vulnerable locations

Further monitoring and assessment is required of the impact of climate change on vulnerable locations within the region, such as Dartmoor, Isles of Scilly and the Somerset Levels.

Agriculture

Research into opportunities for new food and non-food crops, water management and diversification as climate change may result in the loss of the region's competitive advantage in a variety of locations and for a variety of crops.

Further research to produce an authoritative, comprehensive and detailed study on climate change and agriculture in the South West in order to identify key issues and recommendations.

Biodiversity

Investigate further the effects of climate change on habitats and species in the region, including:

1. contemporary monitoring;
2. computer modelling;
3. analysis of long-term biological records.

Coastal Issues

Monitor the erosion of coasts and beaches, and examine further the vulnerability of coastal defences.

Research into the movement of sand and shingle to ensure the maintenance of beaches.

Assess the risk of re-mobilisation of toxic substances in riverine/estuarine sediments.

Research within the coastal zone to assess the impact of climate change upon transport infrastructure eg rail network.

Forestry

Research the impacts of climate change for forestry and woodland ecosystems.

Marine Fisheries

Investigate the shifting geographic ranges of fish species based upon an understanding of thermal boundaries for fish species.

Maintain, develop and utilize existing databases (e.g. ERICA, operated out of the Cornwall Wildlife Trust) providing long-term data on marine fisheries.

Create a baseline mapping of stocks and species of marine fisheries presently found in the region.

Undertake continuous monitoring and the upkeep of databases to identify changes in fish species and stocks as well as to monitor temperature changes in the marine environment.

Rivers and Flooding

Research is still required into how aspects of water quality will change with global warming and for assessing the ecological impacts of those changes in rivers and other freshwater ecosystems.

Prepare detailed baseline information on the quality of rivers in the South West on which to base future predictions of climate change impacts, using available models.

Prepare accessible future-based information on the impacts of flooding and low-flow at a regional scale.

Investigate the impacts of climate change on other catchment processes such as soil erosion, sediment mobilisation and yield and land slipping.

Assess the risk of re-mobilisation of toxic substances in riverine and estuarine sediments.

Identify locations of drainage infrastructure which will be particularly vulnerable to flash flooding.

Develop further understanding of potential applications of Sustainable Urban Drainage Systems (SUDS).

Water Resources

Investigate further the potential changes in demand for quality and quantity of water.

Investigate the potential for more efficient use of piped water through the use of alternative sources of water, such as grey water, in domestic and other applications.

Society and Lifestyle Domains

General

Track possible lifestyle changes and their wider implications, especially for the socially excluded.

Built Environment

Undertake action research in the construction sector to develop sustainable design strategies (and products) to respond to the anticipated climatic conditions, particularly in response to increased summer temperatures.

Develop regional or sub-regional climate scenarios to be used for modelling, for example thermal performance as part of a decision making and design process, as in the BRE tools for determining insulation, glazing etc. Such work informing building design and construction at a sub-regional level can achieve a local distinctiveness.

Health

Investigate the thresholds for heat related deaths and illness, and the vulnerability of particular localities.

Investigate the role of temperature in food and water-borne disease transmission.

Investigate the uncertainties which currently exist on such matters as:

- How fast will people acclimatise to the warmer climate?
- How great is the risk of introduction of "new" diseases?
- How will adaptation measures in other sectors affect health, for example, increased use of insecticides in agriculture or home gardening?

Increase knowledge and understanding of the implications of climate change and appropriate changes in lifestyles to enhance good health.

The biggest challenge and easiest way to protect and improve the health of those living in the region is to increase awareness of issues and responses.

Many health risks relating to climate change will be avoidable if appropriate changes in behaviour are encouraged.

Heritage

Establish vulnerability of specific heritage landscapes and determine policy for defence or retreat, in conjunction with landlords and tenants.

Establish vulnerability of specific heritage buildings and determine policy for management, in conjunction with landlords and tenants.

Confirm anecdotal evidence that environmental stratigraphy may be disrupted as a consequence of increased seasonal waterlogging.

Housing

Investigate potential issues of fuel poverty related to the need for summer cooling, and link to current issues of fuel poverty for winter heating.

Undertake action research to develop appropriate strategies for responding to changing climate in each of the different modes of housing tenure (eg. private rented, social housing, owner-occupied).

Transport

Identify more accurately the specific locations within the region where transport infrastructure is vulnerable to flooding; landslips; tidal surges; etc.

Utilities

Undertake further research into the impacts of changing climate on each of the renewable energy technologies, as the greater use of renewable energy will both reduce greenhouse gas emissions and sustain economic growth. There are opportunities to build on existing regional strengths including wind, tidal, biomass and earth energy systems.

Undertake specific regional research into the impacts of changing climate on offshore renewable energy sources (eg wind, wave, tide) and reassess the environmental and economic effects of the Severn Barrage.

Business Domains

General

Research is required within all major sectors as although many impacts are generic (eg buildings) others are sector specific and require detailed understanding of the different goods, services, markets, processes, etc.

