



Worcestershire Climate Change Impact Study



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Summary Report

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Introduction

Worcestershire is located in the heart of England and is home to spectacular topographical features such as the Malvern Hills, one of Britain's most picturesque geological features. The County is exceptionally rich ecologically, encompassing the southern limit of many northern plant and animal species, and the northern limit of species found in the south. Worcestershire also has a varying economic character; the service sector is the largest employer, there is a large manufacturing base in part serving the South Birmingham Motor Industry, and Tourism is a major industry for the County.

This study was commissioned by the Worcestershire Partnership to investigate the impacts of climate change on Worcestershire as part of the development of a Climate Change Strategy for the County. Using a baseline climate for the County as 1961-1990 average, this study investigates what the future may hold for Worcestershire in terms of change in its climate and the consequences of this. Using data developed by the UK Meteorological Office Hadley Centre for Climate Prediction and the Tyndall Centre for Climate Change Research, and provided through the UK Climate Impacts Programme, this study investigates predicted changes in Worcestershire for three thirty-year periods centred on the 2020s, 2050s and 2080s under two different global emissions scenarios.

Worcestershire's Baseline Climate

The current baseline climate (1961-1990) in Worcestershire is as follows:

- | | |
|----------------------------|-----------------|
| • Annual mean temperature | 9.5°C |
| • Mean maximum temperature | 13.4°C |
| • Mean minimum temperature | 4.9°C |
| • Mean annual rainfall | 669 mm |
| • Mean number of snow days | 17 days |
| • Average cloud amount | 70% (5-6 octas) |
| • Mean daily wind speed | 8.5 knots |

Climate change is already occurring

The climate has changed significantly in the UK and in Worcestershire in the last century, compared to the average baseline climate (1961-1990 average).

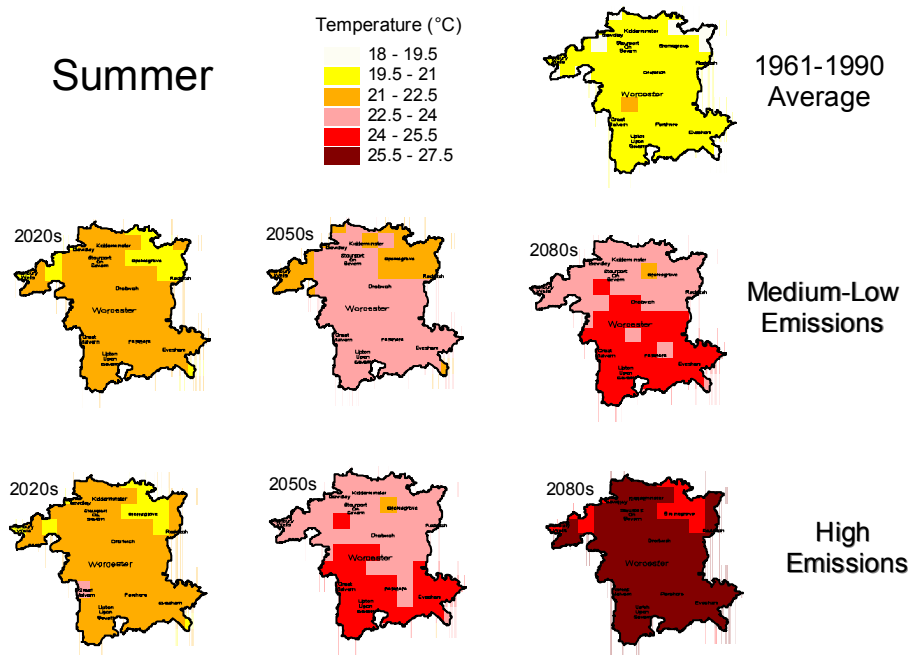
- Air temperature
 - Annual temperature has risen by 0.6°C since the 1900s
 - The 1990s was the warmest decade since records began in the 1660s
 - Growing season has increased by 30 days since the 1900s
- Rainfall
 - Winters have become much wetter relative to summers
 - Increased intensity of rainfall events
- Snowfall
 - Fewer snowfall events and smaller snowfalls
- Wind speed
 - Record wind speeds in 1987 and 1990
 - A cluster of severe gales in the 1990s but no long-term trend

Climate Change – What does this mean for Worcestershire?

