LDĀDESIGN

Central Bedfordshire Climate Change Adaptation Evidence Base

A report For Central Bedfordshire Council

Final report – April 2012

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This document has been prepared and checked in accordance with ISO 9001:2000

Executive summary

We are adding greenhouse gases to the atmosphere faster than ever before. The International Energy Agency has warned that to avoid 'catastrophic and irreversible' global warming this trend must be reversed quickly. We are already experiencing some of the consequences and it is imperative that we plan ahead to mitigate the most serious risks. Climate change must be viewed as a very practical challenge and one that affects almost all parts of our lives. It will force economic and social change, as well as putting pressure on the ecosystem services we rely upon.

LDA Design was commissioned by Central Bedfordshire Council to conduct a local climate change adaption study to help define and understand the risks to and opportunities in the area. The study provides the evidence needed to inform the Council's Climate Change Adaptation Plan, which will contribute to the preparation of the Development Strategy, corporate policies and to emergency planning. The evidence used to develop our advice and recommendations has been gathered from:

- A local climate impacts profile (LCLIP) which helps to demonstrate and communicate the message that Central Bedfordshire is already affected by extreme weather events
- An analysis of climate change projections which identifies likely changes to the local climate and how this can be expected to affect weather patterns
- A climate change risk assessment which uses national and local evidence to identify and prioritise risks

Climate change risk assessment

The first national Climate Change Risk Assessment (CCRA) was published in January 2012 and provides supporting evidence to the National Adaptation Plan (NAP) that is expected in 2013. The CCRA has been used as the basis for the local assessment of Central Bedfordshire's climate change risks. The impacts likely to affect Central Bedfordshire most are:

- Flooding
- Water resources
- Overheating
- Subsidence
- Risks to the Natural environment

A selection of the risks specific to Central Bedfordshire in each impact category is highlighted below. The wider set of likely risks are included in the main report with more detailed information on the risks, response functions and costs available in the CCRA reports*.

In order to present evidence to support effective policy and decision-making, we only draw on data from credible sources. Where data is not available at the right level we have not used it. As a consequence, unavoidable gaps may exist or certain risks may appear more important than others.

* The national Climate Change Risk Assessment and its supporting documents can be found at: http://www.defra.gov.uk/environment/climate/government/risk-assessment/

Flooding

More than 5,000 homes and 200,000m² of commercial floor space are located in the flood plain (flood zone 2). Almost half of these buildings are also within flood zone 3 and are at an increased level of risk from river flooding. The level of risk is also increasing. Evidence in section 3.3.3 shows that a 1 in 100 event is expected to occur 1 in 63 years in the 2050s and 1 in 48 years in the 2080s; becoming roughly twice as likely.

An even greater number are at growing risk of surface water flooding. 15,000 homes and 1.1million m² of commercial floor space are located in areas that are susceptible. This represents 9% of all homes and 34% of all commercial floor space in Central Bedfordshire. Evidence in section 3.3.3 suggests that a 1 in 30 year event is expected to occur 1 in 18 years in the 2050s and 1 in 14 years in the 2080s.

Flooding is also a cost to businesses, who are either located in the flood plain or depend on infrastructure and services that can be affected by floods, i.e. roads, agriculture and suppliers. While no estimates of the potential cost of flooding to businesses in Central Bedfordshire have been provided, 1 in 5 businesses are affected by disruption and disasters each year, and of these 1 in 10 go out of business.

Water resources

Water resources are already under pressure across the East of England. Parts of Bedfordshire have been officially in drought since April 2011. Groundwater levels are reported to be 'exceptionally low'. The Environment Agency has identified Central Bedfordshire as an area at 'high risk' of continued drought through 2012.

Long term projections of water availability project a reduction in deployable output of 30% by the 2080s leading to a deficit in water supplies. While new infrastructure can help increase supplies, these projections do not take changes in population or changes in personal water consumption into account which are likely to exacerbate the issue. The implications for the economy should not be ignored. The example of PepsiCo's concern over the longer term viability of their Copella plant in Boxford is useful in illustrating the economic implications of reduced water availability.

Overheating

High and sustained temperatures have potentially serious consequences for health, productivity in the workplace and for the environment. Local microclimates, like the urban heat island (UHI) effect can increase the level of risk, particularly for vulnerable groups such as the very young and elderly. While it has not been possible to estimate the potential intensity of the UHI in Central Bedfordshire, we have identified urban areas which have lower levels of green infrastructure and are therefore potentially more susceptible to the UHI effect relative to others. The maps produced can be used to target investment in new green and blue infrastructure, such as street trees, green walls, open water and fountains to the appropriate areas.

Higher temperatures will also bring benefits. Milder winters will reduce winter mortality, demand for heating and can also cause a general reduction in the number of days of snow and ice each year; potentially reducing delays and disruption on the transport network. Longer warmer summers will also have economic benefits for the tourism sector.

Subsidence

Subsidence of residential buildings is an existing problem in Central Bedfordshire. Climate change will increase the likelihood of prolonged dry spells, which increases the amount of soil shrinkage in certain soil types. Subsidence due to shrinking soils is primarily a risk for low rise homes built before 1979 because of the less stringent construction standards that existed prior to this time. More than 18,788 houses are located in areas identified as being at 'high risk' of subsidence. Evidence suggests that Central Bedfordshire will experience an additional 22 subsidence incidents per year on average in the 2050s and 33 per year on average in the 2080s. Extremely dry years will result in a higher number of claims.

Advice and recommendations

This study has used the most up to date evidence of the projected impacts of climate change to identify the most important risks and opportunities for Central Bedfordshire. Advice and recommendations are provided as to how the evidence can be used to inform the Council's response. Our advice and recommendations have been targeted at:

- The Development Strategy – site selection, protection and enhancement of the natural environment and policy supporting climate resilient new development
- The Council's Climate Change Adaptation Plan – managing risks to authority services and directing investment through corporate strategy
- The Local Resilience Forum – contributing new evidence to emergency planning through the Bedfordshire and Luton Community Risk Register

The development strategy

New development proposals should demonstrate how they have considered climate change resilience in their design. Many design requirements can be achieved through with the existing sustainable design requirements of the Code for Sustainable Homes and BREEAM. Developers should be encouraged to describe the measures taken to mitigate risks that cannot be made through these schemes. This approach will help to minimise the planning burden on developers while providing a robust and measurable response for development managers to assess.

It is recommended that the following credits be made mandatory for all developments which are required to conduct a Code assessment:

Ref	Code name	Credits
Sur 1	Management of Surface Water Run-off from Developments	(already mandatory)
Sur 2	Flood Risk	1
Wat 1	Indoor Water Use	3
Wat 2	External Water Use	1
Eco 2	Ecological Enhancement	1

Overheating risk is not dealt with sufficiently through Building Regulations, the Code or BREEAM. New development proposals should therefore explain the measures taken to manage the risk of internal overheating, today and in the future.

The uncertainty in the level of subsidence risk to new developments means that there is insufficient evidence to support higher standards. However, proposals in vulnerable areas should be asked to include a subsidence risk assessment and for the development to respond accordingly.

Delivery of new green infrastructure and maintenance of the size and ecological quality of existing resources should continue to be a local priority as should recognition of its ability to contribute to wider climate change resilience and carbon reduction. New development may be able to contribute to this through planning conditions and Community Infrastructure Levy (CIL) contributions.

The Council's Climate Change Adaptation Plan

The Council's Climate Change Strategy acknowledges the risks of climate change to Central Bedfordshire and sets out strategic goals and targets for reducing carbon emissions and for increasing preparedness which will need to be carried through into the Climate Change Adaptation Plan. A management board should be given responsibility for delivering the Adaptation Plan. It should have responsibility for ensuring that:

- The Plan is prepared and endorsed by the Council. It should include a prioritised list of adaptation measures and the appropriate routes for delivery
- The risks identified are acknowledged and communicated to each department, local communities and strategic partners
- The local evidence base is kept up to date following publication of the Economics of Climate Resilience, National Adaptation Plan and future editions of the CCRA
- Records of weather related incidents and impacts on local authority services are maintained and used to supplement the local evidence base
- The local evidence base is taken into account when the Council is designing projects, programmes and plans across all services, strategic partners and the Local Resilience Forum
- Each department considers and responds to the consequences for service delivery internally. Departments should be required to report back to the management board throughout this process, for support and for critical scrutiny

A tree policy

Trees in and around urban areas provide significant co-benefits, supporting a range of adaptation and other corporate objectives. Existing urban green and blue infrastructure should be protected and maintained. In addition, new street trees and other green features should be actively encouraged and integrated into urban areas where possible. The Council should consider the benefits that a tree policy for Central Bedfordshire could bring and should use it along with other delivery mechanisms to support implementation.

The Community Infrastructure Levy and infrastructure

CIL can be used to raise a proportion of the funds needed to deliver local infrastructure that increases the resilience of Central Bedfordshire to climate change. It could be used to contribute towards flood defences, the green infrastructure network, a retrofit programme or urban greening projects including street trees. To do so, the development vision used for setting the CIL should include the Council's climate change objectives and a prioritised list of infrastructure that needs funding should be identified on the CIL charging schedule.

Risks and Opportunities for Departments and the Local Resilience Forum

Each local authority department and the Bedfordshire and Luton Local Resilience Forum will need to consider how the impacts and opportunities identified in this report could affect the service they provide. A comprehensive assessment of those consequences should be undertaken with the outcomes used to inform an adaptation action plan which identifies priority issues and the resources required to manage them.

1.0 Introduction

LDA Design has been commissioned by Central Bedfordshire Council to conduct a local climate change adaption study to help define and understand the risks and opportunities to the area from climate change.

It provides Central Bedfordshire Council with an evidence base which connects an understanding of existing vulnerabilities to extreme weather with climate change projections and a spatial understanding of the impacts and the consequences for development, service delivery and the community. Where possible, the local costs of climate change have been monetised, helping to make the case for a strategic response to long-term risks.

The study provides the evidence needed to develop the Council's Climate Change Adaptation Plan, to understand the existing and emerging risks to service provision, to support the preparation of the Development Strategy for the newly unified authority and as a contribution to emergency planning.

The evidence base highlights a wide range of direct and indirect impacts which are likely to affect Central Bedfordshire. More detailed analysis has been conducted on those issues which the Council has most potential to influence; the built environment and strategic infrastructure. Importantly, in order to present evidence to support effective policy and decision-making, we only draw on data from credible sources. Where data is not available at the right level we have not used it. As a consequence, unavoidable gaps may exist or certain risks may appear more important than others.

The evidence base can also help the Council decide what they want to achieve, what infrastructure might be needed to deliver those priorities and to help them find ways, using the range of available incentives such as the Community Infrastructure Levy or the New Homes Bonus, to make it happen through a positive cycle of investment and delivery.

The Council is also taking an ecosystem services approach to development planning. In a separate commission running in parallel to this study, a 'Green Framework for Growth' is being prepared which will map important regulating services (water runoff; nitrate, pesticide and soil erosion risk; soil carbon storage and sequestration) in support of local land use decisions. Where appropriate, information on future risks to the natural environment can be used to support this on-going work.

The objectives for this study have been delivered by bringing together the findings from three strands of work into targeted advice and recommendations:

Section 1: Introduces the study, its aims and objectives, and sets out its political and environmental context

Section 2: Local climate impacts profile (LCLIP) – a review of local media reports to demonstrate the ways extreme weather already impacts on the Council's service delivery

Section 3: Climate change projections – using the UKCP09 climate projections to understand how existing risks are expected to change and what new or emerging risks will need to be managed in future

Section 4: Climate change risk assessment – using national and local evidence to identify and prioritise risks for Central Bedfordshire and to support a spatial response to development planning in a changing climate

Section 4: Advice and recommendations – helping the Council and its partners identify how the risks identified can be managed through the planning system, corporate strategies and emergency planning

The appendices include the LCLIP media database, information supporting the climate change risk assessment and site specific risks to potential site allocations.

1.1. Climate change in context

We are adding greenhouse gases to the atmosphere faster than ever before[i]. The International Energy Agency has warned that to avoid 'catastrophic and irreversible' global warming this trend must be reversed quickly. In spite of this, there is a growing consensus that a comprehensive global agreement to reduce our emissions is unlikely to be in place soon[ii]. To continue following this path would mean around a 50% chance of a rise in global average temperature of more than 4°C by 2100[iii]. An increase in global temperatures of this magnitude would increase the likelihood of some extreme weather events[iv]:

- Extremely hot days and heat waves will increases in frequency, magnitude and length. Conservative projections estimate that a 1-in-20 year hottest day is expected to become a 1-in-2 year event by the end of the century
- Longer dry periods will be accompanied by heavier rains. Comparable projections indicate that a 1-in-20 year rainfall is likely to become a 1-in-5 to 1-in-15 year event
- Mean sea level rises will contribute to upward trends in extreme coastal high water levels in the future which may be exacerbated by more intense storm systems

The projected impacts associated with an increase of 4°C in global average temperatures are severe, particularly as even higher levels of change may be experienced locally. Sea level rises, desertification and the increasing likelihood of extreme weather events have the potential to cause the migration of millions of people around the world and severe and sustained conflict[v].

Limiting temperature rises to 2°C has long been the principle target of international debate. Intensifying our efforts to mitigate climate change is essential but an increasing awareness that this target is likely to be exceeded makes adaptation an urgent concern.

Closer to home, negative impacts are already being felt in the region. For example, in the August 2003 heat wave heat related excess deaths rose by 20% in the region and it is predicted that heat-

related patient-days in hospitals will increase significantly. Climate change is no longer a philosophical debate but a very practical one, affecting most parts of our lives.

Climate change also affects water, and this has economic implications. For example, PepsiCo have expressed concern that uncertainties over water availability and the potentially negative connotations of their competing for water with users perceived to be more important is causing them to think carefully about the future of their Copella plant in Boxford[vi]. (The site is anticipated to be classified as Extremely Scarce or Scare for water by 2020).

1.1.1. Adapting to climate change

The aim of adaptation is to reduce the impact of changes to the climate which are happening now and to increase our resistance and resilience to future impacts. The adaptation process requires that risks, and any opportunities, are identified and action is taken to develop appropriate responses.

The case for designing for future climate is strong. Buildings and infrastructure have long life spans and what we build today will, in many cases still be around in 50 years or more. We generally build to suit the current climate and take no account of their performance in future. As a result, the impacts of climate change can make buildings and infrastructure uncomfortable, unsafe or even commercially unviable to maintain.

The persistence of carbon dioxide in the atmosphere gives global warming inertia, so temperatures are projected to continue rising for decades after greenhouse gas emissions peak. The change will be incremental and will result in an on-going process of change and uncertainty[vii]. Adaptation needs to be a dynamic and flexible process, with decisions made in light of the long lifespan of buildings and infrastructure, and what opportunities might be exploited to adapt existing buildings and towns.

Adaptation measures can therefore help avoid significant costs in future. This must be reconciled with the commercial realities of developing new and maintaining existing towns. This requires a creative approach to developing adaptation strategies, focusing on measures that increase resilience while providing multiple social, environmental and economic benefits. For example, increasing the amount of green and blue space can help absorb floodwater and can help make buildings and public spaces more comfortable in hot weather. They can help improve air and water quality; encourage use of public spaces; biodiversity; all while adding to the value of nearby homes[viii].

1.2. The policy context

The Climate Change Act 2008 creates a legal requirement for the UK to reduce carbon emissions by at least 80% below 1990 levels by 2050 and to put in place measures to adapt to climate change. Although the Act is not directly linked to local action, local authorities are integral to this effort and are already playing an important role in delivering a wide range of policies which are targeting renewable energy generation, energy efficiency and adaptation.

Key drivers for this study, as well as policy areas which can be directly influenced by it are briefly described below.

1.2.1. The National Adaptation Programme

The Government is required by the Act to carry out a UK wide Climate Change Risk Assessment (CCRA) every five years, using the latest science to assess the vulnerabilities and opportunities as a basis for putting in place a National Adaptation Programme (NAP) which addresses the most serious risks.

The first CCRA was published in January 2012 and will be followed by a study of the Economics of Climate Resilience (ECR) later in 2012 which will identify options for addressing some the priority risks; their costs and benefits. The NAP is expected in 2013.

The national evidence base underpinning the CCRA will be used as the basis for the local climate change risk assessment.

1.2.2. The Council's Climate Change Adaptation Plan

Climate change will affect the social, economic and environmental well-being of Central Bedfordshire's communities. The Council is responsible for maintaining, and must identify vulnerabilities to service delivery and improve resilience where necessary. They should also be ready to take advantage of any opportunities that result from climate change.

In response to this the Council have committed, through their Climate Change Strategy, to preparing and implementing a Climate Change Adaptation Plan that considers the impacts of climate change on Central Bedfordshire, the Council's services and estate.

1.2.3. Development Strategy

Central Bedfordshire is in the process of developing a new set of planning policies. The plan, known as the Development Strategy, will set out how much development is required and broadly where that development should go. The Development Strategy will replace the legacy North Central Bedfordshire Core Strategy and South Bedfordshire Local Plan. It is anticipated that there will be a consultation on a draft plan in June/July 2012 with formal adoption in early 2014.

The preparation of the Development Strategy creates an opportunity for the local impacts and consequences of climate change to be considered in the plan making process and in the allocation of strategic development sites.