Continuous monitoring of key determinants of environmental quality is essential to monitor change in the region and encourage proactive industry responses.

Tourism

Further work is required, In conjunction with trade associations etc, to assess the impact of the climate on existing and future tourism provision, as tourism plays a significant role in the South West Region and much of its business is weather sensitive.

Specifically, identify the scope for extending the tourist season, and therefore enhancing the regional economy, as a response to predicted climate change in the region, and recommend appropriate courses of action for relevant agencies.

Local Authority Domains

Action research to assist local authorities to develop detailed adaptation responses across the wide range of activities for which they are responsible and which are vulnerable to climate change. Some of this work may be undertaken at a regional level, but it is probably more appropriate to work at a sub-regional scale, in clusters or partnerships of local authorities.

Investigate the ways in which traditional land-use planning will need to change to accommodate climate change and sustainability issues.

Action research to identify the appropriate strategic frameworks in which to nest adaptation strategies.

Action research to explore how climate change might be further incorporated into emergency planning systems.

Others

Further work at Regional, Sub-Regional and Local levels to encourage integrated planning in response to climate change adaptation.

Investigate the effectiveness and further potential of initiatives such as the Dorset Coastal Forum, Local Strategic Partnerships, Strategic Coastal Plans as appropriate partnerships and inter-agency co-operation in addressing cross-sectoral issues.

Investigate the most effective means of increasing awareness of climate change adaptation issues, both within organisations and amongst individuals across the region.

In particular seek to understand why it might be (as the Scoping Study suggests) that individuals do have some general understanding of climate change impacts and potential adaptation responses, but that this understanding is not applied within organisations.

CHAPTER 14

CONCLUSIONS

Introduction

In addition to the specific impacts that have been identified and the challenges and opportunities which they represent the following more general observations have been drawn from the study.

Awareness

Adaptation to climate change is not generally perceived to be important across the South West Region. The significance of potential changes in the climate is most apparent to those with responsibilities for and interests in the natural environment.

Natural scientists and academics dealing with ecology, geology, hydrology, flora and fauna etc especially those with responsibility for nature conservation and biodiversity are particularly concerned. Similar awareness and concern is expressed by those with responsibility for managing rivers, coasts and water resources. Generally this concern does not extend to the more commercial applications in the natural environment, particularly agriculture, where other pressures seem to predominate.

The public sector is aware of the issues surrounding climate change, but is not generally advanced in its thinking. Local government is generally subject to initiative overload, and diminishing units of resource. Climate change issues do feature, for example through the Nottingham Declaration, but the focus is mainly upon mitigation and sustainability issues, rather than adaptation.

The private sector is generally notable for its lack of concern, both with regard to potential threats and to potential opportunities. Some notable exceptions include the water industry and parts of the environmental technology sector.

Literature

The literature on climate change adaptation is generally addressed to national and international issues, rather than regional. There is very little literature on socio-economic issues, potential changes in lifestyle and impacts on the world of commerce and industry. The available literature is mainly focussed on physical impacts, and generally identifies problems rather than opportunities resulting from climate change.

Opportunities

The project Steering Group has been keen to identify opportunities as well as problems arising from climate change. This has revealed two different dilemmas in seeking to identify more positive implications.

The first dilemma concerns the idea of making commercial benefit from what might be seen as other people's misery. Some consultees have felt uneasy about exploiting business opportunities arising from, increased flooding or structural damage. Such unease is unfounded. These services will be much appreciated in the event of predicted impacts.

The second dilemma concerns the reluctance of policy makers to admit to any possible benefits arising from climate change. This assumes that people will be less inclined to commit themselves to reducing further climate change if there appear to be lots of benefits forthcoming. The study has assumed that the public is sufficiently sophisticated to appreciate both challenge and opportunity, and has presented its findings accordingly.

Regional Dimension

The South West Region is both extensive and diverse. This is reflected physically (coast, sea, moor and urban settlements), climatically (spatial variations in temperature, rainfall, and exposure to winds and storms), and economically (M4 corridor and Cornwall).

It will be appropriate for some adaptation strategies to be orchestrated at a regional scale. Other initiatives will be more appropriate at a sub-regional scale. Some local agencies, working in partnership (eg. Dorset Coastal Forum), are well advanced with their thinking and are well positioned to implement appropriate adaptation strategies in their localities.

Sustainability

Although the focus of this study has been on adaptation to climate change, it is essential also to consider the human activity which increases the rate of that change. There is a potential conflict between pursuing mitigation issues at the expense of adaptation concerns, or *vice-versa*. The study has revealed a greater awareness of mitigation, and a limited appreciation of the need to adapt. The sustainability agenda can only be achieved through engagement with both mitigation and adaptation. We can neither continue to accelerate climate change nor ignore its potential impacts.

The Way Forward

The Scoping Study provides only the start to an ongoing process of regional activity. The involvement of key stakeholders in the study, from private, public and voluntary sectors, has been crucial to its findings and recommendations. The continuing engagement of these and other stakeholders will ensure that both the challenges and opportunities presented by climate change are the subject of appropriate concern across the region.