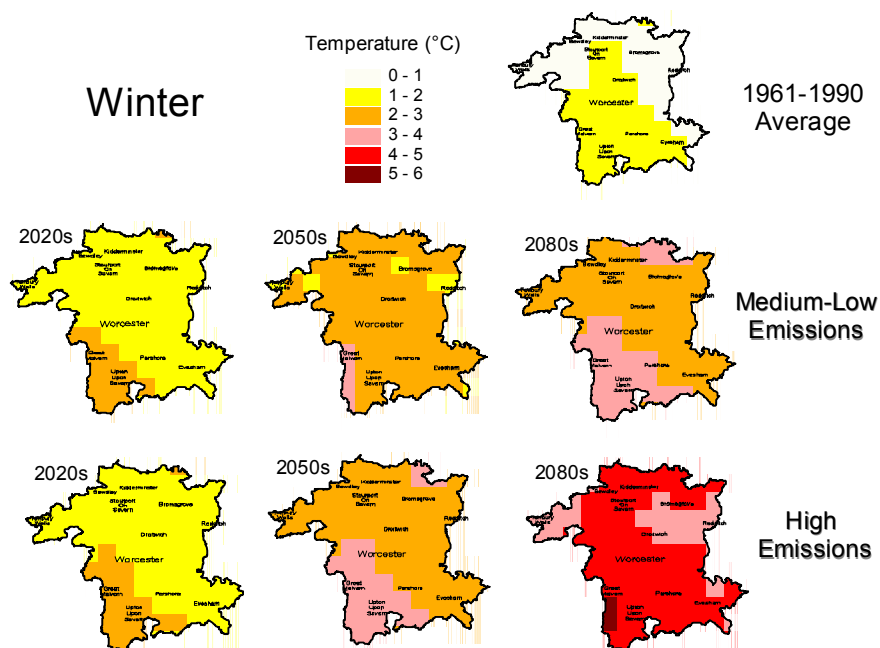
In Worcestershire, the following changes to the climate are expected:

Air temperature

The average summer maximum temperature is expected to increase between 3.6-6.1°C by the 2080s, depending on the emissions scenario. The average winter minimum temperature is predicted to increase by between 2-5°C by the 2080s. This may present benefits to agriculture, such as fewer frost days and a longer growing season, but may create also problems, especially limiting bud burst in trees.



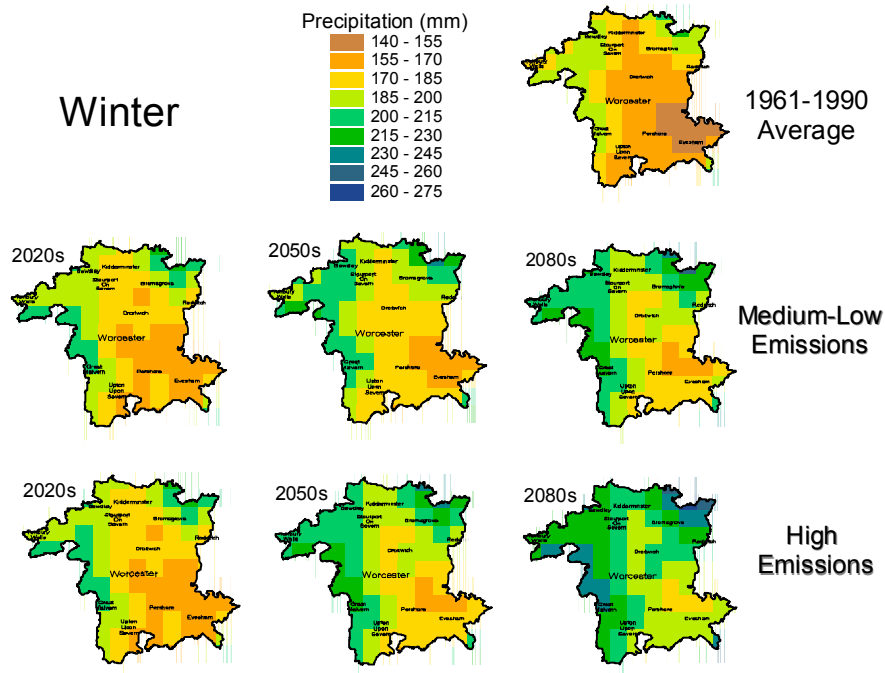
Summer Maximum Temperature (June – August)