1.2.4. Bedfordshire and Luton Local Resilience Forum

The Local Resilience Forum* is responsible for ensuring that Central Bedfordshire is prepared for extreme weather events and other civil emergencies. The Forum plans for events like flooding, heat waves and drought and is already exploring how the changing climate will affect the likelihood and severity of these events.

The findings of this study will be able to support their forward planning and can form part of the evidence behind the community risk register they maintain which prioritises contingency planning.

* For more information visit: http://www.bllrf.org.uk/

2.0 Local Climate Impacts Profile

A Local Climate Impacts Profile (LCLIP) provides an understanding of the current weather related impacts for an area. The impact and frequency of weather events are looked at to help develop an understanding of what consequences weather events have had on residents and on the local authority. It does not provide evidence of a changing climate but does help highlight local vulnerabilities to extreme weather events.

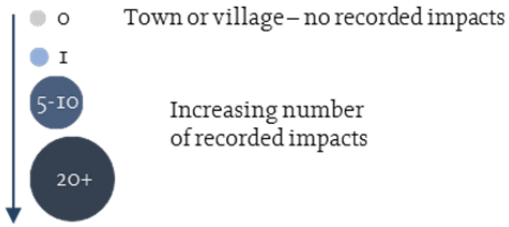
LCLIPs are based upon reports in the local media. A review of articles in local newspaper and online archives is used to build up a picture of weather events impacts. The search covered a 5 year period and found 150 news stories describing almost 250 weather impacts on the Council and its strategic partners.

The media trawl is not intended to provide an exhaustive review of all weather events and their consequences. It is intended to provide a snapshot of existing weather related vulnerabilities on service delivery. This can help communicate the risks the area is currently exposed to and provides useful context for considering how we should manage the effects of climate change. The following potential biases should be taken into account when interpreting the findings:

- The media trawl covered a 5 year period, as a result it may not capture all of Central Bedfordshire's existing vulnerabilities
- Many articles are written about serious weather events. They are also reported in greater detail and this can bias findings
- During a serious weather event, leading to flooding, storms and snow minor impacts are unlikely to be reported
- Weather events which lead to regular but mild impacts are likely to be underreported
- The media are more likely to report events occurring in larger towns

Accordingly, the LCLIP should be read alongside the climate projections in section 3.0. The collected records have been analysed to help understand the most significant cause of impacts locally and their consequences. Trends are identified where possible but should be treated with caution because of the method of data collection. The full set of media records can be found in appendix 1.

The maps shown below represent the spatial distribution of impacts as points with larger, darker points indicating a higher number of records.



2.1. All recorded impacts

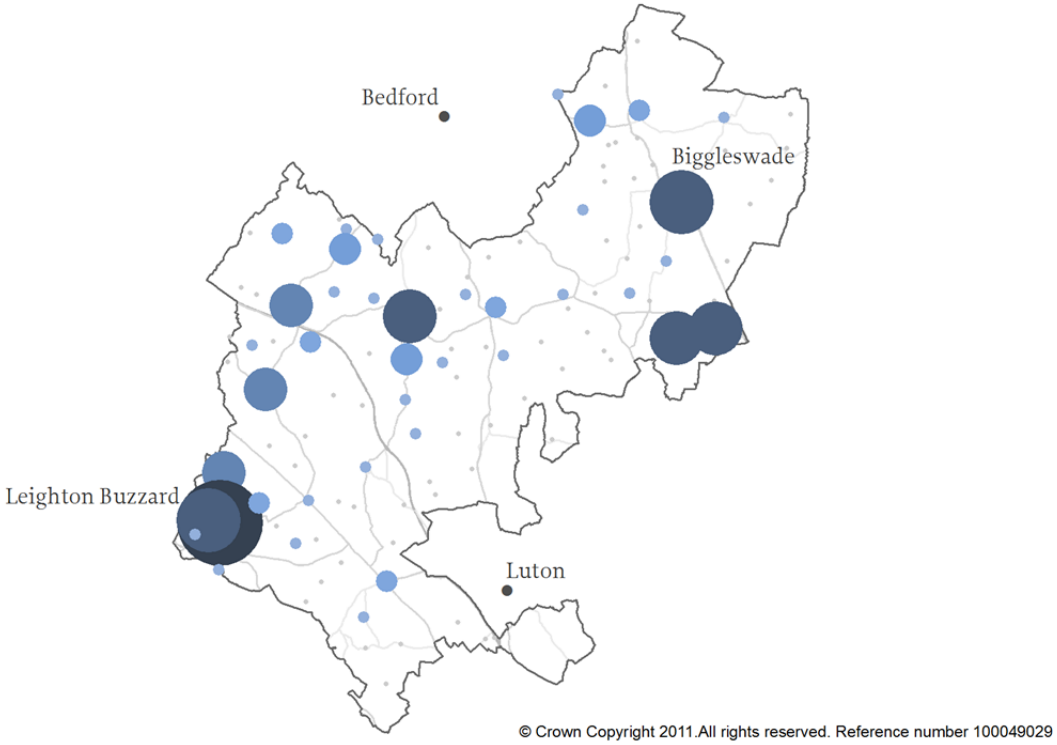


Figure 1: Map of Central Bedfordshire showing the location of all recorded weather related impacts

The LCLIP media review found that:

- Frost, ice or snow was responsible for causing the majority of weather related impacts
- Leighton Linslade suffered the most recorded impacts in a single area
- Few, if any, incidents due to high temperatures or heatwaves; and fog, mist or low cloud were recorded
- The emergency services would have been involved in a majority of the incidents and had primary responsibility for responding to a third of the recorded events
- Beyond the involvement of the emergency services, Highways and Transport were affected by almost half of all recorded weather events

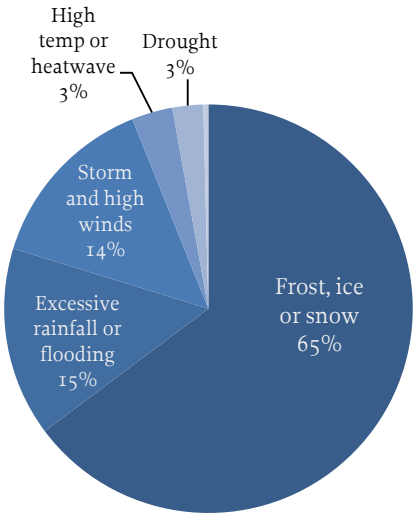


Figure 2: Proportion of all recorded impacts by type of weather event

Two thirds of all recorded impacts were due to frost, ice or snow. Excessive rainfall leading to river or surface water flooding and storms and high winds were each responsible for the majority of other impacts. A small number of impacts are related to high temperatures or heatwaves; drought; and fog, mist or low cloud.

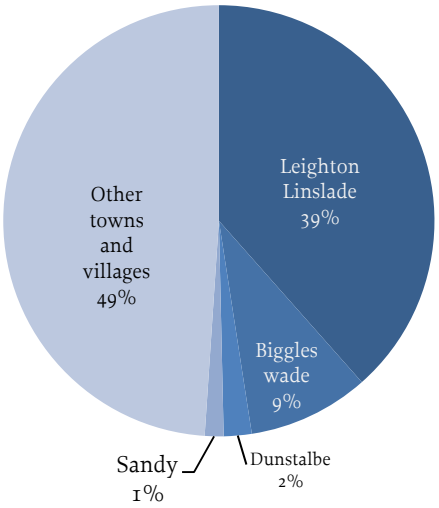


Figure 3: Proportion of all recorded impacts by location

Almost half of all recorded incidents could not be linked to a specific location and were reported as affecting the Bedfordshire area generally. These events are likely to have caused many low severity impacts. Of the news reports which provide more detail on the type and location of impacts, 39% were in the Leighton Linslade area with an additional 9% in Biggleswade. Impacts for other large settlements, such as Dunstable, Houghton Regis were reported far less frequently, if at all. This could in part be due to impacts being ascribed to Luton and therefore not included in our search.

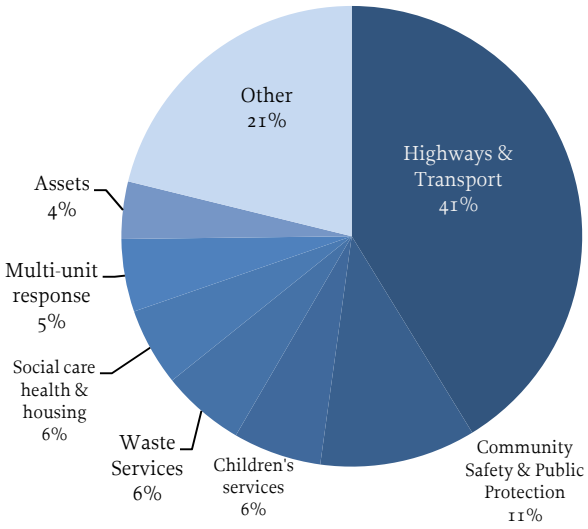


Figure 4: Proportion of all recorded impacts by departmental responsibility

A wide range of local authority departmental activities and services have been affected by extreme weather events in the past 5 years. Highways and Transport has been reported on most (41%), due overwhelmingly (83%) to the impacts of winter snow on roads and railways. It should be noted that traffic problems may be more likely to be reported than some other types of impact. Risks to human health requiring some involvement from Community Safety and Public Protection (11%) have been caused by a range of weather events but most commonly due to flooding (48%). All recorded weather events having an impact on Children's services (6%), waste services (6%) and social care health and housing (6%) were due to frost, ice or snow, often as a consequence of disruptions to the transport network. All recorded incidents requiring a major multi-unit responses (5%), and are therefore likely to involve the Local Resilience Forum, have been due to flooding events.

The consequences of each of the impacts are shown below. It is important to note how they are interlinked, with flooding affecting water supply and affecting biodiversity

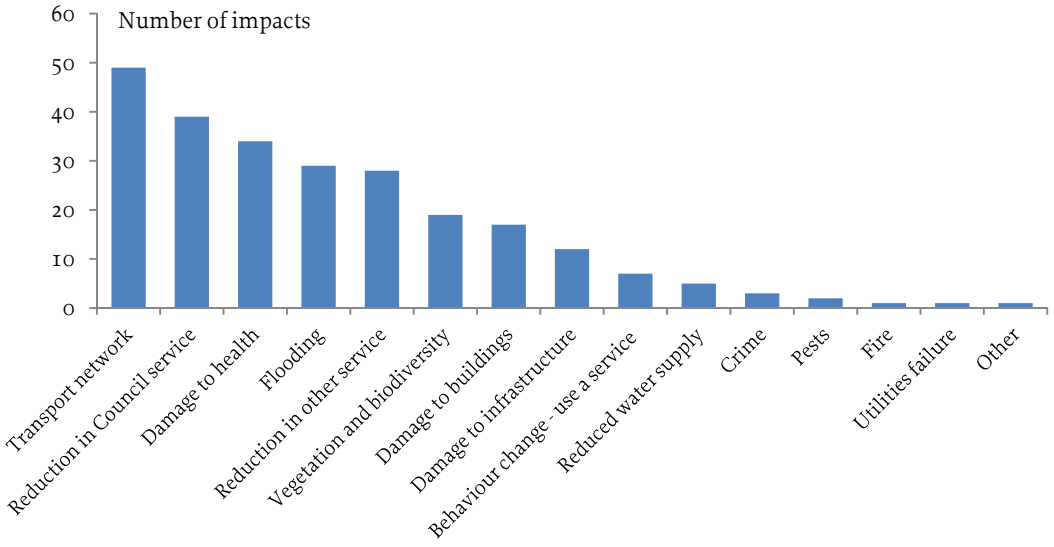


Figure 5: Number of recorded impacts by consequences

2.2. Frost, ice or snow

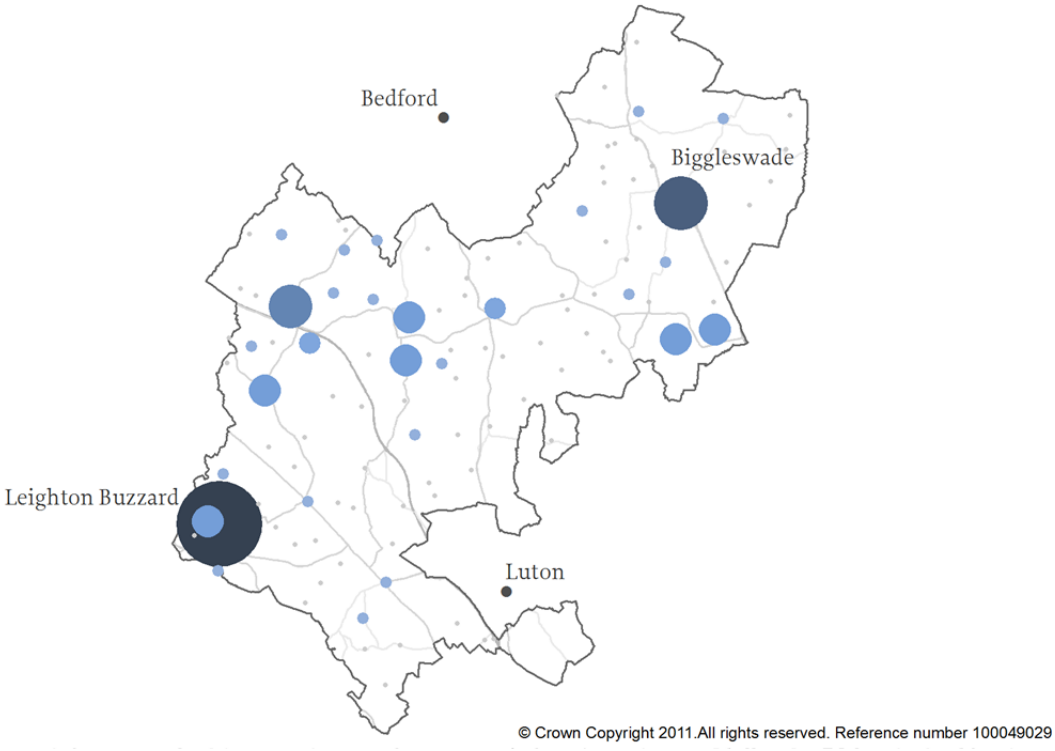


Figure 6: Map showing location of all recorded frost, ice or snow related impacts for Central Bedfordshire

Frost, ice and snow are a source of regular seasonal disruption and have caused 65% of all recorded impacts in Central Bedfordshire. The articles found examples of the following consequences:

- Reduction in access to Council services, particularly Highways and Transport
- Damage to the road network
- Compromising health and safety

Frost, ice and snow events regularly cause disruption to transport infrastructure, accounting for over 90% of impacts on transport. This often has subsequent indirect impacts disrupting the provision of Council and other services. 68% of impacts resulting in damage to health are as result of road traffic accidents.

Managing impacts due to frost, ice and snow is primarily the responsibility of Highways and Transport. Dangerous driving conditions increase the risk of accidents resulting in higher call out rates for the emergency services.

2.3. Excessive rainfall and flooding

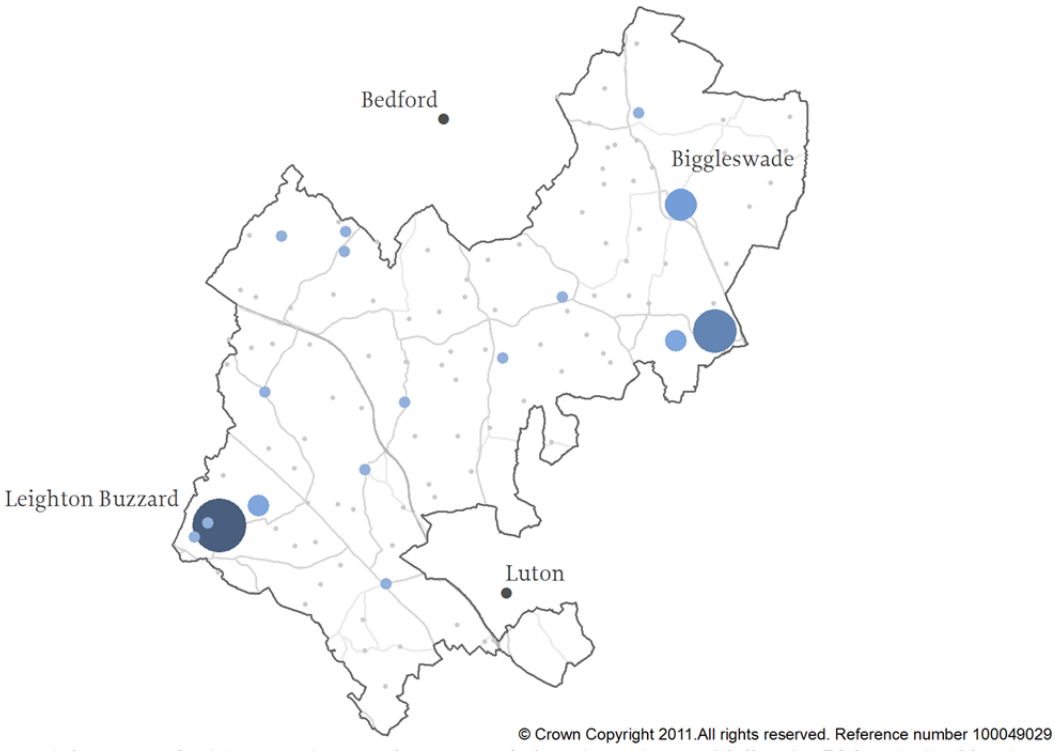


Figure 7: Map showing location of all recorded excessive rainfall and flooding related impacts for Central Bedfordshire

The LCLIP identified 37 media articles related to excessive rainfall, the second most common impact category. In many cases excessive rainfall led to flooding, which subsequently causes major disruption and damage. The articles found examples of the following consequences:

- Damage to buildings, infrastructure, trees and vegetation
- Compromising health and safety
- Reduction in access to Council and other services, such as transport

Many of the reported flooding incidents have required a major multi-departmental response, with a common need for Community Safety and Highways and Transport to respond. The articles suggest that flooding is a widespread risk for towns and villages across Central Bedfordshire with Leighton Linslade and Stotfold subject to the highest number of incidents.