ANNEX 1

GLOSSARY OF TERMS

adaptation	action taken by society in response to the potential impacts of predicted climate change.
adaptive capacity	the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
anthropogenic component	that part of the driving forces of climate change which is attributable to human activities.
baseline climate	the thirty-year period from 1961-1990 relating to either observed data or model simulated data which is used as the standard reference point from which future changes in climate are currently based.
climate	the average weather experienced in a region over a long period, (normally 30 years).
climate change	the continuous pattern of changes in climate, in response to a variety of natural and man-made causes.
climate change scenario	a coherent and internally-consistent description of the change in climate by a certain time in the future, using a specific modelling technique and under specific assumptions about the growth of greenhouse gas and other emissions and about other factors that may influence climate in the future.
greenhouse effect	the result of certain gases in the atmosphere (so-called greenhouse gases) absorbing energy that is radiated from the Earth's surface, and so warming the atmosphere.
Intergovernmental Panel on Climate Change (IPPC)	an international forum of experts brought together by the United Nations to undertake periodical assessments addressing how climate will change, what its impacts may be and how we can respond. It was originally formed in 1988 and published its Third Assessment Report (TAR) in 2001.
mitigation	activities which seek to reduce the human effects on global warming by reducing the quantity of greenhouse gases released to the atmosphere.
natural component	that part of the driving force of climate change which is attributable to natural activities.
precipitation	water falling in some form be it rain, snow, sleet or hail.
return period	the average time between climate events of a given magnitude. For example, in parts of Southern England, a rainfall total of 100mm in one day has a return period of 100 years. A 100-year return period is the equivalent of the event that has a 1% probability of occurring in any one year. Nevertheless, it should be remembered that this might occur in the current year!
sensitivity	the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli.
vulnerability	the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

ANNEX 2

METHODOLDOY FOR THE INVESTIGATION OF IMPACT DOMAINS

Introduction

The method adopted for assessing the potential impacts of climate change was to nominate a selection of impact domains as the subject of detailed study. This approach was based on the methods adopted in previous regional studies. This allows the particular operational, locational and managerial factors important to each domain to be assessed with regard to possible changes in the weather.

It is acknowledged that the broad headings, and the categories of individual domains themselves, are both overlapping and arbitrary. Inevitably there will be overlaps between domains, duplication of reporting and some omissions and misplaced emphasis. Nevertheless, they provide a relatively simple platform upon which the different studies can be built.

Types of Impact Domain

There are three different types of domain reported in the South West study. These are:

1. Individual Impact Domains
2. Local Authority Domains
3. Cross-sectoral Impact Domains

1. Individual Impact Domains

For the Southwest Scoping Study the approach has been to cluster the individual domains into three groups:

1. Natural Environment Domains;
2. Society and Infrastructure Domains;
3. Business Domains.

These areas of study have been based upon the experience of previous regional studies although the business sector has been given particular emphasis here. Some important sectors (for example education) have not been included simply because of limited project resource. Within the business domains a selective approach has been adopted again to work within resource constraints. Here the chosen domains were selected from the priority sectors within the SWRDA economic development strategy.

The table below lists the individual domains in their clusters. The clusters themselves are arbitrary but their use has made it easier for researchers and respondents to engage with what would have been twenty different domains.

Natural Environment Domains

agriculture and horticulture
bio-diversity, habitats, nature conservation
coastal
fisheries
forestry
rivers, fluvial flooding & drainage
water resources: supply, demand, quality

Society and Infrastructure Domains

built environment
heritage
health
housing
transport
utilities

Business Domains

advanced engineering
biotechnology
environmental technology
financial services
food and drink
ICT
leisure and tourism
marine engineering
telemarketing

Table A.1
Individual Impact Domains in their clusters

2. Local Authority Domains

Many of the adaptation strategies that are recommended for implementation across the region will depend on the planning, co-ordinating and enabling role of government at regional and local levels. So, Local Authorities have been identified as a distinct domain, to be studied in terms of their principal service functions, their role as corporate managers, and community leaders.

3. Cross-Sectoral Impact Domains

In addition to the individual impact domains three cross-sectoral domains have been studied in order to understand the complex interactions between the various domains in a particular locality. Although some interactions between domains are reported in individual domains it was agreed with the Steering Group that the study would benefit from specific investigations of cross-sectoral aspects. It was decided that these could be best explored through focussing on particular locations as the setting within which interactions might occur. Therefore three different types of locality were chosen, as follows:

1. Coastal Environments;
2. Urban Environments;
3. Rural Environments.

Following discussions with the Steering Group and representatives of each of the localities the following locations were chosen as case-study examples for each locality type:

1. Coastal Environments: The Dorset Coast;
2. Urban Environments: Bristol City;
3. Rural Environments: The Tamar Valley.

These offered suitable regional and spatial variety and also provided a single agency as a convenient point of contact.