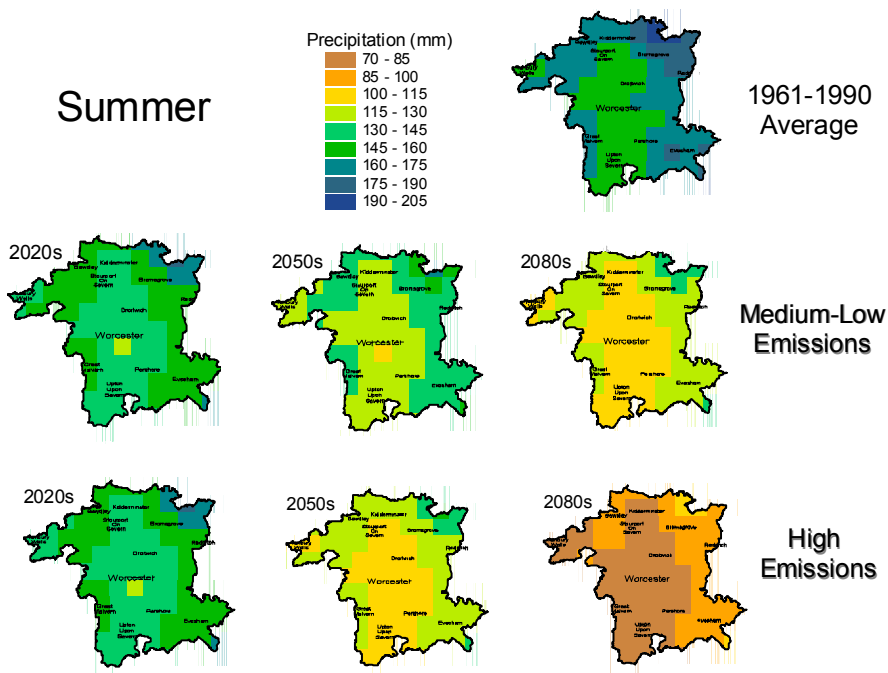
Winter Minimum Temperature (December – February)

Precipitation

By the 2080s, reductions in average annual precipitation are between 7%-14%, depending on the emissions scenario. This represents an annual reduction of up to 100mm, or 1½ months of rainfall in Worcestershire. Seasonal rainfall changes are more severe. Winter precipitation may increase 13% to 23% by the 2080s. An increase in winter precipitation of 23% is approximately equivalent to an extra ⅓ of a months rain falling during winter (Dec-Feb). Summer rainfall may see a more drastic decrease of up to 29% to 50% depending on emissions scenario.



Predicted average winter precipitation (December – February)



Predicted average summer precipitation (June – August)

Other predicted changes in Worcestershire's Climate

- Cloud – cloud amounts are predicted to decline overall annually. Summer cloud cover may decrease by up to 15% by the 2080s. This is likely to mean longer hours of sunshine and therefore increased risk of heat stroke and sunburn for humans, plants and animals.
- Wind speed – there is lower confidence in predictions of wind speed, however, winter mean wind speed may increase by between 4% to 6%, which could mean greater damage to buildings and infrastructure.
- Relative humidity – predicted increases in summer temperature mean a possible decrease in relative humidity of 6% to 12% by the 2080s. This may mean a reduction in the amount of fogs.
- Soil Moisture – Soil moisture is predicted to decrease by between 12% to 23% annually, and even greater reductions are expected in the summer. A warmer and drier Worcestershire in summer will cause the soil moisture to decrease by 22% to 42% by the 2080s. This is likely to mean increased problems of subsidence.

The frequency of extreme weather will increase

High summer temperatures are expected to become more frequent and very cold winters will become increasingly rare. Extremes of climate are expected to be experienced much more frequently. A very hot August, such as experienced in 1995 with an average temperature 3.4°C above normal, may occur as often as 1 year in 5 by the 2050s, and 3 years in 5 by the 2080s. Virtually every summer by the 2080s will be warmer and drier than the summer of 2001. Extreme winter rainfall will become more frequent. Very wet winters like 1994/5 (67% wetter than average) may occur almost once a decade by the 2080s (Hulme *et al.*, 2002).