2.4. Storms and high winds

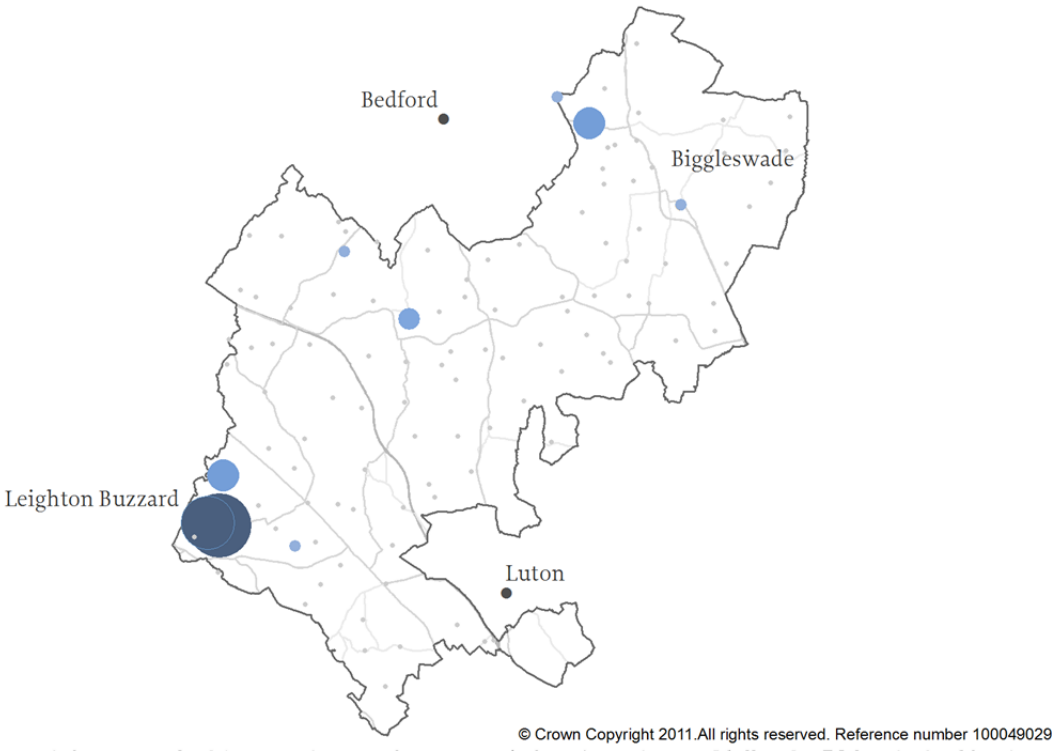


Figure 8: Map showing location of all recorded storm and high wind related impacts for Central Bedfordshire

The LCLIP identified 35 media articles related to storms and high winds. The articles highlighted the following consequences:

- The primary consequence of storms of and high winds was damage to buildings and vegetation; roof tiles being removed and falling trees damaging buildings
- Disruption on the transport network and, on 1 occasion this resulted in power cuts

The recorded consequences of storms and high winds have been felt across Central Bedfordshire but most acutely around Leighton Linslade.

2.5. High temperatures and heatwaves

The LCLIP identified seven media articles related to high temperatures and heatwaves. The small number of records means that they have not been mapped. The articles highlighted the following consequences:

- An increase in open water rescues during the summer as people attempt to cool off in rivers and lakes
- High temperatures resulting in poor conditions for animals and plants
- Sustained high temperatures causing complaints regarding nuisances from refuse
- Hot dry weather increasing the risk of forest fires spreading

The small number of articles suggests that overheating was not a major existing problem in Central Bedfordshire over the period studied. The small number also limits the extent to which they can be used to infer wider trends.

2.6. Water availability and drought

The LCLIP identified 6 media articles related to drought. Most of the articles were from 2011 and relate to public statements from Government and Anglian Water regarding the regional drought. Parts of Bedfordshire have been officially in drought since April 2011 and the 2011/2012 winter period in the region has been the driest on record[ix]. Groundwater levels are reported to be 'exceptionally low' with little recharge taking place. Management of this drought has required special measures to help refill reservoirs while abstraction licences have been restricted making conditions difficult in agriculture. A hosepipe ban came into force in April 2012. The Environment Agency (EA) has identified Central Bedfordshire as an area at 'high risk' of continued drought through 2012.

Figure 9: Drought risk in 2012 across England and Wales, Environment Agency

2.7. Land instability

The LCLIP did not identify any media articles related to land instability. The risk of landslides was considered in the Bedfordshire and Luton Community Risk Register[x] which ascribed the likelihood as 'negligible' suggesting that land instability is not a specific known risk in Bedfordshire.

3.0 Climate projections

3.1. Existing trends

The Met Office has used weather records, based on observational data from the period 1961 to 2006, to produce a climate baseline dataset for use by the UK Climate Projections (UKCP09). The recent climate trends presented in Figure 10 and Figure 11 show that change is already occurring.

Mean temperatures for both the summer and winter periods have increased across the UK and in the Midlands, South East and East of England in particular. Annual rainfall levels in England have changed little since 1961. The trends in seasonal precipitation are more striking with reduced rainfall in summer (10-50% lower) and more in winter (10-50% higher) across the south of England. Across the UK the number of days each year with snow cover is declining quickly and the number of days with frost has decreased by between 25-35% since 1961.

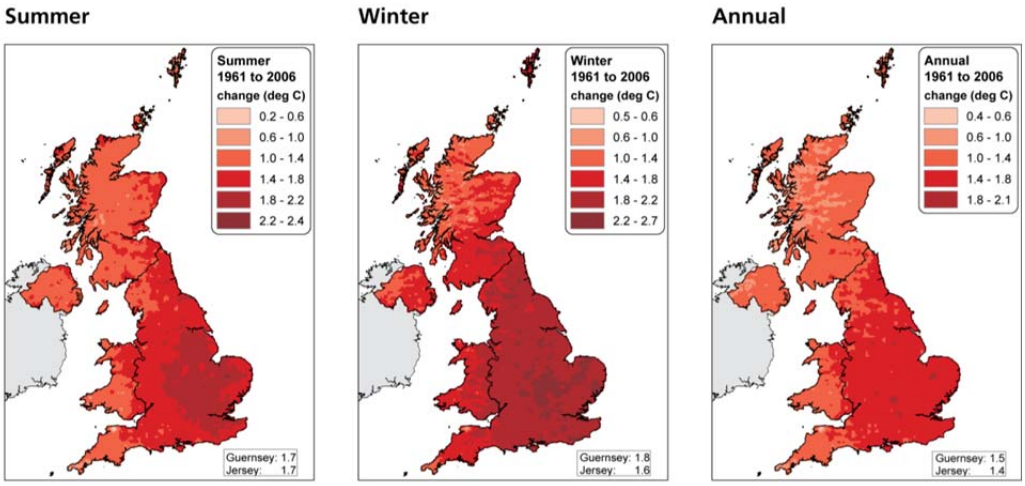


Figure 10: Change in average daily mean temperature (°C) from 1961 – 2006, UKCP09

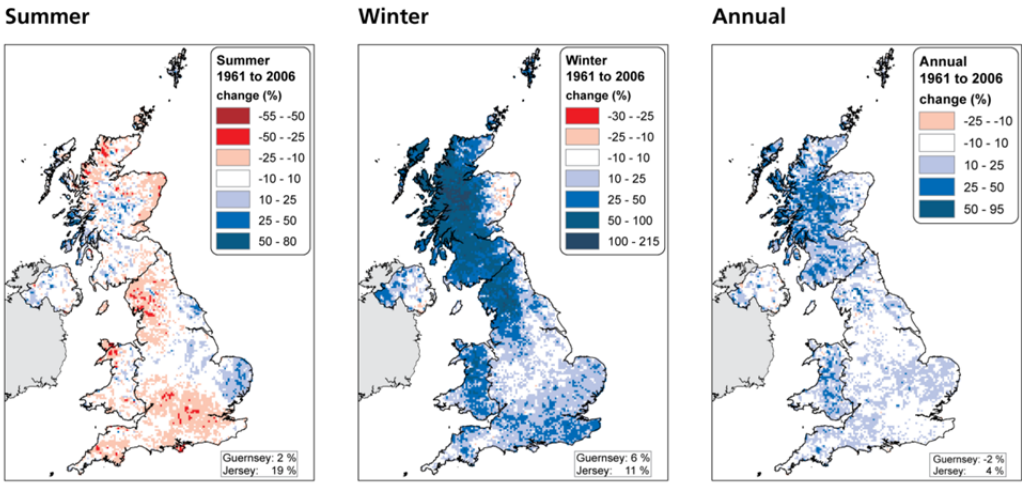


Figure 11: Change in average total precipitation (mm) from 1961 – 2006, UKCP09

3.2. Climate projections

The UKCP09 is a resource which provides probabilistic projections*of key climate variables at a higher geographic resolution than has ever been available before. The continued global growth in carbon emissions and investment in energy intensive infrastructure is consistent with the Intergovernmental Panel on Climate Change's 'business as usual' emissions trajectory which is equivalent to UKCP09's high emissions scenario. Since there are no signs of this trend being reversed, and no immediate prospect of a global deal on emissions reduction, this scenario is used throughout this study unless otherwise stated.

3.2.1. Temperature projections for Central Bedfordshire

The temperature is likely to increase throughout the year in future, with an increasing likelihood of prolonged hot periods and higher peak temperatures:

- Summer mean temperature increase 4.5°C; it is very unlikely to be less than 2.4°C or more than 7.5°C
- Winter mean temperature to increase but by a smaller amount. The central estimate is 3.7°C; it is very unlikely to be less than 2°C or more than 5.7°C
- The temperature of the hottest day in summer will increase by a greater amount with mean daily maximum temperature expected to reach 6.2°C; it is very unlikely to be less than 2.8°C or more than 10.6°C

3.2.2. Rainfall projections for Central Bedfordshire

The amount of annual rainfall is not expected to change significantly but changes to hydrological patterns make it likely that rainfall in summer will be reduced, increased in winter and with a greater proportion of all rainfall arriving as intense rainfall

- Rainfall in winter is expected to increase 17% in winter by the 2050s and by 26% in the 2080s
- Summer rainfall is expected to decrease by 18% in the 2050s and by 27% in the 2080s. The uncertainty in summer rainfall projections is larger than for winter, suggesting lower confidence in the scale of projected changes that are expected
- Little change in overall annual mean precipitation is expected; it is very unlikely to be more than 8% higher or lower
- The amount of precipitation on the wettest day in winter will increase by a greater amount with an increase of 17% in the 2050s and by 29% in the 2080s (this climate variable is considered in more detail in section 3.3.3 below)

3.2.3. Wind speed projections

Changes in wind speeds were included in the 2002 edition of the UK Climate Projections. In the 2009 edition they were assigned a very low level of confidence and were therefore not reported. While Association of British Insurers note that the potential impact of increasing wind speeds and

*A projection of future change in climate (relative to a baseline period) that assigns probability levels to different climate change outcomes. This projection provides a change value for the future climate, expressed as the difference from the (modelled) 1961–1990 baseline climate (as opposed to the absolute value expressed in probabilistic climate projections). For more information refer to: www.ukclimateprojections.defra.gov.uk

storms is considerable, the uncertainty in the projections of windstorms in UKCP09 means that there can only be limited value in taking precautionary measures at this point.

3.2.4. Spatial projections

The severity and likelihood of extreme weather events are influenced by local topography, catchments factors and land use. The scale at which the UKCP09 projections have been developed mean that they do not capture such local variations. The adjacent figure shows how trends in temperature projections can be only differentiated at the regional scale and above. As a result the spatial UKCP09 projections for Central Bedfordshire presented in Figure 13 and Figure 14 do not show any of the local variations that are likely.

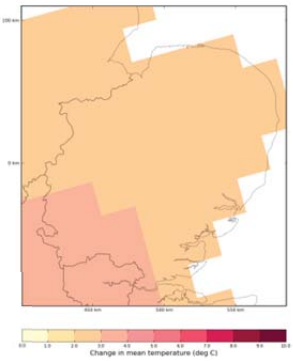


Figure 12: UKCP09 projections for the East of England showing spatial variations in mean temperature change

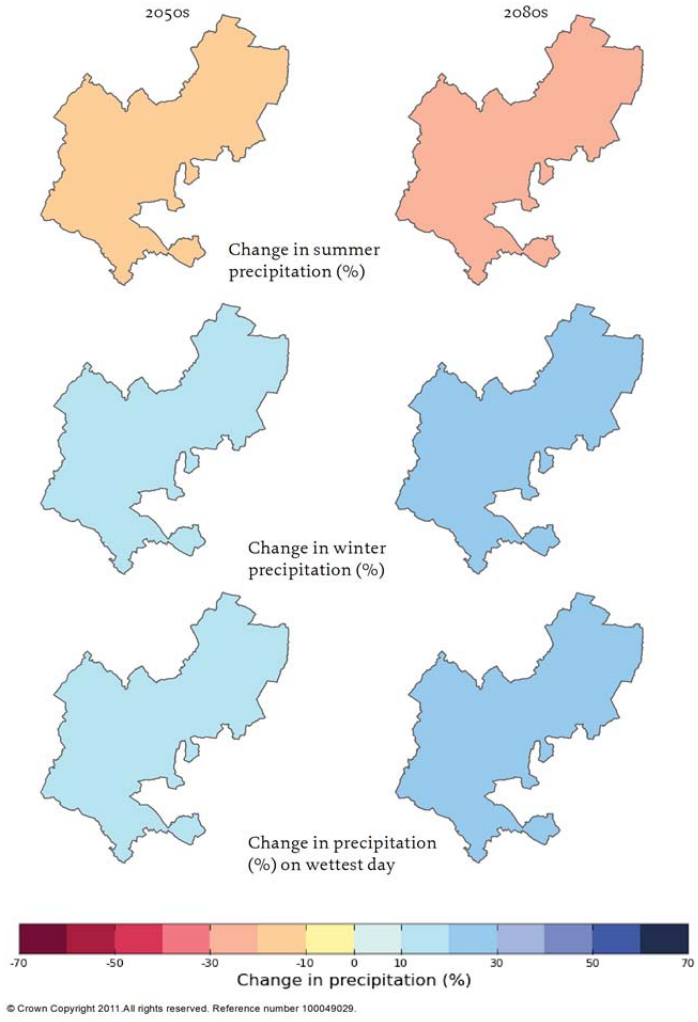


Figure 13: UKCP09 spatial projections for Central Bedfordshire. Changes in precipitation in the 2050s and 2080s

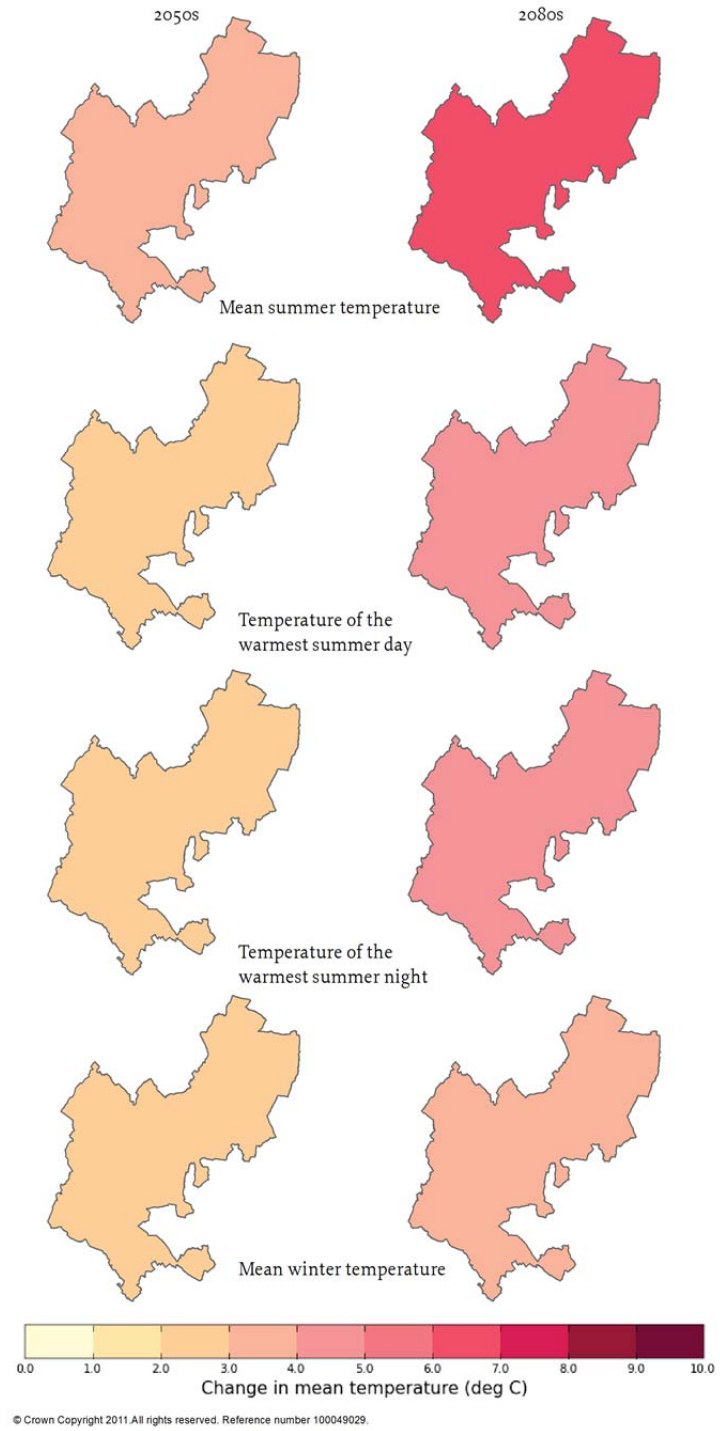


Figure 14: UKCP09 spatial projections for Central Bedfordshire. Changes in mean temperature in the 2050s and 2080s

3.3. Changing weather patterns

UKCP09 have provided a suite of tools which can be used to translate the climate projections (long term trends) into an interpretation of changes to weather patterns (short term fluctuations). The Weather Generator is a tool that can be used to assess vulnerability to impacts which occur over shorter time periods.