Approach to Stakeholders and Individual Domains

At the heart of the Scoping Study was the need to identify the views of key stakeholders with regard to the potential impacts of Climate Change upon their domain. This was, therefore, the main feature of the research method. Enquiries were made of key stakeholders through questionnaire, personal and telephone interview, and follow-up discussions. Nevertheless, it was recognised that it would not be sensible to rely simply upon stakeholders' perceptions where there is strong evidence available from other sources. So, the methodology for studying the domains strikes a careful balance between the straightforward reportage of stakeholder views, and the additional perspectives available from published research, specialist knowledge, etc.

'Interviews'

The arrangements for stakeholder contact within individual impact domains have operated in three ways:

1. questionnaire
2. one–to-one interviews
3. follow up work

Questionnaires were distributed by e-mail to stakeholders and other contacts for each individual domain. The questionnaire was largely concerned with two sets of issues: 1. awareness and understanding, and 2. possible responses to climate scenarios. *(See Annex 5 for further details of Questionnaire.)*

The list of contacts was generated from a variety of sources of which the following were the most significant: delegates at previous climate change conferences in the Southwest; contacts known to subject experts; suggestions from members of the Steering Group; a stakeholder membership drawn from regional promotional events. Over 700 questionnaires were distributed, an average of between 35 and 40 for each domain.

The choice of e-mail distribution was chosen for reasons of efficiency, although it was recognised that this might exclude certain categories of respondents. Where possible these exclusions were addressed though personal contact.

Climate Scenarios

The world of climate change is overwhelmed with a plethora of different scenarios for different time periods, different interpretations of the anthropogenic effects, and different predictions on future emissions of greenhouse gases. The new UKCIP02 dataset, published in April 2002, provides the latest and the most reliable data for the UK. Scenarios are presented for the South West region on a grid of 50km squares, and are offered for the thirty-year periods around the 2020s, around the 2050s, and around the 2080s, at four different levels of greenhouse gas emissions.

Whilst this level of detail may be available, and of interest to specialists, it was judged to be potentially confusing to most respondents, certainly initially. Therefore, the questionnaire did not present these multiple scenarios as the basis for exploring respondents' understanding of adaptation issues.

Instead the questionnaire used data from the 2050s scenario for medium-high greenhouse gas emissions, but offered them as possible scenarios that might occur at an unspecified time, rather than as a firm prediction. So, questions were formulated as follows: 'How would the activities for which you are responsible be affected if the following climate conditions were to exist?'

This approach was extended to include concepts of 'challenge' and 'opportunity' to encourage respondents to think in both positive and negative terms.

Eight climatic variables were presented, including:

- summertime temperature;
- wintertime temperature;
- flooding;
- summertime precipitation;
- wintertime precipitation;
- sea levels and tides;
- growing season and frosts;
- winds and storms.

So for example, for summertime temperature the question was formulated as follows: 'How would the activities for which you are responsible be affected if the average summertime temperature were to be increased by 3^0C?' The description of this new climate was reinforced by the use of other descriptors (eg. the temperature that we have experienced in recent summers, and a location in Europe that experiences similar summertime temperatures).

It was anticipated that in the discussions with the more expert stakeholders, it would be appropriate to consider a wider range of scenarios, and their potential impacts. In practice this did not prove to be the case. With only a few exceptions (for example the water PLCs) the deliberations of

respondents were not dependent upon any more detailed knowledge of climate scenarios. A useful development for discussing impacts proved to be a simple characterisation of seasonal climate scenarios (for example warmer, wetter winters, and warmer, drier summers).

Responses

The response rate to the questionnaire (less than 5%) was disappointing, even though such surveys might normally be expected to yield no more than 10%. Three main reasons are suggested for this poor response:

1. general lack of priority attached to climate change adaptation;
2. apparent complexity of climate based questions; (see below)
3. non-allocation of responsibility for climate change adaptation to individuals within organisations.

One-to-one interviews were carried out with a short list of key stakeholders, which was identified for each domain. Typically this involved three or four individuals for each domain. This included: members of the project Steering Group; enthusiastic respondents to the questionnaire; members of the stakeholder group; subject specialists from Sustainability South West; sector development co-ordinators within the SWRDA, and appropriate academics and practitioners. Structured interviews were either face-to-face or by telephone as appropriate.

Follow-up work was undertaken to check the outcomes of questionnaires and interviews, and to deal with any obvious technical queries. The practice here varied considerably, so that for example there was considerable dialogue with respondents concerned with rivers and water resources, whereas very little follow-up work was undertaken in some of the business domains.

Reportage

The study of each Impact Domain was based upon a standard template, the main headings for which are outlined below:

- Data availability and gaps and uncertainties in current knowledge;
- Perceived significance of climate change impacts to stakeholders;
- Likely impact(s) of a range of climatic variables selected from UKCIP climate change scenario(s);
- 'Opportunities' and 'Challenges' presented by these impacts, and their potential significance;
- Adaptation responses currently being considered by stakeholders;

In practice it was not always possible to observe the full discipline of this template, mainly as a result of the interests, enthusiasms and approach of individual respondents. Nevertheless it was possible to investigate and report on most of these aspects for most of the impact domains.