Climate Change Analogues for England and Wales

Climate	Anomaly	2020s	2050s	2080s
A hot '1995-type' August	3.4°C warmer	1	20	63
A warm '1999-type' year	1.2°C warmer	28	73	100
A dry '1995-type' summer	37% drier	10	29	50
A wet '1994/5-type' winter	67% wetter	1	3	7

Source: Hulme *et al.* (2002). Medium-High emissions scenario.

Recent climate and weather extremes have resulted in the following costs, which may become even greater in the future unless measures to adapt to the future climate are achieved now.

- Flooding in Autumn 2000 caused an estimated damage to agriculture of £6.7 million in the West Midlands (estimate based solely on potatoes and wheat).
- £70.1 million in property damages in the West Midlands were caused by the flooding in 2000. Two of the four locations with over 100 properties flooded were in Worcestershire – 140 properties in Bewdley and 505 in Stourport.
- The cost of the flooding in 2000 on transport as a result of road closures and flood damage to major roads was estimated to be £19.7 million in the West Midlands. This does not include railway disruption (Entec, 2003).
- 2000 excess deaths in the UK resulted from the hot summer of 2003.
- Subsidence claims in 2003 were an estimated £400 million in the UK (ABI, 2004).

Impacts of Climate Change in Worcestershire

Due to the long memory of the climate system and inertia in our energy systems, the human contribution to climate change will become increasingly important relative to natural climate variability in the next century, and efforts to reduce emissions will only slow the rate of future warming. It is therefore important to identify the impacts that may be presented due to climate change in order to prepare for necessary adaptation.

This study has selected areas of the four sectors considered most vulnerable to climate change, identified as the built environment, industry and commerce, public services and natural environment, and considered the impacts that predicted climate change could have on them. It makes recommendations for adaptive action needed and poses key questions for those in each sector to consider, enabling them to decide whether and what kind of action they need to take.

The key potential climate change impacts on these sectors are summarised in the following sections.

Built Environment

The main climate change impacts on the built environment were identified as:

- Overheating in buildings – 63% of Worcestershire's housing stock is pre-1980s, much of which will be vulnerable to changes in structural and environmental forces due to climate change. As natural ventilation will not provide sufficient comfort, there is likely to be an increased demand for air conditioning, leading to an increase in energy use and CO₂. Alternative cooling methods such as night cooling should be used to decrease the demand for air conditioning.
- Wind damage – increases in average wind speeds will cause greater damage to buildings, and will also affect the safety of temporary building structures and cranes. Old buildings tend to have been built with lower wind design standards and therefore are at most risk from wind damage.
- Subsidence caused by drought – buildings on clay soils are particularly at risk from subsidence damage, and include areas in eastern Worcestershire, especially Evesham and Pershore.
- Flooding – 5,800 properties in Worcestershire lie in the indicative floodplain and are likely to be at risk from the predicted increases in incidences of flooding and a lengthening of the flood season. Flash flooding is also an increasing problem and is much more difficult to anticipate where it will occur.

Industry and Commerce

The climate change impacts on industry and commerce were sector specific, but main impacts were identified as:

- Energy benefits – due to warmer winters, it is likely that there will be less energy usage in winter (but this may be offset by increased costs of air-conditioning in summer).
- Markets may change in response to climate change and associated changes in consumer behaviour e.g. textiles, building design, health, and pharmaceuticals. This could mean positive or negative affects.

- Difficult working conditions for employees and customers due to higher summer temperatures. Air conditioning and cooling systems will be required in more factories, offices and retail facilities.
- Industry and business premises and operations will be affected by increased flooding and flash flooding problems, which will disrupt transport and distribution. Many areas of Worcestershire such as Worcester City and Bewdley are particularly sensitive to flooding due to the main routes crossing the River being flooded in low frequency events e.g. 1 in 2 year floods (e.g. Hylton Road).
- Discouraging businesses from setting up within flood risk areas, particularly in market towns such as Bewdley (there is evidence of this already).