The Weather Generator has been used in conjunction with a threshold detector to predict changes in likelihood of heatwaves and the number of days with freezing temperatures in future climate scenarios.

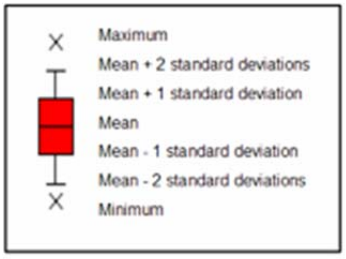


Figure 15: Legend for threshold detector outputs

It is not possible to use the Weather Generator to assess whether intense rainfall will become a more common occurrence in future because of the uncertainty in climate models of precipitation over periods shorter than 1 day. An alternative analysis by the Met Office is discussed in section 3.3.3.

3.3.1. Heatwaves

A heatwave in the East of England region is defined in the Bedfordshire and Luton Heatwave Plan 2011[xi] as a 3 day period in which daytime temperatures exceed 30°C and night time temperatures remain above 15°C.

- The baseline climate in the weather generator indicates that the current likelihood of this is low to zero
- In the 2050s the likelihood of a heatwave increases between June and August. The mean average number of annual events is 0.4, which suggests that heatwaves will occur every 2-3 years
- In the 2080s the mean average number of annual events increases to 2, suggesting that heatwaves will become a regular annual occurrence. The likelihood of prolonged events lasting 2 weeks or more is also greatly increased

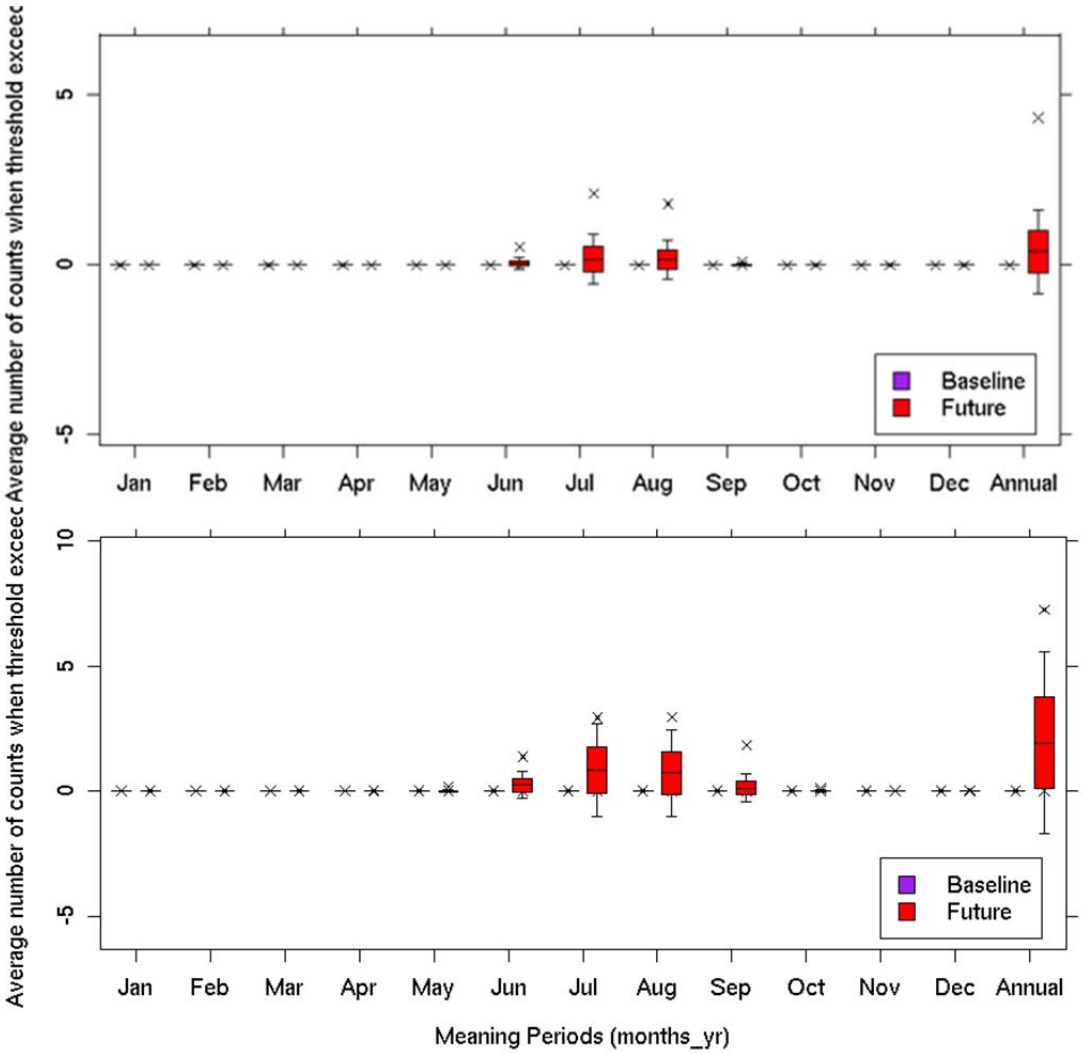


Figure 16: Weather generator output of average number of heatwave events in the 2050s (above) and the 2080s (below)

3.3.2. Number of days with temperatures below zero

The weather generator has been used to assess the change in frequency of days with minimum temperatures below zero. This can be used when considering the likely change in the number of days when the transport network is vulnerable to frost, ice and snow and when gritting might be needed:

- The baseline climate in the weather generator indicates that 60 days with minimum temperatures below zero are expected , occurring between October and May.
- In the 2050s the mean number of days with minimum temperatures below zero decreases to 25, sub-zero temperatures are likely to become increasingly rare outside December to March.
- In the 2080s the mean number of days with minimum temperatures below zero decreases to 18, within a range between 42 and 2.

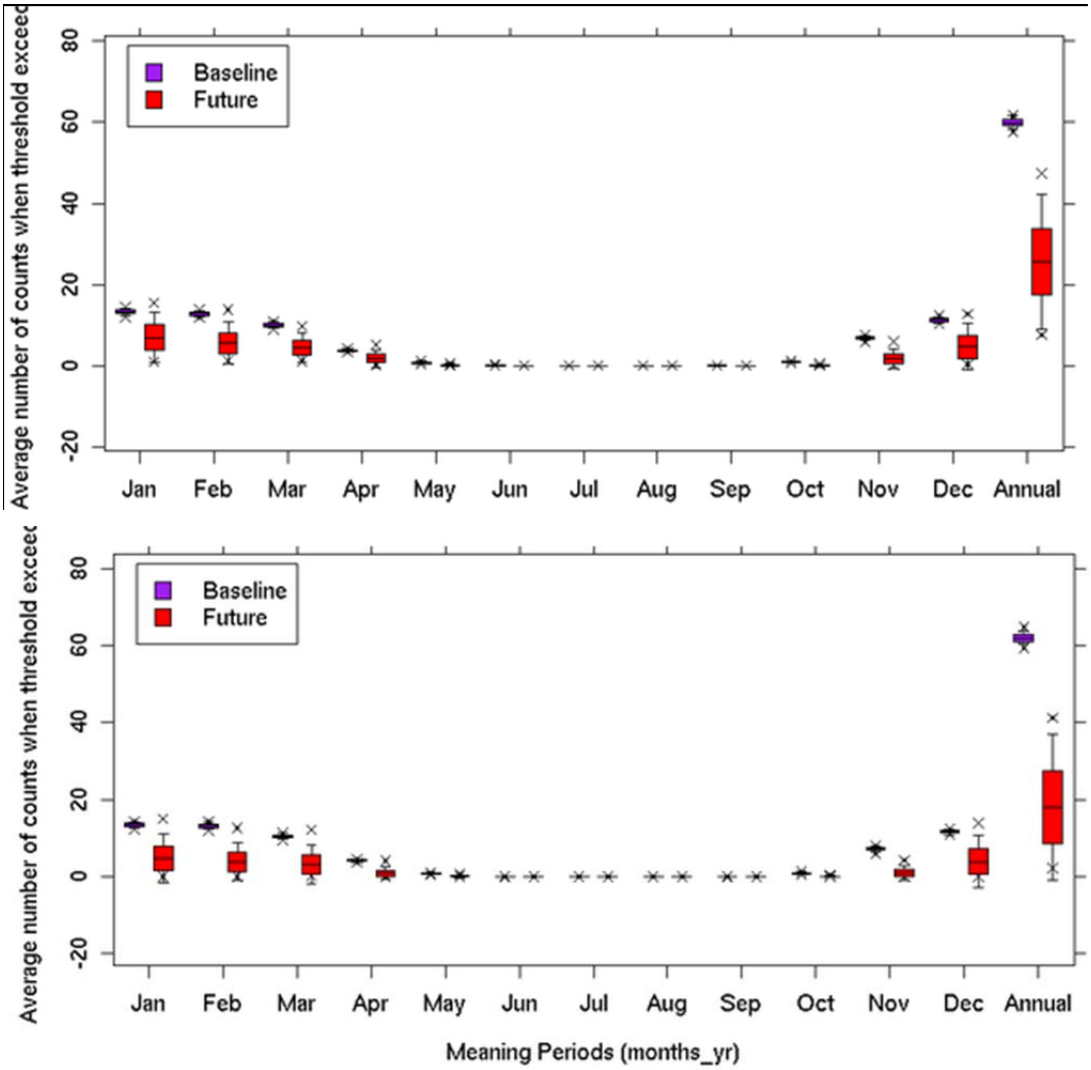


Figure 17: Weather generator output of average number of days with minimum temperatures below zero in the 2050s (above) and the 2080s (below)

3.3.3. Intense rainfall

Rainfall events leading to flooding can be intense and may last for only a few hours. The Weather Generator is not statistically accurate over such short time periods. The Met Office[xii] has used an alternative technique to estimate changes in the frequency of extreme rainfall events due to climate change. Northampton was the nearest town to Bedfordshire assessed in the study. Its proximity means that the projected changes will be very similar.

Figure 18 shows how the return period for a range of different rainfall events is likely to change. For instance, a winter rainfall event that is expected at present to occur once every 30 years (the solid orange line) is projected to become more than twice as frequent; an18 year return period in the 2040s and a 14 year return period in the 2080s.

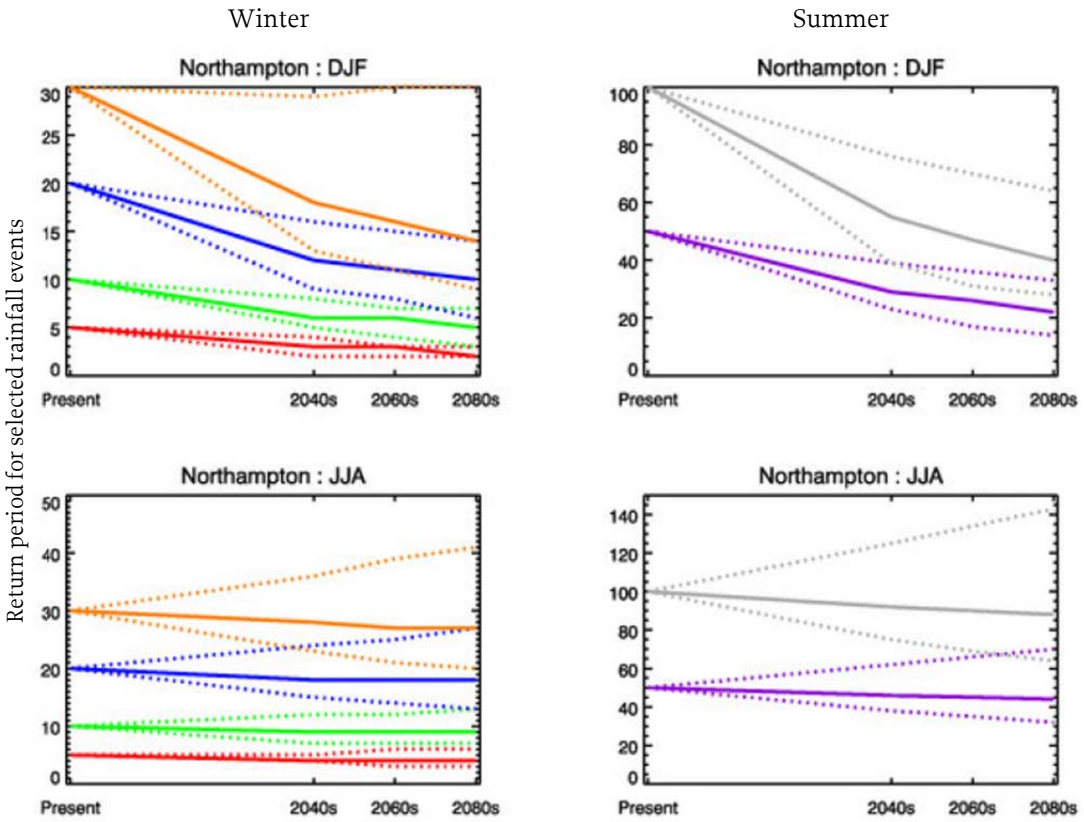


Figure 18: Projected changes in the likelihood of selected rainfall events in Winter (DJF) and summer (JJA) - The central estimate (50th percentile) is indicated by a solid line, and the 10th and 90th percentiles, illustrate the possible range of return periods and are shown by dotted lines. Note that Northampton has been used as it's the closest town to Central Bedfordshire assessed in the study. Source: Met Office, 2010, Changes in the frequency of extreme rainfall events for selected towns and cities

The LCLIP media trawl identified a number of flooding events that have affected Central Bedfordshire. The events which caused the most significant impacts occurred in January 2007, July 2007 and October 2010. During the most recent of these events, the highest recorded daily fall was 37.1 mm*which equates roughly to a 1 in 10 year event[xiii].

Figure 18can be used to crudely estimate how often an event similar to that of October 2010 will occur in future. During the winter period it is projected to occur twice as frequently; a 1 in 10 year event becomes a 1 in 6 year event in the 2040s and a 1 in 5 year event in the 2080s. It is also important to note the level of uncertainty in these projections, shown by the dotted lines.

* Weather data is based on Monthly Summaries for Luton provided by www.weather-uk.com, accessed on 22nd February 2012

3.4. Summary of climate projections

The UKCP09 projections confirm that the national climate trends are broadly applicable to Central Bedfordshire:

- Warmer wetter winters
- Hotter drier summers
- Fewer days of ice, frost and snow
- A higher likelihood of extreme weather events including heatwaves and intense rainfall
- The impact of climate change on wind speeds is uncertain and little confidence is assigned to existing projections.

4.0 Climate change risk assessment

Having identified Central Bedfordshire's existing vulnerabilities to today's climate and having reviewed projections of climate change, we are now in a position to examine how the level of risk might change in future and what the Council's priorities should be in responding to these.

DEFRA and the UK Climate Impacts Programme (UKCIP) help government and businesses incorporate uncertainty into their decision making. UKCIP supports an approach to prioritising risks according to likelihood (the probability of an event occurring as well as its frequency and duration) and its consequence (the impact of that event on buildings, infrastructure and people).

The risk assessment for Central Bedfordshire has been undertaken in two stages. The initial assessment is based on the key risks which have been identified in the CCRA at the national level. The initial risks identified have then be explored in more detailed using a local assessment of the impacts and their potential costs, where appropriate.