Review

The study benefited considerably from a series of textual reviews. In addition to those undertaken by the research team there was extensive input from members of the Steering Group at Initial Draft and Final Draft stages. Further, Dr Richenda Connell (from the UKCIP team) and Pete Grigorey (from the South West office of the Environment Agency) provided a rigorous final review which was invaluable in correcting technical aspects of climate scenarios and impacts as well as textual editing. These contributions are much appreciated.

Critique of Method

Both the strengths and the weaknesses of the method outlined above arise from its dependence upon contributions from the wide range of stakeholders.

The strengths derive particularly from the contributions of stakeholders in exploring the levels of awareness and understanding within and between different domains. The contribution from the wide range of stakeholders has ensured that the real world of practice has been represented in the findings.

The weaknesses derive from the fact that, as the study reveals, in some domains there is only limited understanding of the climate scenarios and the implications of potential changes in the weather. Therefore, some of the responses, particularly those within the tables listing challenges and opportunities, may not stand up to rigorous examination. Whilst every effort has been made to filter out the least plausible impacts it is beyond the collective expertise of the research team to ensure that all of these suggestions are sound.

This is not a serious criticism for this type of study. A Scoping Study is not intended to be definitive or comprehensive. It is intended to be wide-ranging and exploratory. On balance therefore, it is judged to be better to include the perceptions of a wide variety of stakeholders, than to insist on absolute verities from a more restricted set of sources.

Overall the methodology has been effective in revealing different levels of awareness within the different domains, identifying what each domain considers to be its key issues, and reporting on the potential challenges and opportunities of climate change. These were the key objectives.

ANNEX 3

BIBLIOGRAPHY

A. Books, Journals, etc

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ABI	Review of the Impact of Variable and Changing Climate on UK Wind Claims Research Report no. 8	2001	ABI
Anon	Cool Space: Buildings and Thermal Comfort, and Reacting to Climate Change	2001	Architects Journal 213 (9) 42
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Causer, P and Williams, T (Eds)	Region in Figures: South West	2002	Office for National Statistics: HMSO
Centre for Ecology and Hydrology	Flood Estimation Handbook	1999	CEH
Chamberlain, DE and Fuller, RJ	Contrasting Patterns of Change in the Distribution and Abundance of Farmland Birds in Relation to Farming System in Lowland Britain	2001	Global Ecology and Biogeography, 10, 399-409
Chambers, FM and Ogle, M (Eds)	Climate Change: Critical Concepts in the Environment. Volume 1 'Global Warming': Carbon Dioxide and climate change	2002a	Routledge
Chambers, FM and Ogle, M (Eds)	Critical Concepts in the Environment. Volume 2. Natural forcing factors for climate change on timescales 10^{-1} to 10^{5} years	2002b	Routledge
Chambers, FM and Ogle, M (Eds)	Climate Change: Critical Concepts in the Environment. Volume 3. Natural climate change: proxy-climate data	2002c	Routledge
Chambers, FM and Ogle, M (Eds)	Climate Change: Critical Concepts in the Environment. Volume 4. Evaluating recent and future climate change	2002d	Routledge
Chartered Institute of Insurers (CII)	Research Report: Climate Change and Insurance	2001	CII
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DEFRA, I&DeA, LGA, and SOLACE	Community leadership and Climate Change: Guidance for Local Authorities	2001	DEFRA
DEFRA	Flood and Coastal Defence Project Appraisal Guidance	2000	MAFF, DEFRA
DEFRA	National Appraisal of Assets at Risk of Flooding and Coastal Erosion in England and Wales	2001	HMSO
DETR	Climate Change: Draft UK Programme	2000	DETR
DETR	Potential Adaptation Strategies for Climate Change	2000	HMSO
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Department of Health	Health Effects of Climate Change in the UK. An expert review for comment	2001	Department of Health
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Entec (UK) Ltd.	The Potential Impacts of Climate Change in the East Midlands	2000	East Midlands Sustainable Development Round Table
Environment Agency	The Implications of Climate Change for the Environment Agency	1999	Environment Agency
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FBE	Report 2 – Potential Implications of Climate Change in the Built Environment	2001	Foundation for the Built Environment

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WS Atkins	TVMMS Thames Valley Multi-Modal Study: Consultation Document	2002	WS Atkins Planning Consultants
Yates, TJS	Climatic Variability and Climate Change – Implications for Design and Construction	1998	Proceeding of the World Building Congress, Sweden 507-512
Zinyowera *et al*. (Eds)	The Regional Impacts of Climate Change: An Assessment of Vulnerability. A Special Report of the IPCC Working Group II	IPCC	1998

B. Website Addresses

The following is a selection of the vast amount of information available regarding climate change to be found on the internet. Several of these resources were used during the production of this study. Please note that while all links were correct as of January 2003, the authors cannot guarantee their long-term validity or the information contained thereon.