Additionally, the following impacts were identified for the tourism and insurance industries:

Tourism

- Growth in more active leisure pursuits and activity holidays – Worcestershire needs to encourage growth in infrastructure in these areas, for example, working with the agricultural sector.
- Steady increases in boating holidays – Worcestershire is currently promoting waterways and marinas, including promoting boat tourism in the Droitwich Ring and could benefit from this trend.
- Increased interest in culture and the arts – this will also benefit Worcestershire, with clear links to the arts through Edward Elgar.
- Growth in environmentally sustainable tourism activities, such as walking and cycling, and a move away from car visits to access by public transport – tourism needs to be considered in the Local Transport Plan to ensure walking and cycling increases are not accompanied by increasing road accidents, and that more attractions can be accessed by public transport, particularly better services to rural locations and market towns.
- Increase in holidays to rural locations to escape cities – market towns could benefit from this expected trend, but rural hotspots such as the Malvern Hills could face environmental capacity problems.
- Reduced attractiveness of Mediterranean locations due to extreme summer temperatures and an increase in pests and diseases, causing more domestic holidays to be taken – Worcestershire will not benefit from this expected trend as much as coastal resorts.
- Greater demand and further increase in outdoor café society – this could create conflicts with licensing laws as Worcestershire's towns and cities are alcohol free zones.

Insurance

- Increase in weather-related claims due to increasing incidences of:
 - Storms – increasing mean wind speeds and extreme storms are possible.
 - Subsidence – increasing claims due to trees and tree roots have been received by Worcestershire County Council Insurance Services, but the total impacts of the hot 2003 summer on the county are not yet known.
 - River flooding – recent floods in 1998, 2000 and 2002 cost a considerable amount of damage across Worcestershire.
 - Flash flooding – incidences are increasing and it is very difficult to anticipate where problems will occur across the County.

Public Services

The main climate change impacts on public services were identified in sectors, as follows:

Health Services

- Rising air pollution – a current concern in Worcestershire and across the country. There are 5 air quality management sites in the County.
- Increases in flood frequency and the length of the flood season – Worcestershire already experiences frequent severe flooding. Flooding causes adverse health effects such as diarrhoea, as well as trauma, depression and shock. Sandbags are necessary not just for keeping out floodwaters, but also for holding back silt and sewage. Emergency planning is needed to guide support not only for River flooding, but also flash flooding, which is an area with limited resources at present.
- Increases in food poisoning cases - predicted hotter temperatures in summer are likely to cause the already increasing number of cases to rise considerably. Warmer weather may also encourage more outdoor eating, particularly barbecues, which could further increase risk of food poisoning. Worcestershire's district councils' role in education is becoming increasingly important, and this may help to reduce future food poisoning cases.
- Increases in pests due to warmer weather. There are increasing problems with pests such as cockroaches, rats and termites, particularly in winter.

Transport

- Potential for cheaper road construction materials (as larger chippings may be used) and quicker resurfacing and maintenance.
- Increased walking and cycling for leisure and work benefiting health and reducing travel by car.



Warmer temperatures may increase walking and cycling for leisure and work

- Potential cost saving in winter road maintenance for road and rail sectors, fewer accidents and delays due to ice and snow.
- Increasing costs of repair of existing roads, especially in summer and due to flash flooding.
- Increased incidences of melting roads and flooding roads causing accidents, delays and requiring increased maintenance.
- Increased numbers of leisure journeys made by car. This will benefit tourism e.g. scenic routes around Worcestershire.
- Increased accidents due to reduced driver concentration in hot weather. This needs to be addressed through road safety campaigns.



Flooding on Hylton Road in Worcester, 2004

Drainage and Sewerage Systems

- Health risks from more concentrated sewerage due to predicted decreases in summer rainfall.
- Predicted increases in short intense periods of rainfall inundating drainage and sewer systems, causing flash flooding. Sustainable urban drainage systems can help to hold back storm water.

Emergency Planning

- Increased incidences of heavy rainfall causing flooding – emergency planning will need more support to set up flood groups across the County.
- Fewer severe weather warnings for ice and heavy snow.
- Greater incidences of very hot temperatures may need links to be developed between the emergency plans and the National Heat-Health Watch developed by the UK Meteorological Office and Department of Health.