4.1. Initial risk assessment

The CCRA provides a comprehensive and up-to-date evidence-based set of prioritised impacts. Over 700 potential impacts were reviewed and more detailed analysis was undertaken for over 100 of these impacts across 11 key sectors, on the basis of their likelihood, the scale of their potential consequences and the urgency with which action may be needed to address them.

The evidence which has underpinned the national CCRA's assessment of vulnerability has been published in a series of evidence base reports which summarise the findings of literature reviews, stakeholder participation and research studies*.

The risks considered in the initial risk assessment for Central Bedfordshire includes the selection of priority opportunities and threats for each of the 11 sectors identified in the CCRA summary report. In addition, all of the priority risks identified in the built environment specific report[xiv] have been included. This is because the Council has a greater ability to influence new and existing development and because of the opportunity to help shape the emerging Development Strategy. Other risks and opportunities, including secondary issues of lower national importance are included in the CCRA evidence base reports.

Opportunities and threats which are not relevant to Central Bedfordshire (e.g. coastal issues) or that do not form part of the Council's remit (e.g. impacts on the insurance industry) are not considered further. The remaining impacts have clear themes and have been divided into 5 impact categories that allow us to focus our analysis of local risks:

- Flooding
- Water resources
- Overheating
- Subsidence
- Natural environment

* The national Climate Change Risk Assessment and the supporting evidence base can be viewed at: http://www.defra.gov.uk/environment/climate/government/risk-assessment/

Figure 19 presents the nationally identified climate impacts split into the 5 categories. The magnitude of the consequences and confidence levels that can be assigned to the projections are rated in different future time periods. The magnitude of the consequences are categorised based on the relative impact on economic, environmental and social factors. The confidence levels can be broadly summarise as:

- Low: expert view based on limited information, e.g. anecdotal evidence
- Medium: estimation of potential impacts of consequences, grounded in theory, using accepted methods and with some agreement across the sector
- High: reliable analysis and methods, with a strong theoretical basis, subject to peer review and accepted within a sector as 'fit for purpose'

Flooding		2020s	2050s	2080s	Confid.
EN1	Energy infrastructure at significant risk of flooding				
HE10	Effects of floods/storms on mental health				
FL11b	Sub-stations at significant risk of flooding				
FL12a/b	Hospitals and schools at significant risk of flooding				
FL13	Ability to obtain flood insurance for residential properties				
FL7a	Non-residential properties at significant risk of flooding				
FL7b	Expected Annual Damage (EAD) to non-residential property due to flooding				
FL6b	Expected Annual Damage (EAD) to residential property due to flooding				
FL6a	Residential properties at significant risk of flooding				
FL15	Flood risk for Scheduled Ancient Monument sites				
FL11a	Power stations at significant risk of flooding				
FL8a	Roads at significant risk of flooding				
FL8b	Railways at significant risk of flooding				

BU2	Monetary losses due to tourist assets at risk from flooding	
WA10	Combined Sewer Overflow spill frequency	
FL1	Number of people at significant risk of flooding	
TR6	Scouring of road and rail bridges	
TR1	Disruption to road traffic due to flooding	
BU5	Loss of productivity due to ICT disruption	

Water resources

		2020s	2050s	2080s	Confid.
WA3	Reduction in water available for public supply				
WA8	Number of unsustainable water abstractions (total)				
WA5	Public water supply-demand deficits				
WA6	Population affected by water supply-demand pressures				
AG5	Increases in water demand for irrigation of crops				
WA4	Change in household water demand				
EN4	Risk of restrictions in water abstraction for energy generation				

Overheating

	Opportunities	2020s	2050s	2080s	Confid.
BE9	Reduction in energy demand for heating				
HE5	Decline in winter mortality due to higher temperatures				
	Threats				
HE1	Summer mortality due to higher temperatures				
BE3	Overheating of buildings				
EN2	Energy demand for cooling				
BU10	Loss of staff hours due to high internal building temperatures				

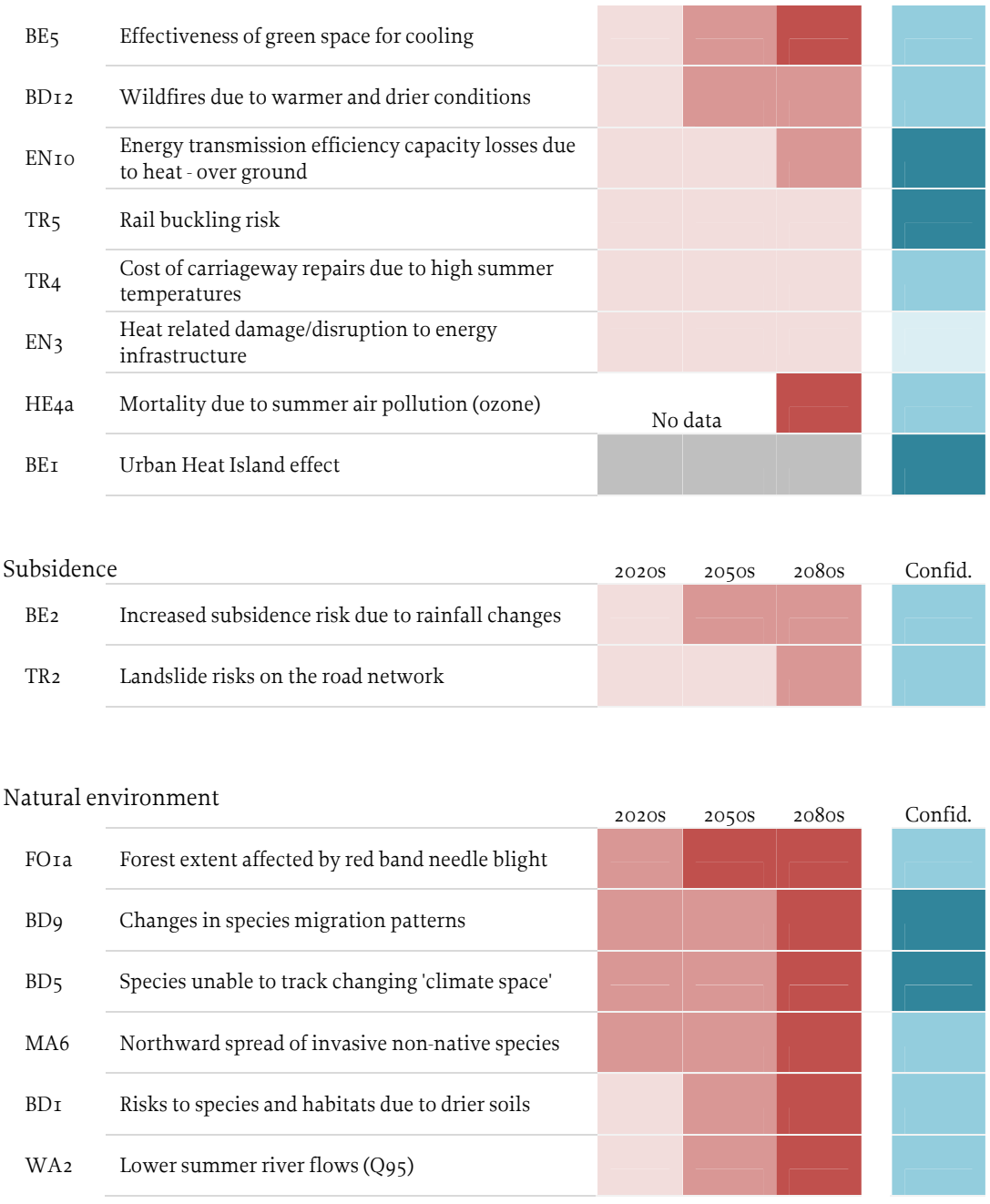


Figure 19: Categorised threats and opportunities identified in the CCRA that are applicable to Central Bedfordshire

The full table of impacts considered in this initial risk assessment are included in appendix 2.

4.2. Local risk assessment

The initial risk assessment has identified which of the UK-wide risks are most relevant to Central Bedfordshire. A number of these are now explored further in a local risk assessment which will look in more detail at the potential consequences and, where appropriate, costs.

The local dimension of each of the 5 impact categories are assessed in turn. The list of impacts from the CCRA is presented alongside the local evidence, which is spatial where available. The spatial data has been provided by the Council and from other sources which are referenced in the text. The GIS resources produced during this study have been made available to the Council and will allow further interrogation at a more refined spatial scale or with the benefit of new information as it becomes available.

It has only been possible to explore a limited number of the total potential risks in more detail. In many cases, it is not appropriate to assess the anticipated impacts at the authority scale (e.g. species migration). In others, our understanding of the risks is limited or the information needed has not been available. Our understanding of the risks that have not been assessed in detail here may well become clearer when the government publishes its Economics of Climate Resilience report and National Adaptation Plan. These risks are not considered further in this section, with more details on each of the impacts, their response functions, adaptive capacity and uncertainty found in the CCRA reports on DEFRA's website*.

The methodology used to define risks and for estimating financial costs is consistent with those used in the CCRA. Use of the national methodology helps to make the study compatible with new research and the evidence that will support further iterations of the CCRA and the National Adaptation Plan. Where this has not been possible, the alternative methodology is described. This means that the level of confidence and uncertainty in the findings and conclusions should be considered to be equivalent to CCRA confidence level unless otherwise stated.

* The national Climate Change Risk Assessment and the supporting evidence base can be viewed at: http://www.defra.gov.uk/environment/climate/government/risk-assessment/

4.2.1. Potential sites for new development

The resilience of new development to climate change can be managed through good design but also by sensitivity to location. Building in areas of higher risk should be accompanied by more stringent design standards where it can be supported by the available evidence, reducing the vulnerability of resident businesses, householders and land uses in future.

In order to amalgamate and update the existing planning frameworks which reflect legacy District Council boundaries, Central Bedfordshire is in the process of developing a new Development Strategy. This will replace the recently adopted North Central Bedfordshire Core Strategy and Site Allocations documents, the 2004 South Bedfordshire Local Plan and also the Luton & South Central Bedfordshire Core Strategy, which was endorsed by the Council as a material consideration but not formally adopted.

The new Development Strategy will determine where future growth will happen in Central Bedfordshire up until 2031, along with the planning policies that will place requirements on development and shape its design.

To demonstrate the impact of site location and sensitivity to climate change, this study assessed those sites considered in the above documents which will help inform the selection of the most resilient development locations in the future. The data in Figure 20 was provided by the Council in February 2012, and whilst many of these sites will be considered as part of the process of putting together the new Development Strategy, the sites under consideration may change as a result of the Council's call for sites.

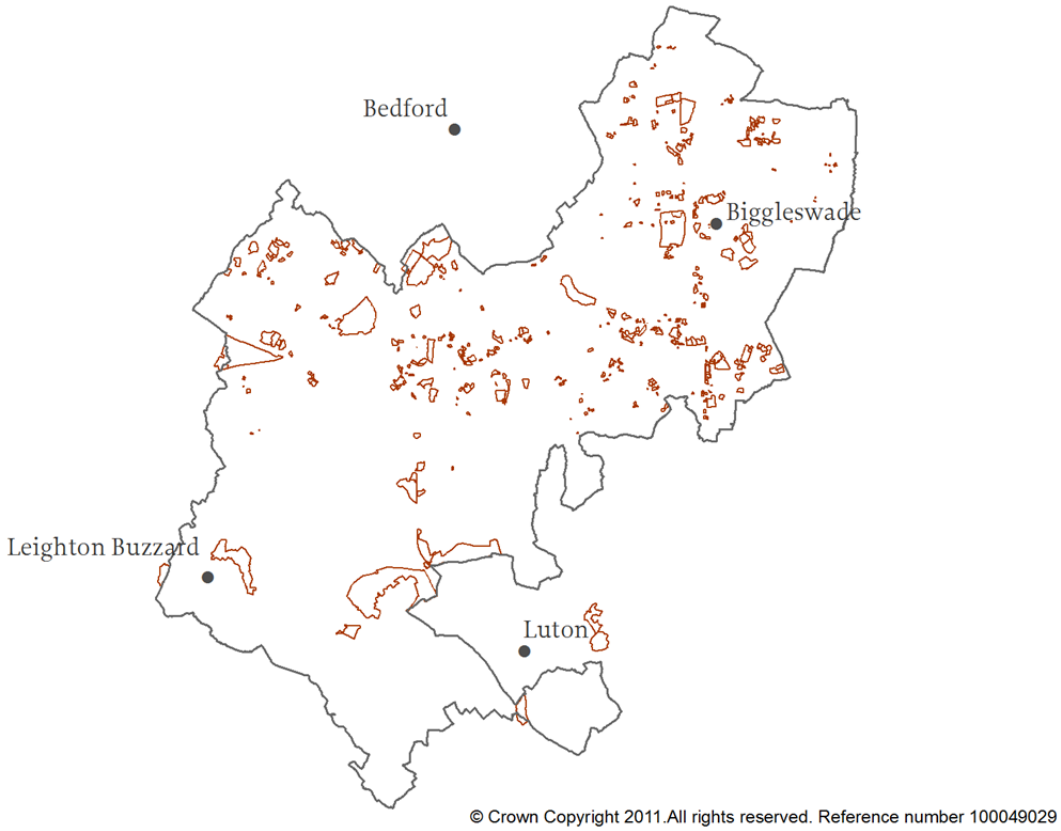


Figure 20: Map showing sites being considered for allocation in the Development Strategy (March 2012)

4.2.2. Vulnerable groups

The impacts of climate change will not affect all groups in society equally. Health, age, income inequalities other social characteristics can contribute to the 'social vulnerability' of a neighbourhood[xv]. For instance, the effects of floods/storms on mental health (see impact HE10 in section 4.1 above) could potentially be more acute here as could the ability of deprived communities to respond themselves to climate impacts. Thought it should only be treated as a guide, we have used Indices of Multiple Deprivation (IMD) as an indicator of how vulnerable an area might be to climate change. The measure takes into account were: income, employment, health deprivation and disability, education skills and training, barriers to housing and services, crime and the living environment. The relative IMD should be factored into planning and decision-making.

Data is available at the lower super output area (LSOA) level. Central Bedfordshire is comprised of 154 LSOAs, each containing around 1,500 people[xvi]. Figure 21 presents the most deprived areas in Central Bedfordshire, with the categories aligned with the terms of the Environment Agency's funding criteria (discussed further in section 5.3. They have been used to identify areas which are likely to be most vulnerable to climate change. The most deprived areas are:

- Dunstable Manshead
- Parkside
- Houghton Hall
- Tithe Farm
- Leighton Buzzard North
- Dunstable Northfields
- Sandy
- Flitwick

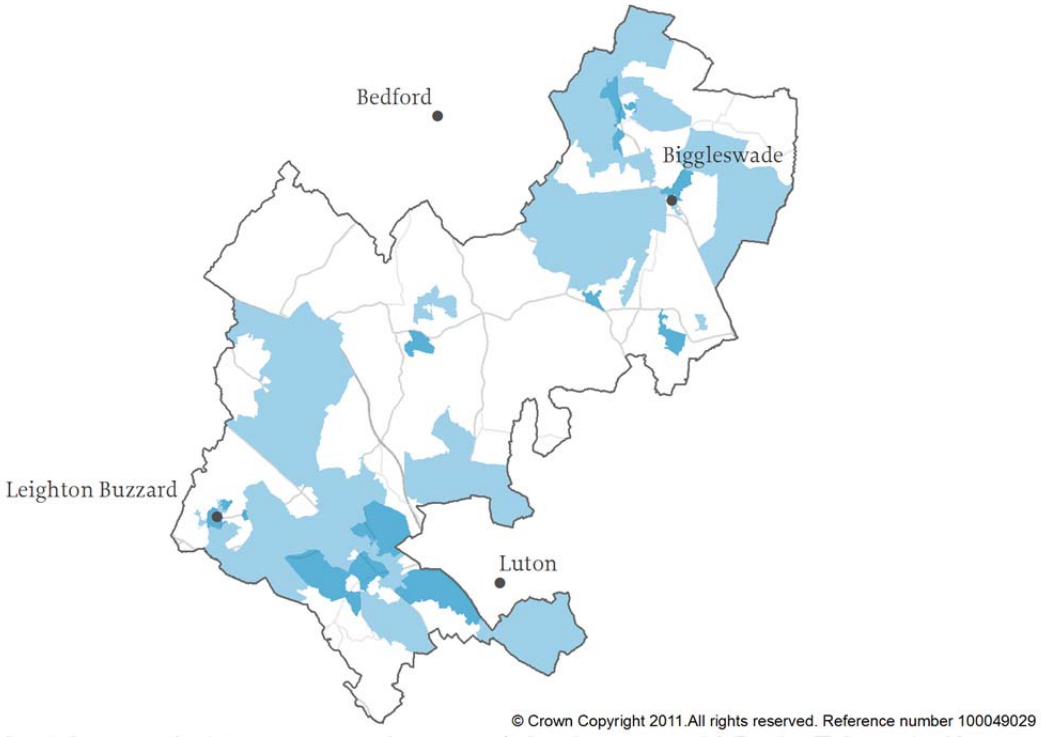


Figure 21: Map showing Indices of Multiple Deprivation by LSOA, 20% most deprived areas in Central Bedfordshire in dark blue, 21-40% most deprived areas in Central Bedfordshire in light blue