www.c-clif.co.uk/

www.chelt.ac.uk/cccf/

www.cla.org.uk/climatechange/

www.cru.uea.ac.uk/

www.cru.uea.ac.uk/link/

www.dft.gov.uk/itwp/paper/index.htm

www.dft.gov.uk/trans2010/plan/index.htm

www.eci.ox.ac.uk/monarch/

www.environment-agency.gov.uk/

www.europa.eu.int/comm/energy_transport/library/press-kit-lben.pdf

www.glos.ac.uk/

www.ipcc.ch/

www.oceannet.org/

www.phenology.org.uk/

www.southwestrda.org.uk/Downloads/development/raildoc.pdf

www.swarmms.org.uk/

www.swenvo.org.uk/

www.thamesvalleytransport.org.uk/index.htm

www.ukcip.org.uk/scenarios/

www.ukcip.org.uk/sectoral_pubs/sectoral.html

ANNEX 4

LIST OF RESPONDENTS

The following list contains the names of those organisations (and individuals where appropriate) who provided responses upon which the scoping study has been based. We have chosen not to identify the different departments of large organisations such as Local Authorities or the Environment Agency but where multiple responses have been received we have identified these as follows:

***** Denotes multiple responses received (separate individuals)
****** Denotes more than 5 responses received (separate individuals)

Our most sincere thanks go out to all these individuals and organisations, and also to those who wished to remain unrecorded, or who may have been inadvertently missed from this list, (to whom we extend our apologies). Without their input this project could not have been undertaken.

1 Arup Associates
2 Associated British Ports
3 Association of Electricity Producers
4 Bournemouth & West Hampshire Water Plc
5 Bristol City Council **
6 BTCV
7 Business in the Community
8 Camborne School of Mines, University of Exeter
9 Cheltenham Borough Council *
10 Confederation of British Industries
11 Cornwall College
12 Cornwall County Council **
13 Cornwall Farmers Ltd.
14 Cornwall Sea Fisheries Committee
15 Cotswold Water Park
16 Countryside and Community Research Unit, University of Gloucestershire *
17 CSMA Consultants Ltd. *****
18 Devon County Council ******
19 Devon Wildlife Trust
20 District Councils especially in the SW ******
21 Dorset Coastal Forum **
22 Dorset County Council
23 Eden Project Ltd
24 English Nature
25 Environment Agency ******
26 Exeter City Council
27 Exeter Enterprises Limited
28 Federation of Small Businesses
29 Fielden Clegg Bradley, Architects

30 First
31 Forest Enterprise
32 Forest Research
33 Forestry Commission
34 Gloucestershire County Council
35 Government Office for the South West (GOSW)
36 Hanover Housing Association
37 Highways Agency
38 Housing Corporation SW Region office
39 Independent Farmer/Landowner **
40 Independent Horticulturalist
42 Institute of Chartered Foresters
43 Institute of Grassland and Environmental Research (IGER)
44 London School of Tropical Medicine
45 Marine Biological Association (MBA)
46 Moog Controls
47 National Farmers Union (NFU)
48 National Grid Company Plc
49 National Trust *
50 NHS Medical Professional
41 Plymouth City Council
51 Plymouth Marine Laboratory
52 Radfords Hotel
53 Rail Passengers' Committee, Western England
54 Railtrack
55 Renewable Energy Office for Cornwall (REOC)
56 Royal Agricultural College, Cirencester
57 RSPB
58 Seale Hayne, University of Plymouth
59 Somerset Agricultural Advisory Service
60 Somerset Moors and Levels Partnership
61 Somerset Trust for Sustainable Development *
62 South West Regional Assembly (SWRA) **
63 South West Regional Development Agency (SWRDA)
64 South West Tourism **
65 South West Water (SWW) *
66 Stagecoach
67 Sustainability South West **
68 Sustrans
69 Tamar Valley Service
70 TCPA
71 The Queen's Harbour Master, Plymouth
72 Torbay Council

73	UK Climate Impacts Programme *
74	University of Exeter *****
75	University of Gloucestershire *****
76	University of Plymouth *****
77	Vent-Axia
78	Wessex Water *
79	Western Power Distribution
80	Wing of St. Mawes

ANNEX 5

QUESTIONNAIRE

This Annex contains an example of the questionnaire which was distributed (mainly electronically) to key actors in each of the Impact Doma
text of the covering message.

South West Region Climate Change Impacts Partnership (SWRCCIP)

Agriculture and Horticulture Impact Domain

The attached questionnaire is intended to identify the way that **potential changes in the climate will act upon your business, organisation or sector**. The survey forms part of a study which constitutes the South West Region's contribution to the United Kingdom Climate Impacts Programme (UKCIP). For more details go to www.ukcip.org.uk. The study will ultimately influence regional and national policy and form the base for future studies and policy developments. It will be a major contribution to the study if you could assist by spending a few minutes answering a few questions.