Natural Environment

The main climate change impacts on the natural environment were identified as:

Biodiversity

- Changes in the natural distribution limits for species or communities. Worcestershire is very important for biodiversity as it contains the northern limit for many warmth-loving species and the southern limit for many cold-adapted species. Climate change will shift these boundaries, and it is important that adequate habitats and corridors exist to enable movement.
- Higher wind speeds may cause increased damage to trees and woodlands.
- Drought may cause wetlands to dry out, causing lower species diversity. The restoration projects for wetlands at Longdon Marsh and Gwen Finch Reserve in Worcestershire will need to consider these impacts.
- Increased risk of outdoor fires will also impact on plants and animals in Worcestershire. Areas of minimal or rough grazing, enabling gorse, bracken and heather to establish are the most vulnerable, including the Wyre Forest, Lickey and Clent Hills, Kempsey, Malvern Hills and Hartlebury Common.

Increases in outdoor fires are likely



- Increase in the growing season may benefit growth of plants and food availability for animals, but these changes may have negative impacts on wildlife, for example change from Spring to Winter sown cereals impacts on bird life.
- More winter rainfall and greater precipitation intensity will increase the incidences of flooding. Flooding can benefit some species, but can also destroy habitats.

Agriculture

- Higher summer temperatures and lower cloud cover mean that greater heat stress to livestock is likely, which is linked with problems such as; a reduction in dairy cow and pig fertility, loss in milk yields and quality, and lower egg production. Changes in demand for salads and fruits could benefit the horticultural industry strongly established in the Vale of Evesham.
- Higher wind speeds may cause increased damage to crops.
- Increased winter rainfall and rainfall intensity is likely to mean more flooding, which will have significant effects on agriculture. The flooding in 2000 cost an estimated damage to agriculture of £6.7 million in the West Midlands (Entec, 2003).
- Reduced summer rainfall may mean that more irrigation is needed. An increase in irrigation of 23% is estimated for the West Midlands by the 2050s (Downing *et al.*, 2002). Greater water efficiency and on-farm water storage are needed.
- A longer growing season may mean more crops can be grown a year, e.g. strawberries. There may also be an opportunity for different crops to be grown. Worcestershire is the warmest and sunniest county in the West Midlands and crops such as lavender, lupins, sunflowers, hemp and mint may become more widespread.



Increased winter rainfall will cause more flooding



Opportunities for growing new crops may arise from warmer temperatures and a longer growing season

- Warmer winters and fewer frosts may mean that crops are more susceptible to radiation frost and could also mean that winter chilling requirements are not met, which can adversely affect crop yield. Pests and diseases may increase, as they will not be limited by freezing temperatures.

Public Open Spaces

- Higher summer temperatures and more hours of sunshine are likely to increase demand for outdoor leisure and recreation, which may also bring opportunities for developing Worcestershire's leisure and tourism sectors. Provision of urban open space will become particularly important with the current trend to increase density of urban development.
- Lower summer rainfall and higher temperatures may need consideration in design and management of public open spaces in the County, particularly regarding planting of suitable drought-tolerant species, water features, shading and grass-cutting operations.



***Public open space will be in greater demand,
such as at Quayhead in Worcester***

Water Resources

- Severn Trent Water have identified a probable need for a new reservoir somewhere in the Lower Severn Catchment area (which includes Worcestershire).
- Expected increased irrigation need for agriculture due to drier summers has caused the Severn Corridor Catchment Management Abstraction Strategy (CAMS) to time limit all abstraction licenses to March 2010.



***A new reservoir may be needed
in the Lower Severn Catchment***

The need to raise awareness of climate change across Worcestershire

A number of meetings and interviews were organised with individuals and organisations in Worcestershire and the West Midlands to discuss predicted changes in climate and impacts on the different sectors identified by the Worcestershire Climate Change Group Partners. The meetings enabled key impacts to be identified in each sector as well as highlight the main concerns in these sectors. These meetings also acted as an awareness raising and education exercise. General observations from the meetings indicated that:

- Most individuals were aware of the general predicted climate changes in the UK, especially a predicted warming and higher summer temperatures
- However, due to the recent media focus on the cooling impacts of the shut-down of the Gulf Stream, some individuals were not convinced that an overall warming would occur in the UK
- Most individuals were unaware of the work being done by the UK Climate Impacts Programme (UKCIP) and the recent West Midlands Climate Change Impact Study
- Most individuals had not thought about how climate change would impact on their sector, but could quite easily identify possible impacts when prompted
- Few individuals held or analysed data on impacts of weather on their sector or budgets, but most said that they had not yet seen increased costs due to a changing UK climate
- Large organisations such as Severn Trent Water, Environment Agency and Forestry Commission were most informed of impacts of climate change, as their strategies and plans are for long time-scales e.g. water demand management.