4.3. Flooding

4.3.1. Selected threats from flooding in the CCRA

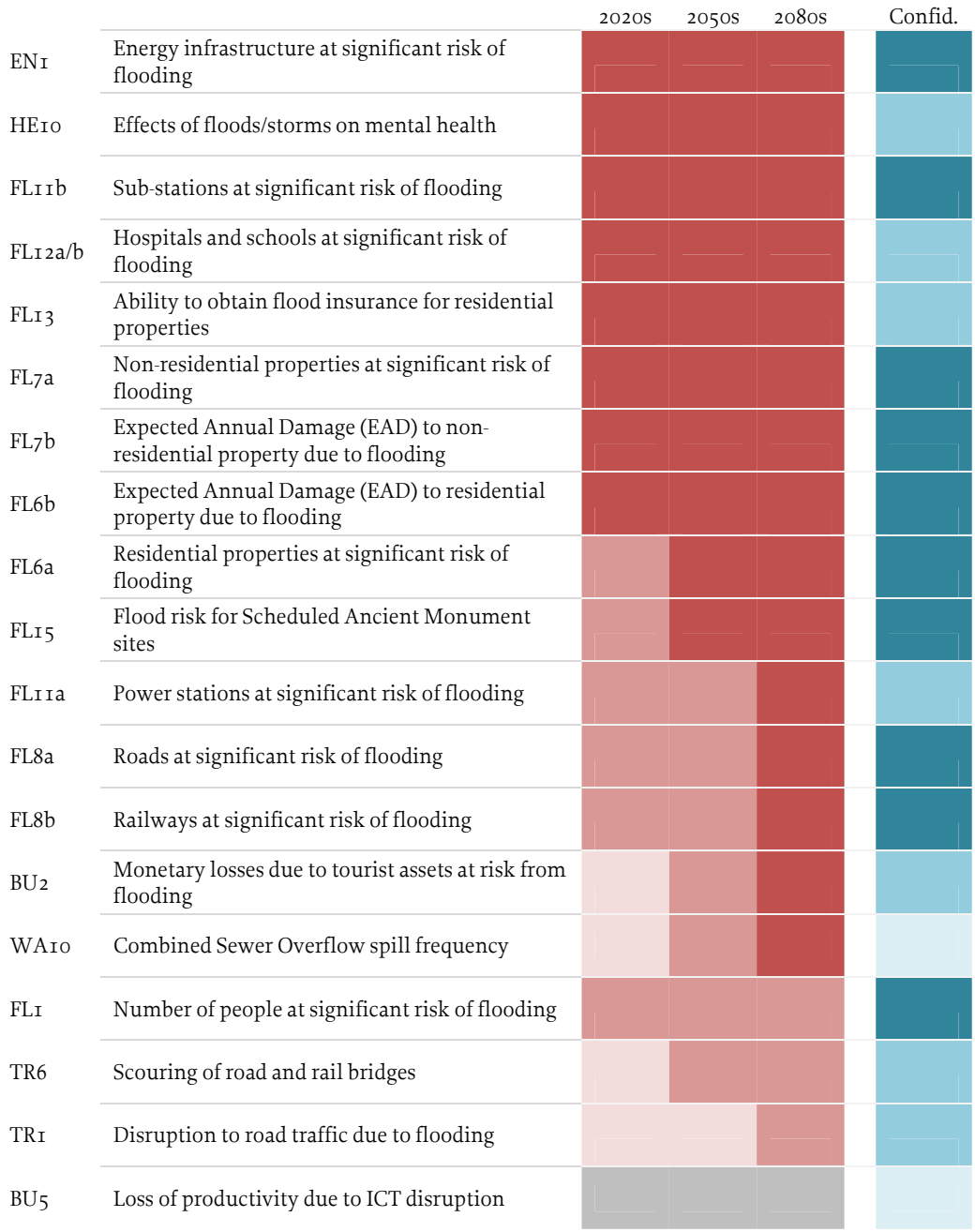


Figure 22: Summary of risks related to flooding that are most relevant to Central Bedfordshire

4.3.2. Local evidence of flooding risks

Figure 23: Map showing areas of Central Bedfordshire at risk from river and surface water flooding, Environment Agency and Central Bedfordshire Council

More than 5,000 homes and 200,000m² of commercial buildings are located in the flood plain (flood zone 2) and are at increasing risk from fluvial flooding. Buildings that are currently in the Environment Agency's flood zone 3 (at risk from a 1 in 100 year event) are considered to already be at an increased level of risk. The risk of flooding from rivers is increasing. Evidence in section 3.3.3 shows that a 1 in 100 event is expected to occur 1 in 63 years in the 2050s and 1 in 48 years in the 2080s; becoming roughly twice as likely. 2,659 homes and 105,000m² of commercial buildings are located in these areas.

The Environment Agency's new Areas Susceptible to Surface Water Flooding map was published in November 2010 and is currently the primary national source of information on surface water risks. The maps used provide an indicative estimate of present day surface water flood risk for 1 in 30 year events. The map suggests that 15,000 homes and 1.1million m² of commercial buildings are located in areas that are susceptible. This represents 9% of all homes and 34% of all commercial floor space. Evidence in section 3.3.3 suggests that a 1 in 30 year event is expected to occur 1 in 18 years in the 2050s and 1 in 14 years in the 2080s.

Some buildings located within the flood plain whilst also being susceptible to surface water risks. These properties are distributed across Central Bedfordshire, with concentrations in some towns and villages. Most at risk of fluvial flooding appear to be Leighton Linslade and Eaton Bray. Surface water flooding is also a significant risk in Leighton Linslade as well as Dunstable, Flitwick, Ampthill, Sandy, Biggleswade and Potton. The GIS data provides more detail.

The legend below is for Figure 23 to Figure **27**, showing buildings at greater risk of flooding.

- Buildings
- Buildings at risk of river flooding (flood zone 3)
- Buildings at risk of surface water flooding
- Buildings at risk of both river and surface water flooding

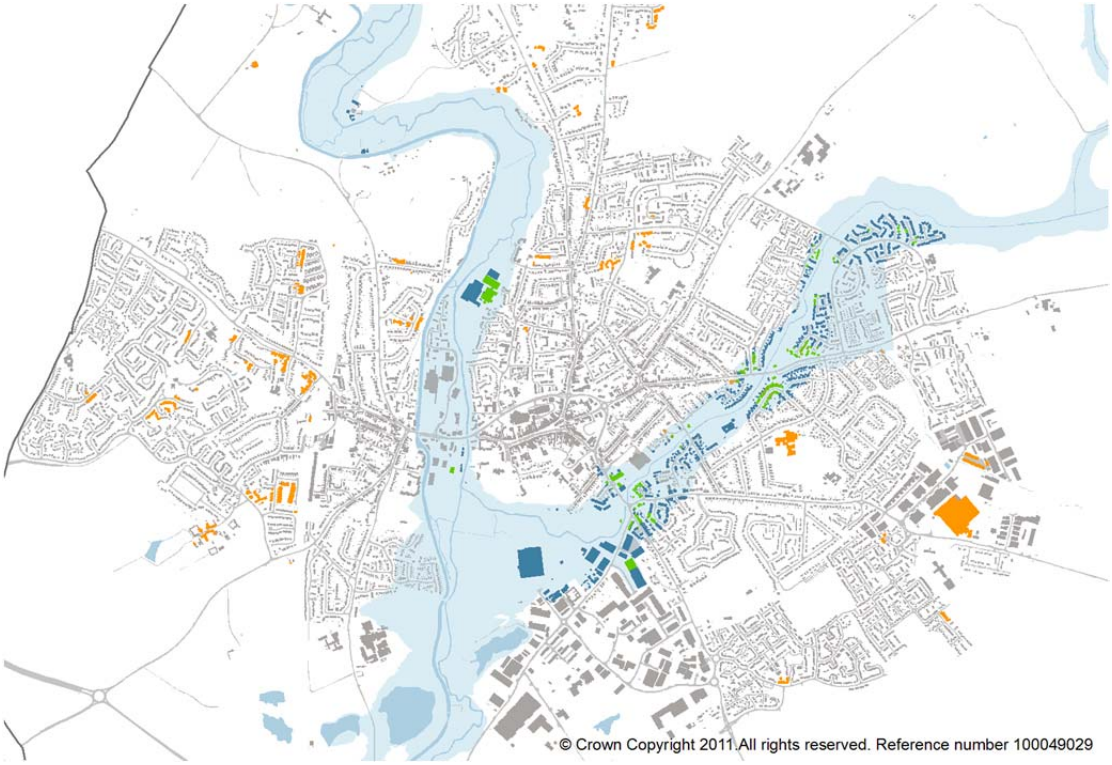


Figure 24: Buildings at risk from river and surface water flooding in Leighton Linslade

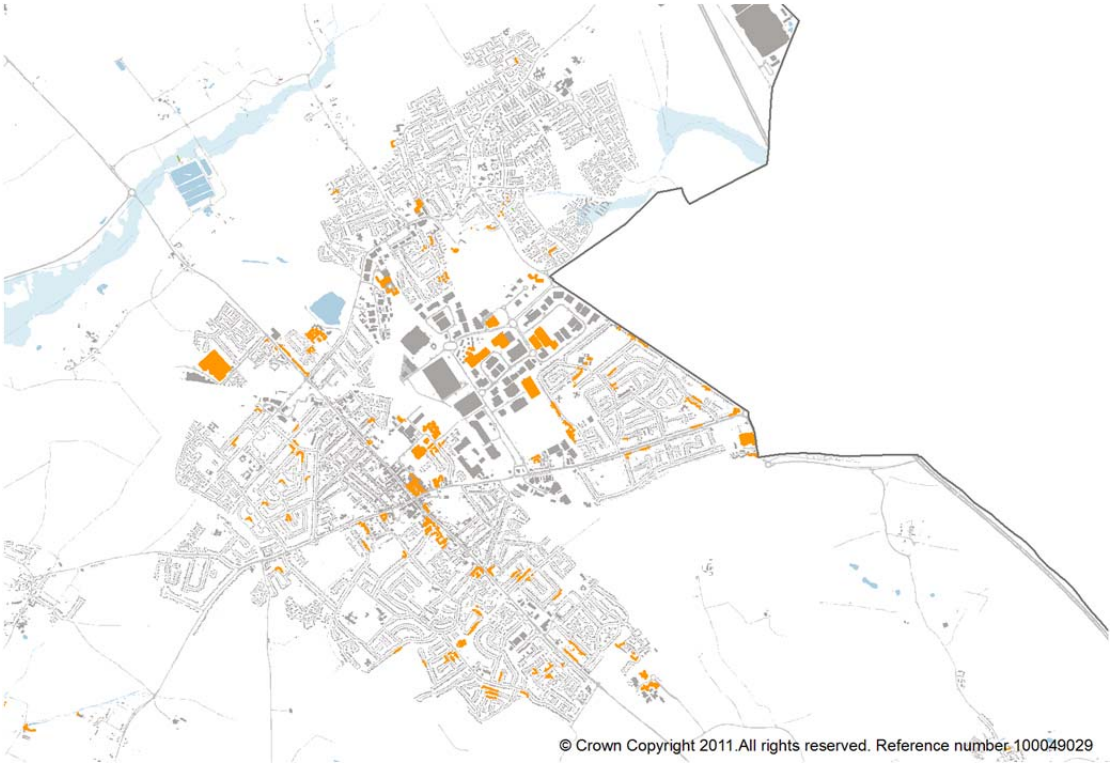


Figure 25: Buildings at risk from river and surface water flooding in Dunstable/Houghton Regis

Figure 26: Buildings at risk from river and surface water flooding in Biggleswade

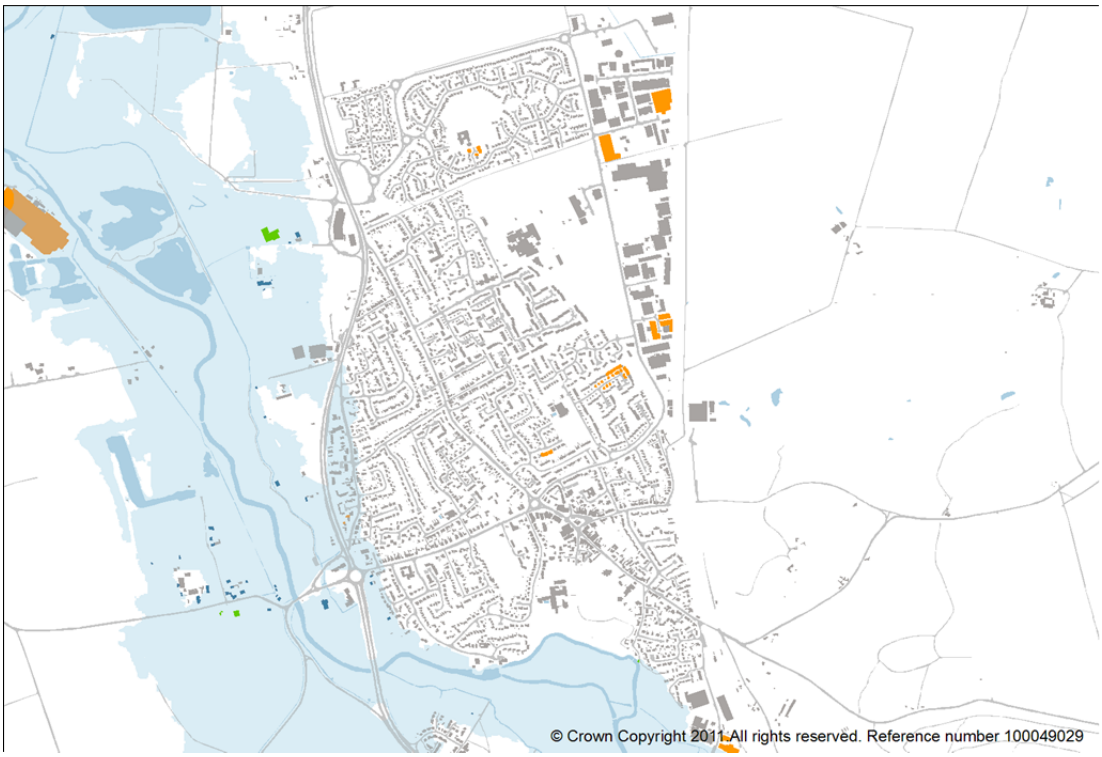


Figure 27: Buildings at risk from river and surface water flooding in Sandy

4.3.3. Vulnerable people and infrastructure

The headline findings reported below can be supported by more detailed appraisal using the GIS data provided.

		No.	Notes
Flood risk zone 3 (1 in 100 year and increasing)	Homes IMD top 20%	63	Majority are in Leighton Linslade
	Homes IMD 21-40%	803	Leighton Linslade, Eaton Bray, Marston Moretaine and Thorncote Green
	Care homes	2	Henlow and Leighton Linslade
	Sheltered homes	10	Eaton Bray
	Schools	2	Eaton Bray Lower School and Hockliffe Lower School
	Hospitals	0	The Luton and Dunstable hospital is not in a flood risk zone
Surface water flood risk areas (1 in 30 year)	IMD top 20%	3,500	Throughout Central Bedfordshire
	IMD 21-40%	2,707	Throughout Central Bedfordshire
	Care homes	18	High proportion in Dunstable
	Sheltered homes	25	Dunstable and Leighton Linslade
	Schools	9	6 in the Dunstable area
	Hospitals	1	Luton and Dunstable hospital in susceptible area and there is a historical precedent of flooding

4.3.4. New development

85 potential development sites are at least partly located in the floodplain. 24 of these sites have potentially more significant constraints with over 50% of their land area located in the floodplain. 9 of these have over 50% of their land area in flood zone 3 and susceptible to flood risk that is already high and increasing.

258 potential sites are susceptible to a degree of surface water flooding.

The list of sites in the flood plain and those at risk of surface water flooding is included in the appendix 3 and can be viewed spatially using the GIS data provided.

4.3.5. Financial cost of increasing risk of river flooding to the residential sector

The risk to homes in flood zone 3 is expected to roughly double by the 2080s. The Environment Agency estimates the value of damages from this change in level of risk to be £450 per household per year[xvii]. We have estimated that there are 2,418 homes in Central Bedfordshire that are in zone 3, equating to an increase in expected annual damage of £1,088,100 per year in the 2080s.

In total there are more than 5,000 homes located in the flood plain (flood zone 2). Many are currently at low risk from serious flooding events. This risk will increase but it has not been possible to estimate the increase in expected annual damage.

Flooding is also a cost to businesses, who are either located in the flood plain or depend on services that can be affected by floods, ie. roads, agriculture and suppliers. While no estimates of the potential cost of flooding to businesses in Central Bedfordshire have been provided, 1 in 5 businesses are affected by disruption and disasters each year, and of these 1 in 10 go out of business

as a result. BLLRF have highlighted that business survival rates can be are improved where a business continuity plan is in place*.