We have identified a series of 'scenarios' for different aspects of the weather (such as summertime temperature, flooding etc). The questionnaire invites you to consider how the impacts of these **different scenarios can provide both threats and opportunities for your organisation and its activities.**

The scenarios themselves are relatively straightforward but it may take a while to consider how these might impact upon your business. It might help to start by thinking about how the impacts will affect your personal life, and the sort of changes that these might prompt. For example: **an increase of summertime temperature is suggested.**

One challenge that this represents might be that our houses become uncomfortably hot, both in the daytime and at night. **An adaptation response** might be to install some form of cooling or air-conditioning. **One opportunity** might be that the summer evenings become more attractive for eating *al fresco*. **An adaptation response** might be to extend the patio, install some decking and not watch any more of Allan Titchmarch!!

The questionnaire has been designed to be completed as easily as possible. You can complete it either electronically and return it by e-mail (cccf@glos.ac.uk) or complete it as paper copy and return by post (to the Freepost address below). The first two pages deal with information about your organisation, your role within it, and the extent to which you are already aware of 'adaptation' to climate change. The following sections deal in turn with each of the different scenarios.

We have found that **it is important to wear your sectoral hat in answering the questions**. For example, flooding arising from increased rainfall may be regarded as a problem for most of us, but for those in the business of flood defences, pumps, and sustainable urban drainage it may represent a commercial opportunity. These are the sort of issues that the questionnaire is intended to reveal.

On a technical note: 1. the boxes provided for you to insert your responses will enlarge automatically as you type. 2. for those that wish to complete the form on paper you may wish to expand these boxes before you print, or use the reverse side of the sheet for extra information.

Finally, we are keen to identify individuals or organisations who are particularly interested in, or concerned about, adaptation to climate change. If you do wish to be further involved please make contact with the research team. There is a box for this on the form.

Many thanks for spending time on the questionnaire.

Gerry Metcalf, Research Project Manager

SW Climate Change Impacts
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Francis Close Hall
CHELTENHAM
Glos, GL50 4ZZ

E cccf@glos.ac.uk)
T 01242 543389
F 01242 543283

A Information about you and your organisation

1	name	
2	job title	
3	name of company/organisation	
4	postal address	
5	postcode	
6	e-mail address	
7	telephone	
8	the main activities of your business, your organisation or the sector within which you work	
9	your main role or responsibilities within the organisation	

B Your understanding of 'adaptation' to climate change

1 **Were you aware of the concept of 'adaptation' to climate change before receiving this questionnaire?**

'adaptation' means responding to the impacts of climate change already in the system
'mitigation' means reducing greenhouse gas emissions, etc in order to limit climate change.

Please state 'yes' or 'no'

B continued

2 **If you were aware of the concept of adaptation, please indicate the source(s) through which you have gained most understanding of the concept.**

general media	
government information *(please specify where source is known)*	
national bodies/trade associations *(please specify where source is known)*	
specialist publications *(please specify where source is known)*	
headquarters of company/group etc	
seminars/conferences etc	
Others *(please specify)*	

C your organisation's strategic response to climate change

1 **Are you aware of policies in your organisation which address climate change issues ?**

Please state 'yes' or 'no'	

2 **If so, do these policies refer to 'adaptation' strategies as well as 'mitigation' strategies?**
'adaptation' means responding to the impacts of climate change already in the system
'mitigation' means reducing greenhouse gas emissions, etc to reduce climate change.

Please state 'yes' or 'no'	

3 **If so, please indicate the broad purpose and content of these policies**

Please proceed to questions on climate change scenarios.

theme 1 summertime temperature

Below is a possible future climate scenario. This shows possible changes from the average climate at the end of the 20th Century (the thirty year period 1961 to 1990).
Please indicate the challenges and opportunities that this presents to your organisation.

new climate scenario is 2°C above the recent average

1 this new climate scenario will be similar to that experienced in the summer of 1997
2 similar conditions currently exist in West Central France.
3 the average summertime temperature (1961-1990) in the SW was about 15°C

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *Please specify the degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change.
Please specify the degree of risk.

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

theme 2 wintertime temperature

Below is a possible future climate scenario. This shows possible changes from the average climate at the end of the 20th Century (the thirty year period 1961 to 1990).
Please indicate the challenges and opportunities that this presents to your organisation.

new climate scenario is 2.0°C above the recent average

1 this new climate scenario will be similar to that experienced in the winter of 1998
2 similar conditions currently exist in North East Spain
3 the average wintertime temperature (1961-1990) in the SW was about 4.5°C

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *Please specify degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change
Please specify the degree of risk.

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

theme 3 summertime precipitation

Below is a possible future climate scenario. This shows possible changes from the average climate at the end of the 20th Century (the thirty year period 1961 to 1990).
Please indicate the challenges and opportunities that this presents to your organisation.

new climate scenario is 15% below recent average (down to 165mm)

1 this new climate scenario will be similar to that experienced in the summer of 1995
2 similar conditions currently exist in West France
3 the average summertime precipitation (1961-1990) in the SW was about 200mm

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *Please specify the degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change
Please specify the degree of risk.