Key questions to ask yourself

Are climate change impacts important to me?

It is likely they are if:

- your business or sector is currently affected – either directly or indirectly by weather or climate
- you make decisions with long-term consequences (decades or longer) for land-use, built assets or population groups
- you are responsible for infrastructure and business areas that are sensitive to *changes* in climate
- you are responsible for contingency planning
- you want to gain an ‘early-mover’ advantage on a climate change business opportunity, before your competitors.

What type of weather affects your sector or business?

Which climatic changes will affect you most?

- wind storms and more frequent storms
- inland flooding
- subsidence
- drought
- flash flooding from short sharp inundations.

What do you need to know about the impacts of climate change on your sector or business?

What information do you need to start planning for, and adapting to climate change?

Questions from UKCIP (2004).

Policy Recommendations

A number of recommendations were made for each of the four sectors identified as the most vulnerable to the changes in climate predicted for Worcestershire. These are summarised below.

Built Environment

Climate impacts are important to the building and construction sector because the built environment, including buildings, roads, drains and utilities is usually designed for the long-term – 50 to 60 years or longer. An understanding of the impacts of climate change on this sector is therefore essential, as structures designed now will need to cope with the climate of the 2060s at least. Much work is already ongoing to adapt to become more sustainable, and these measures will aid adaptation to impacts of climate change. The main recommendations are therefore concerned with ensuring that the planning system takes climate change into account and ensuring development is built to withstand the likely impacts of climate change. This could be achieved by measures such as using a climate change risk assessment for building projects in the County.

Industry and Commerce

It is essential for businesses in Worcestershire to realise the climate changes that are likely to occur in order to assess their vulnerability to impacts and if necessary start planning for adaptation in the future. Businesses in the UK lose thousands of pounds a year due to the weather, and these businesses are most likely to be sensitive to climate change. Simple measures such as location may be an essential decision when starting or expanding a business and may to a more or less extent be affected by climate in the future, such as locating in a flood plain or choosing a building with air conditioning. The main recommendations are therefore concerned with encouraging businesses to assess their sensitivity to climate change, and to factor in climate change when undertaking risk assessments. This could involve using tools developed by the UK Climate Impacts Program such as the risk, uncertainty and decision-making tool. Further study is needed to identify businesses in Worcestershire most sensitive to impacts of climate change and working with those organisations to help them take adaptive action.

Public Services

This sector covers a wide range of services from health to transport and infrastructure. It is essential that these services are informed of the likely impacts of climate change in order to be well placed to adapt to future changes in climate. The main recommendation is to ensure public services in Worcestershire i.e. emergency services, and Highways Partnership Units (responsible for maintenance of roads and drainage systems) are adequately resourced to deal with severe weather, including ensuring severe weather warnings such as flooding and extreme heat are effectively dealt with and coordinated by emergency planning.

Natural Environment

The natural environment is particularly sensitive to climate change. Agriculture is very weather-sensitive and biodiversity is very interlinked with the agriculture sector. The main recommendations are therefore awareness raising of climate change and possible adaptation responses, strengthening the links between agriculture and open spaces, and enhancing biodiversity. Support mechanisms for opportunities need to be integrated into

regional plans, especially the Regional Planning Guidance, with regards to e.g. land for energy crops and local reservoirs.

In all sectors a central recommendation was to keep a watching brief on emerging research, especially national research and signposting relevant services, organisations and businesses to this information.

Policy Proofing

This study identified a lack of climate planning in policies; especially with regards to adaptation rather than mitigation e.g. transport plans. This area clearly needs more consideration and further more detailed research. The next step for Worcestershire is to take forward these recommendations and put them into practise by incorporating the potential impacts of climate change in policies and plans.

References and resources for further information

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UK Climate Impacts Programme
www.ukcip.org.uk

Intergovernmental Panel on Climate Change
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