4.4. Water resources

4.4.1. Selected threats to water resources in the CCRA

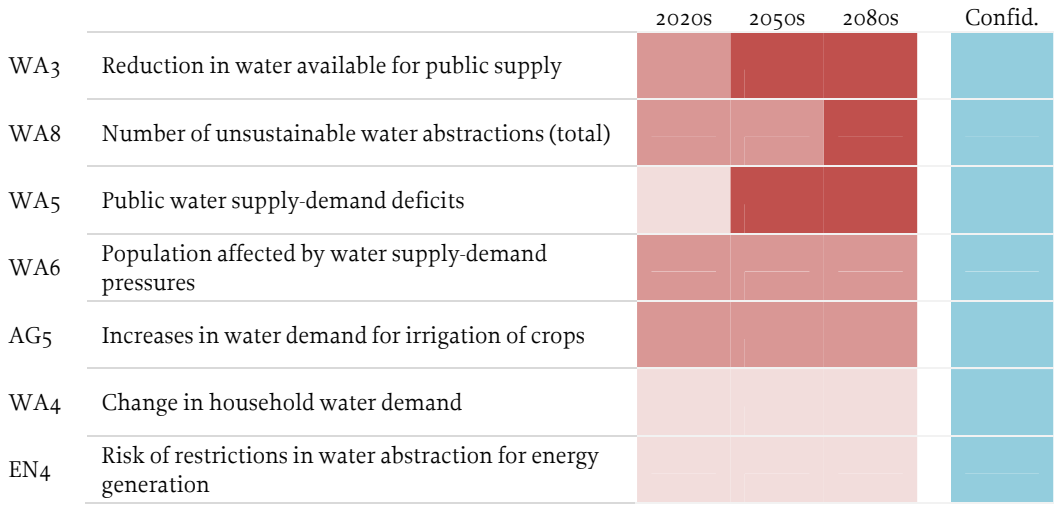


Figure 28: Summary of risks related to water resources that are most relevant to Central Bedfordshire

4.4.2. Local evidence of water resource risks

Most of Central Bedfordshire is located in the Anglian river catchment region, with Anglian Water providing water and wastewater services. Smaller areas in the south of Central Bedfordshire are served by Thames Water and Veolia Water Central and are in the Thames river catchment. Analysis of water resources are usually conducted at the catchment scale. This reflects the scale of integration of water infrastructure. Water supply issues are therefore difficult to assess spatially at the local authority scale and any constraints are likely to affect residents equally, although some sectors will be more sensitive than others. The impact of climate change on water resources has therefore not been mapped for Central Bedfordshire. The results and discussion below are based on findings for the Anglian region with additional information added for the Thames region only where the findings are considerably different.

Water resources are already under pressure across the East of England. Central Bedfordshire is considered to be under serious levels of water stress by the Environment Agency[xviii]. This pressure is expected to increase in future and will reduce the amount of water available for public use; for industry and agriculture; and for the natural environment.

* BLLRF, Survival is not compulsory, available at: http://www.bllrf.org.uk/downloads/survival_is_not_compulsary.pdf

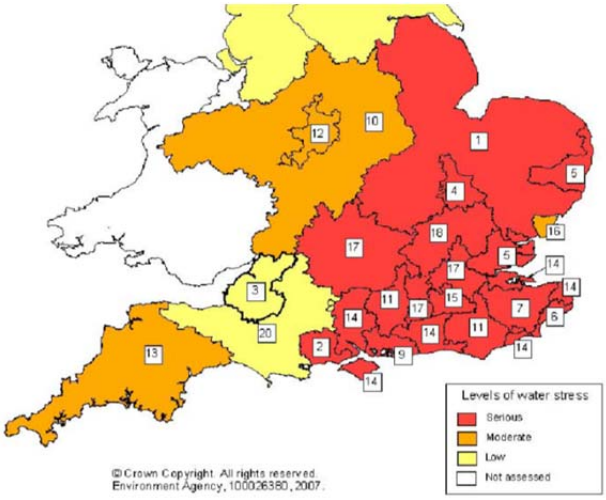


Figure 29: Environment Agency map showing levels of water stress in England (Central Bedfordshire in areas 1, 16 and 17)

The CCRA and the Environment Agency have both assessed the impacts of future pressures on water availability, taking into account climate change, population growth, demand changes and environmental constraints.

The Anglian region currently has a deployable output (water supply available from the water company) of 1,230 million litres per day (Ml/d) and a current surplus of 96 Ml/d; roughly 8% spare capacity. The CCRA has made an assessment of projected changes to deployable output, including a range of contributing factors for each emissions scenario. Their 'wet', 'mid' and 'dry' categories are equivalent to the 10th (unlikely to be less than), 50th (central) and 90th (unlikely to be more than) percentile UKCP09 estimates.

		Wet	Mid	Dry
Anglian	2020s	50	-70	-195
	2050s	-119	-307	-490
	2080s	-245	-368	-490

Figure 30: Change in Deployable Output (Ml/d) for Anglian UKCP09 river basin region

Beyond the 2020s all scenarios project a reduction in deployable output with a consequent reduction in the supply demand balance. The central scenario projects a reduction in deployable output of 30% by the 2080s. When this is taken into account, Anglian's current 8% water surplus changes into a 28% deficit in the 2050s, rising to 38% in the 2080s. The worst case scenario modelled predicts a 57% deficit. These projections do not take changes in population or changes in personal water consumption into account. This is likely to exacerbate the issue although climate change is expected to be the biggest cause of the changes to water resource availability[xix].

		Wet	Mid	Dry
Anglian	2020s	156	-32	-237
	2050s	-114	-417	-715
	2080s	-321	-528	-740

Figure 31: The impacts of climate change alone on water supply surplus/deficit (Ml/d) in each UKCP09 river

Water shortages are generally considered as only affecting non-essential supplies (i.e. gardening) if the reduction in water availability is in the order of 5 to 10%; a reduction greater than this becomes a threat to essential supplies, although exact figures vary between water companies.

An anecdotal consequence of lower rainfall in Central Bedfordshire has been provided by the Council. In 2011 crop roots failed to keep pace with reducing ground water levels, resulting in an increases need for irrigation; even in bean and grain crops. The on-going drought also reduced crop and biomass production. The wet autumn caused an increase in herbicide use to stop tilling and green growth on crops before harvest and on stubble; increasing levels of pollution.

4.4.3. Financial cost of water supply deficits to the region

The CCRA makes an estimate of the cost of climate change to water resources using the cost of supplying water (capital and operational expenditure combined) as a proxy. The central value used in calculations is £50,000 per million litres per day (Ml/d) annually (assuming a 40 year infrastructure lifetime).

Climate change alone (not including factors such as population growth) is expected to create a supply deficit in the Anglian region of 417Ml/d in the 2050s and 528 Ml/d in the 2080s. This is projected to cost £21 and £26 million/year (2010 prices) in each time period respectively. Both Anglian and Thames are among the regions which are projected to face the highest costs.

4.5. Overheating

4.5.1. Selected threats from overheating in the CCRA

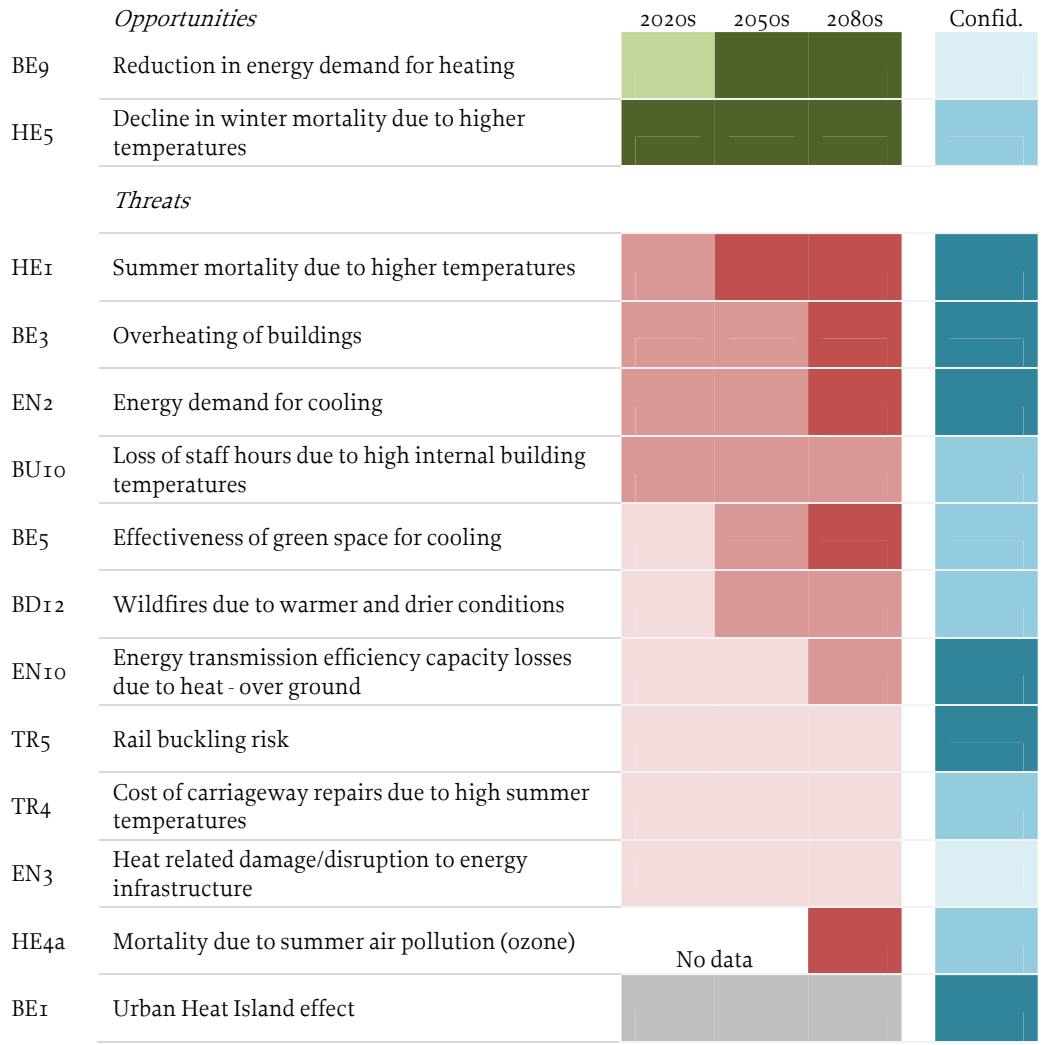


Figure 32: Summary of overheating risks and opportunities from rising temperatures that are most relevant to Central Bedfordshire

4.5.2. Local evidence of overheating risks

The August 2003 heatwave provides the most recent example of how a higher summer temperatures can affect our health and wellbeing. At risk groups, particularly the elderly, were found to be extremely vulnerable to higher temperatures with estimates suggesting an increase in excess summer deaths of 45% for over 75s, compared to 15% for working age people*. Conversely, higher average temperatures in winter have some positives, reducing the number of excess winter deaths; although the potential interrelationships between the phenomena may be more complex.

· National estimates from Environment Agency, 2007, The social impacts of heat waves, Science Report – SC20061/SR6

The spatial projections in Figure 14 indicate that increases in temperature will be similar across Central Bedfordshire. However, local microclimates have the potential to modify the level of risk locally. The Urban Heat Island (UHI) is the microclimate effect created in urban areas when the sun's energy is absorbed by the urban fabric and re-emitted at night. As a result these areas stay warmer than surrounding rural areas, exacerbating the risk from overheating.

Research has estimated the contribution of the UHI to increased summer temperatures in a number of case studies. One study of Greater Manchester suggests that the difference between urban and rural temperatures can be around 3°C during the day and 5°C at night[xx].

The magnitude of the UHI is influenced by urban land-use, the size and shape of buildings, their materials and anthropogenic heat from cars and building services. The most important determining factor is the proportion of green and blue space in and around the urban environment. Another study of Greater Manchester estimated that adding 10% green cover to dense urban areas could help avoid all increases in maximum surface temperatures due to climate change in the 2050s and reduce the impact in the 2080s. Removing 10% would make overheating significantly worse[xxi].

It has not been possible to estimate the potential intensity of the UHI in Central Bedfordshire as it is currently unclear whether it will be significant in the towns and villages found in the district as they are smaller and less dense than the cities where the effect has been documented. Instead the plans of the largest towns in Figure 33 to Figure **36** show the distribution of green space. This can be used to identify areas which are deficient and are more likely to suffer from the UHI relative to others. The maps can also be used to target investment in new green and blue infrastructure, such as street trees, green walls, open water and fountains to the appropriate areas.

Higher external temperatures and the amount of incidental solar radiation both contribute to overheating inside buildings. A building's age, use and design are also important factors and are not necessarily linked to urban density. Impacts related to rising internal temperatures cannot be assessed from a study of urban density and green space and can therefore not be readily inferred from the maps presented in Figure 33 to Figure **36**.

The legend can be used to identify the different land uses in relation in the town centres. Quality and accessible green spaces include public parks, gardens and areas for nature conservation. Mixed green/hard surfaced areas describe the many small green spaces that are found in towns, primarily in private gardens. It is important to note that street trees in areas that are predominantly of hard surfaces may not be shown.

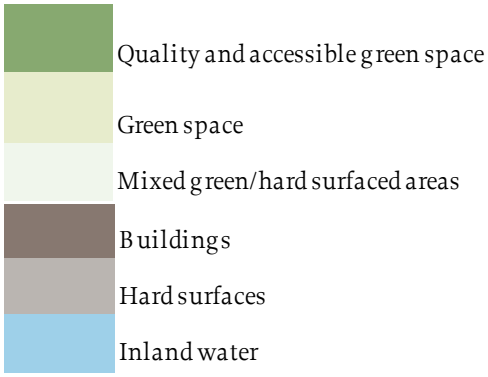


Figure 33: Urban building density and green spaces in Leighton Linslade

Figure 34: Urban building density and green spaces in Dunstable/Houghton Regis

Figure 35: Urban building density and green spaces in Biggleswade

Figure 36: Urban building density and green spaces in Sandy

4.5.3. Opportunities from a warmer climate

Warmer winters will reduce demand for heating, reducing costs which will help relieve pressure on the fuel poor. It may help to reduce carbon emissions although this might be offset by increases in summer cooling demand. There will also be a general reduction in the number of days of snow and ice each year, leading to a reduction in related damages, delays and disruption on the transport network and potentially reduced costs. Longer warmer summers will also have economic benefits for the tourism sector.

4.5.4. Financial costs of overheating-induced loss of staff time

The sectors of the economy most at risk from overheating-induced loss of staff time are wholesaling and retailing, followed by health and education. This is considered to be due to the high staff numbers employed in each of these sectors.

131,700 people are employed in Central Bedfordshire*. Using the methodology set out in the CCRA evidence base report, and assuming a 28°C overheating threshold, the financial cost of lost staff time is expected to increase by £60 million per year in the 2050s and by £200 million per year in the 2080s. It is important to stress that these calculations are based on national averages and the assumption that no autonomous adaptation or behaviour change occurs. Changing standards of thermal comfort and clothing as well as modern buildings services can all help reduce the number of productive days lost.

4.6. Land instability

4.6.1. Selected threats due to land instability from the CCRA

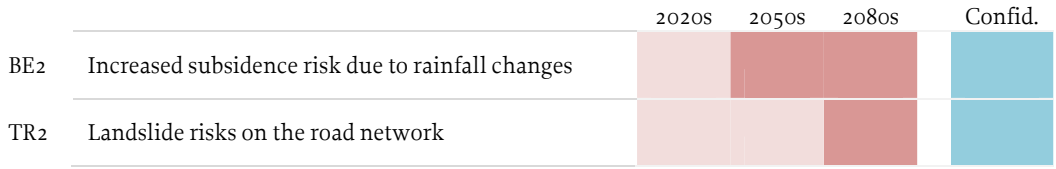


Figure 37: Summary of risks related to land instability and subsidence that are most relevant to Central Bedfordshire

4.6.2. Local evidence

Subsidence of residential buildings is an existing problem in the UK. There were 30,000 notified subsidence claims in 2009 with a total value of £175 million. The majority of claims are made in the South East in areas where clay soils shrink and swell throughout the year. Climate change will increase the likelihood of prolonged dry spells, which increases the amount of shrinkage experienced. Wind is also an important factor in determining how fast soils dry but there is less certainty as to how this might contribute to the overall level of risk. Dry summers have historically led to an increase in claims.

* Data from the ONS official labour market statistics, numbers are for those aged 16 and over for period (July 2010 - June 2011), available at: https://www.nomisweb.co.uk/reports/lmp/la/1946157200/report.aspx

Subsidence due to shrinking soils is primarily a risk for older low rise homes because of the less stringent design standards that have previously been applied. New homes, taller and commercial buildings and infrastructure are all generally considered less susceptible.

The Natural Perils Directory takes into account a range of soil and climate factors in rating the risk of subsidence across the country. More than 18,788 homes (not including caravans or flats) are located in areas identified as being at 'high risk' of subsidence or above.