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

theme 4 wintertime precipitation

Note: Issues relating to flooding are dealt with in theme 6

Below is a possible future climate scenario. This shows possible changes from the average climate at the end of the 20th Century (the thirty year period 1961 to 1990).
Please indicate the challenges and opportunities that this presents to your organisation.

new climate scenario is 15% above recent average (up to 350mm)

1 this new climate scenario will be similar to that experienced in the winter of 1995
2 similar conditions currently exist in West Portugal
3 the average wintertime precipitation (1961-1990) in the SW was about 300mm

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *Please specify the degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change
Please specify the degree of risk.

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

theme 5 sea levels and tides

This theme (or climate variable) is more likely to apply only to certain activities or locations.
Please indicate if indicate if you think this theme is relevant to your activities or location.

Please state 'yes' or 'no'	

new climate scenario anticipates a 35cm rise in sea level

1 this new climate scenario is a result of both climate change and land mass movements
2 scenario anticipates that a tide level now occuring once every 100 years will occur once every 10 years

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *Please specify the degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change. *Please specify the degree of risk.*

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

theme 6 flooding

We have identified three different types of flooding which might arise from climate change.
1. River Flooding 2. Standing Water and Slope Flooding 3. Drainage System Overload
Please indicate if you think this theme is relevant to your activities or location.

Please indicate the types of flooding to which you think your activities are exposed.	1. 2. 3.

Even if your activities are not directly exposed to flooding there may still be challenges or opportunities arising *So, please complete the following sections.*

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *lease specify the degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change. *Please specify the degree of risk.*

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

theme 7 growing season and frosts

We have identified two broad changes which might arise from climate change impacts which could affect crops and other horticultural activities.

1. **the number of frosts during winter months will reduce by 60%**
2. **the growing season will extend by between 5 and 20 days**

If your activities are relevant to, or affected by these climatic changes please complete the following sections.

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *Please specify the degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change. *Please specify the degree of risk.*

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

theme 8 winds and storms

This theme (or climate variable) is difficult to characterise, and in most cases the future scenarios do not show significant changes in storminess and windiness, except perhaps in the autumn months. Nevertheless, the prospect of increases in 'intensity' or 'frequency' represent a serious threat to certain activities or locations. **Please indicate if you think this theme is relevant to your activities/location**.

Please state 'yes' or 'no' for increased **intensity**	
Please state 'yes' or 'no' for increased **frequency**	

ADAPTATION CHALLENGES

Given the scenario outlined above, please record the main way in which any part of your organisation's operations would be vulnerable to this climatic change. *Please specify the degree of risk.*

	High Risk	
	Med Risk	
	Low Risk	

Please indicate ways in which your organisation might adapt to this challenge.
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

ADAPTATION OPPORTUNITIES

Given the scenario outlined above, please record any new or increased opportunities for your organisation's operations arising from this climatic change. *Please specify the degree of risk.*

	High Probability	
	Med Probability	
	Low Probability	

Please indicate ways in which your organisation might adapt to these opportunities
Please specify the timescale over which you will need to make these responses, or the lead-time necessary to implement actions.

	Short Term	
	Med Term	
	Long Term	

E Other information about your organisation's strategic response to climate change

We are interested to include in our report particular examples of good practice concerning adaptation to climate change.

We are also interested to include 'soundbites', anecdotes or examples of adaptation issues that are of particular relevance to your sector, or to the region, or both.

So, please can you use the spaces below to record any such examples of interest to the project.

We are also interested to include in our report particular examples of good practice concerning mitigation of climate change.

So, please can you use the space below to record any such examples of interest to the project.

Please indicate in the box below if you are willing to be contacted further in the project, and aspects of the study that are of particular interest to you and your organisation.

Many thanks for your assistance in completing the questionnaire

This report was commissioned by the South West Climate Change Impacts Partnership. It is a stakeholder-led Scoping Study carried out on behalf of the Partnership.

This study is one of a number linked to the UK Climate Impacts Programme which helps organisations assess how they might be affected by climate change so they can prepare for its impacts.

The South West Climate Change Impacts Scoping Study was carried out by:

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Camborne School Of Mines
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Atkins, Countryside Agency, Environment Agency, Met Office, South West Regional Assembly, South West Regional Development Agency, South West Water, Wessex Water

Further Information:

Further copies of 'Warming to the idea', the SW Region Climate Change Impact Scoping Study and it's Summary Report can be found at www.oursouthwest.com/climate and at www.ukcip.org.uk/south_west/south_west.html

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The Steering Group for the study included representatives of:

Association of Electricity Producers, Bristol City Council, Business in the Community, Confederation of British Industries, Devon Wildlife Trust, Environment Agency, Federation of Small Businesses, Government Office for the South West, National Farmers Union, National Trust, South West Regional Assembly, Royal Agricultural College, South West Regional Development Agency, South West Tourism, Sustainability South West, Wessex Water, UK Climate Impacts Programme

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