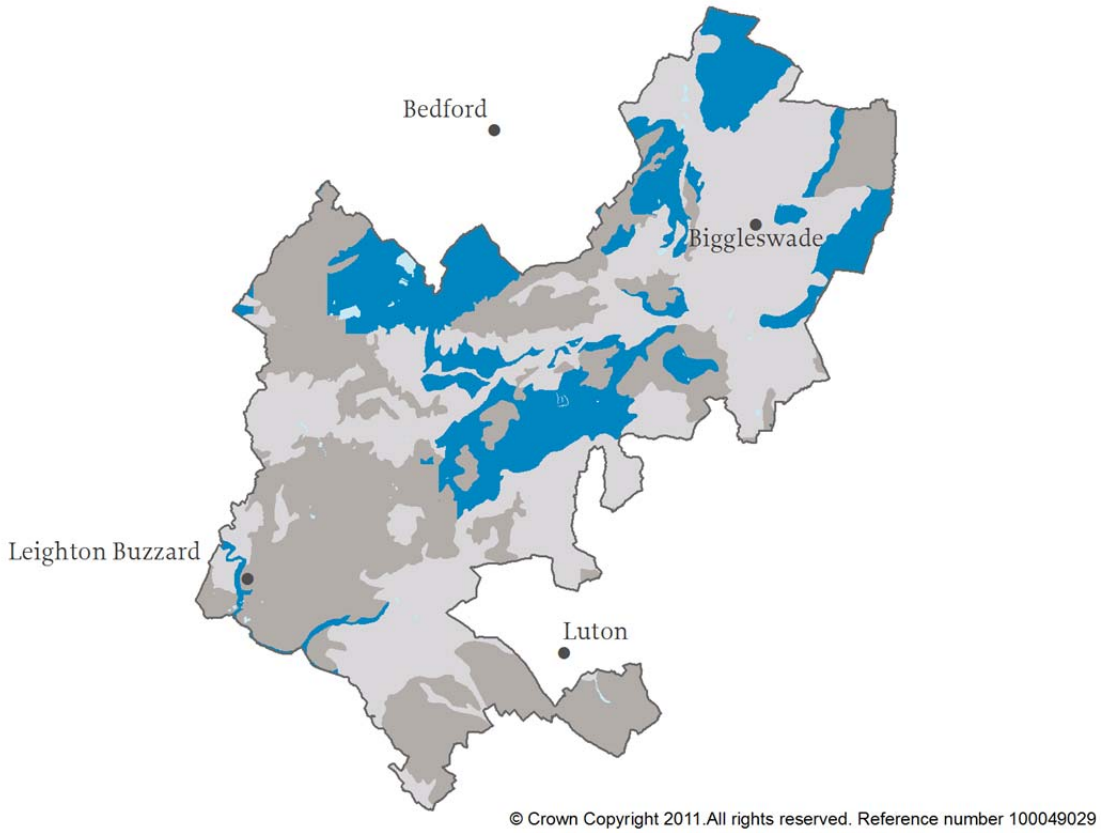


Figure 38: Map showing areas at 'high risk' of subsidence or above in blue, the Natural Perils Directory Cranfield University

The towns and parishes situated in high risk areas include:

Ampthill	Westoning	Barton-le-clay
Shefford	Flitwick	Streatley
Sandy	Houghton Conquest	Sundon
Northill	Upper and Lowe Shelton	Harlington
Ickwell	Marston Moretaine	Blunham
Shillington	Lidlington	Edworth
Greenfield	Leighton Linslade	Studham
Flitton	Cranfield	Caddington

Evidence in section 3.2 indicates that mean summer rainfall is expected to decrease by 18% in the 2050s and by 27% in the 2080s. Applying the calculation methodology used in the CCRA, a 1% reduction in summer rainfall is estimated to result in an extra 274 subsidence incidents per year nationally. A rough calculation, based on the proportion of all at risk homes that are in the area (0.45%), suggests that Central Bedfordshire will experience an additional 22 subsidence incidents per year on average in the 2050s and 33 per year on average in the 2080s. Extremely dry years will result in a higher number of claims.

4.6.3. Vulnerable people and infrastructure

		No.	Notes
In subsidence area classified as 'high risk' or above	Homes IMD top 20%	1,509	Primarily in Shefford and Sandy
	Homes IMD 21-40%	2,476	Marston Moretaine and Northill
	Sheltered homes	0	

The headline findings reported below can be supported by more detailed appraisal using the GIS data provided.

4.6.4. New development

119 potential sites are at least partly located in areas with clay soils that have a high shrink-swell potential. 88 of these are classified for housing or mixed-use development. The list of these sites is included in appendix 3 and can be viewed spatially using the GIS data provided.

4.6.5. Financial cost of increasing subsidence risk in the residential sector

The CCRA includes an assessment of the value of additional subsidence claims. Nationally, increases in annual cost (2010 prices, with no uplift or discounting) are projected to be £52 million in the 2050s and £78 million in the 2080s. These costs are concentrated in areas with soils with a high shrink-swell potential and are therefore mostly felt in the South and East of England.

Our assessment of Central Bedfordshire is indicative of an additional cost of annual claims per year of £220,000 in the 2050s and £330,000 in the 2080s. This is based on an average cost per subsidence incident of £10,000, as used in the CCRA.

4.7. Natural environment

4.7.1. Selected threats the natural environment from the CCRA

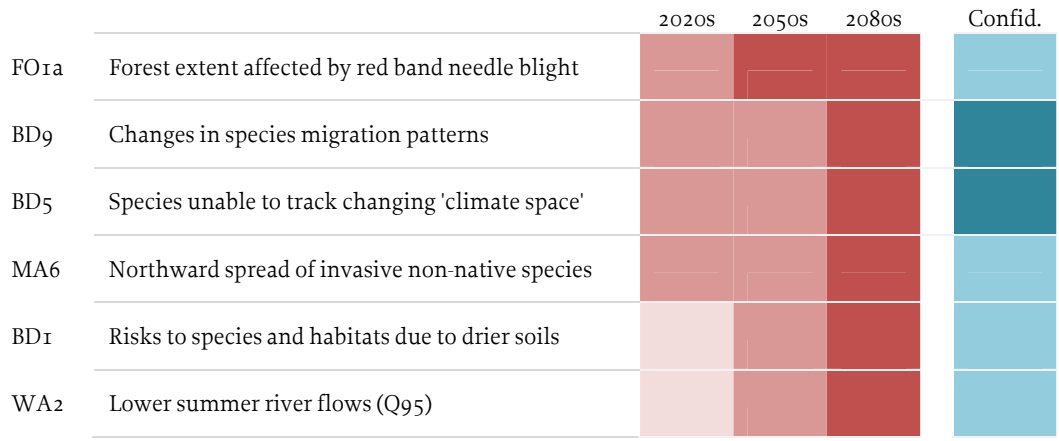


Figure 39: Summary of risks to the natural environment that are most relevant to Central Bedfordshire

4.7.2. Local evidence of risks to the natural environment

The threats selected in the CCRA highlights how a change to conditions in natural habitats is the main driver of the threats. Ecological systems are highly complex, but a number of key trends can be linked to climate change[xxii]. Warming temperatures are encouraging many species to change their geographic distribution, moving northwards or to higher altitudes. Along with changes to the timing of seasonal events, this is causing increasing dislocation between species that depend upon each other. Floods, droughts, changes in local species composition and the way they interact can lead to ecosystem-level changes which can influence the productivity of the landscape in terms of carbon sequestration, water quality, food provision and other essential ecosystem services. Incidences of red band needle blight have been reported in commercial plantation crops in Central Bedfordshire. This indicates that the risk to native tree species from blight type funguses is a problem that is likely to affect the county to an increasing degree.

Migration patterns and changing habitats cannot be readily assessed at the scale of this study. It has therefore not been possible to assess the relative vulnerability of different natural environment assets or to prioritise the delivery of new green infrastructure.

The map in Figure 40 shows natural environment assets in Central Bedfordshire. These are a critical resource (or 'services') in helping species and ecosystems survive in a changing climate, conserve existing habitats, support large and diverse populations and promoting dispersal. Biodiversity and healthy ecosystems can also provide wider benefits and their promotion can form part of Central Bedfordshire's response to the other climate change risks identified in the CCRA.

Central Bedfordshire is assessing what needs to be done to protect and enhance the natural environment through its 'Green Framework for Growth' study. Its findings along with the Green Infrastructure Plan and Biodiversity Strategy should be used to develop a natural environment strategy which responds to the risks identified and recognises the wider adaptation benefits of a coherent and high quality environment (see section 4.5 for example).

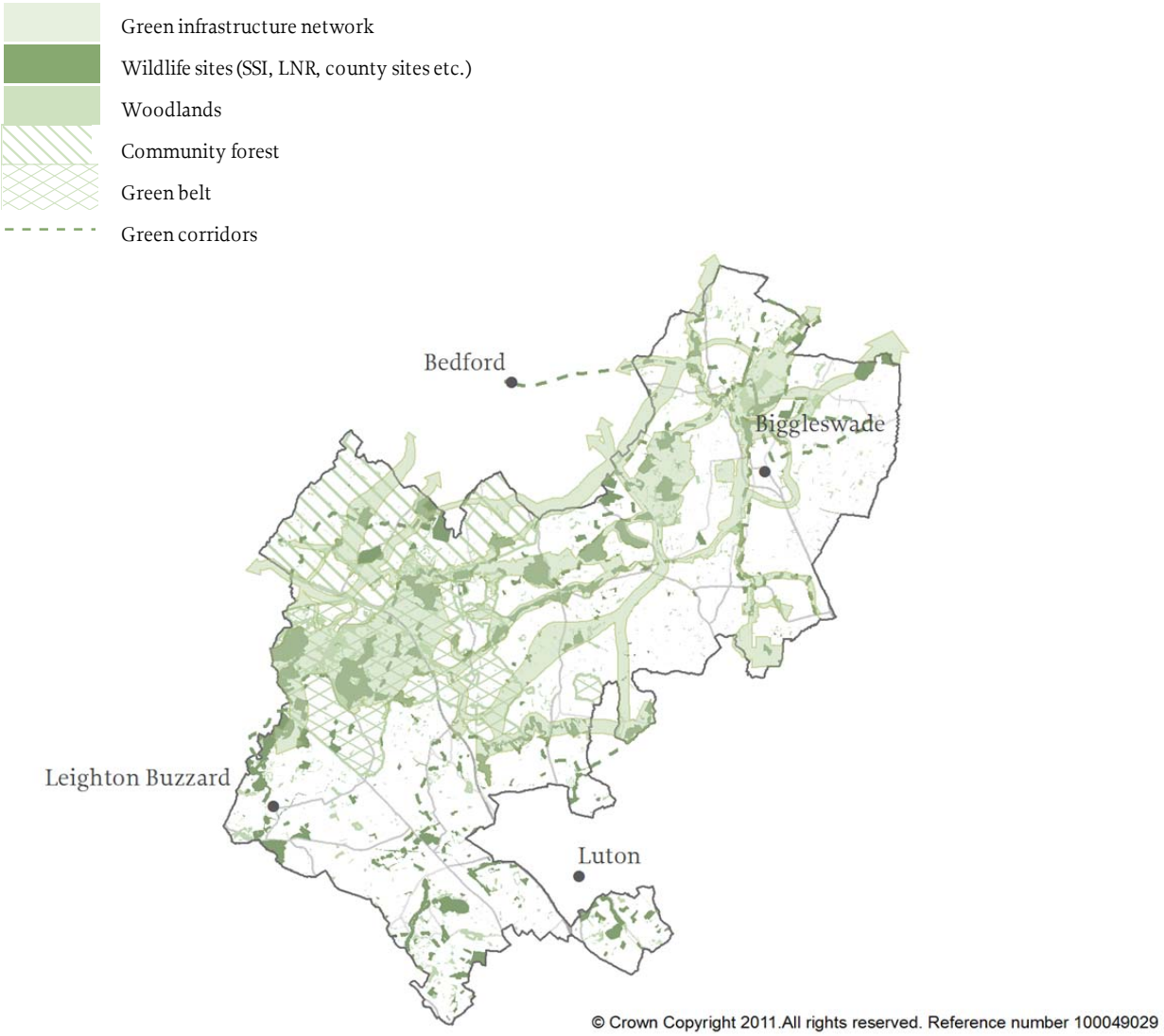


Figure 40: Map showing natural environment assets and green infrastructure network in Central Bedfordshire

4.7.3. New development

155 potential development sites are at least partly located within areas identified as being part of the existing or proposed green infrastructure network. The list of these sites is included in appendix 3 and can be viewed spatially using the GIS data provided.

5.0 Advice and recommendations

This study has used the most up to date evidence of the projected impacts of climate change to identify the most important risks and opportunities for Central Bedfordshire. This section provides advice and recommendations for the Council, as to how the evidence can be used to inform the Council's response. There are 3 areas of policy which can be directly influenced by this study. Our advice and recommendations have been targeted at:

- The Development Strategy – site selection, protection and enhancement of the natural environment and policy supporting climate resilient new development
- The Council's Climate Change Adaptation Plan – managing risks to authority services and directing investment through corporate strategy
- The Local Resilience Forum – contributing new evidence to emergency planning through the Bedfordshire and Luton Community Risk Register

5.1. Advice and recommendations for site selection

Flooding and subsidence are site specific risks. While there is a spatial dimension to the threats to water resources, the natural environment and from overheating, the available evidence has not allowed them to be mapped locally and therefore cannot be used to influence site selection. Instead, they should be taken into account in new development proposals and in determining planning applications.

5.1.1. Flood risk

Flood risks from rivers and from surface water were identified in section 1.1. 85 potential sites were found to be, at least partly, located in the floodplain (flood zone 2). In many cases the area at increased risk of flooding formed only a small proportion of the total site area. In these situations, it is more likely that development can be located in lower risk parts of the site, with the floodplain reserved for compatible land uses, such as accessible green space. Small and urban infill sites which are partly located in the flood zone may be at greater risk because the proportion of the site that is developed might be greater, allowing less space for the integration of flood management features.

24 of these sites are potentially more significantly constrained, with over 50% of their land area located in the floodplain. 9 of these have over 50% of their land area in flood zone 3 (areas with flood risk that is already high and is increasing).

Site allocation should be pursued using the sequential and exception test approach[xxiii] with development in flood zone 1 prioritised and in flood zone 2and 3 where other low risks sites are not viable. . The risk associated with development in flood zone 2 is increasing, with some areas overtime becoming as vulnerable as areas in flood zone 3 are today. This growing risk and the site's potential to successfully mitigate this risk should be taken into account in selecting sites in zone 2.Where some development is to be allocated in the flood plain, the locations should take into account any opportunities for the accompanying flood defences to provide protection to existing buildings at risk. This approach could reduce the overall cost of protecting existing towns at risk and could help to deliver critical infrastructure requirements directly.

258 potential sites are susceptible to a degree of surface water flooding. The surface water flood maps provided by the Environment Agency are considered to be indicative and therefore should be used to support a requirement for more detailed surface water risk assessments. Surface water flood risk should only be considered a barrier to selecting a site where site constraints limit opportunities to manage that risk or more detailed information can support this evidence.

The sites that are at risk from river and surface water flooding are listed in appendix 3 and can be viewed spatially using the GIS data provided.

5.1.2. Subsidence

A subsidence risk was identified in section 4.6 at 119 of the potential residential development sites. Subsidence is primarily a risk for existing developments but the current Buildings Regulations requirements for foundation design take no account of climate change. The risk of structural problems arising may therefore be increasing but further evidence would be required to support an increase in standards. This should be reviewed at such time as relevant national level guidance is published.

As a precaution, sites which are likely to suffer from increasing subsidence risk in future should be given a marginally lower priority in site allocation for housing relative to flood risks.

The sites are located in subsidence risk areas are listed in appendix 3 and can be viewed using the GIS data provided.

5.1.3. Natural environment

The evidence presented in section 4.7 highlighted some of the risks to the natural environment and the network of existing and planned natural environment assets. 155 potential sites were found to be, at least partly, located in existing or proposed parts of the green infrastructure network. Protecting and maintaining the ecological capacity of these sites in a changing climate is a key objective of the Green Infrastructure Plan and Biodiversity Strategy. This objective should be considered through the site allocation process.

While the spatial evidence available cannot be used independently to determine the suitability of potential sites in relation to the natural environment, it does support the principle that development which could compromise the ecological quality or extent of existing or planned green infrastructure should be avoided. Conversely, development that could support the delivery of new infrastructure identified in the Green Infrastructure Plan and Biodiversity Strategy should be prioritised. A separate study by Cranfield University is considering an ecosystems approach to site allocation and the outputs from this could be used to support this objective.

5.2. Advice and recommendations for planning policy

New development proposals should demonstrate how they have considered climate change resilience in their design. Many design requirements can be integrated with the existing sustainable design requirements of the Code for Sustainable Homes. For non-domestic buildings, the appropriate BREEAM credits should also be sought. The impact of the requirements on construction costs and site viability have been taken into account in recommending which credits it is appropriate to target. Where recognised assessment schemes do not support a measurable response to the risks, developers should be encouraged to describe the measures taken to mitigate risks in planning documents, such as the Design and Access or Sustainability statements. A list of requirements could be set out in the validation checklist. This approach will help to minimise the planning burden on developers while providing a robust and measurable response for development managers to assess.

The TCPA, with the Planning and Climate Change Coalition, have developed a set of useful model policies which local authorities can adopt in support of climate change mitigation and adaptation objectives[xxiv]. The policies are generic but could be made both locally specific and spatial using the evidence provided in this report.

Developers proposing new development should be given access to this report and the supporting GIS information. This can be used to inform their baseline assessment of risks and opportunities and can frame their responses and design interventions according to the risks identified.

5.2.1. Code for Sustainable Homes/BREEAM standards

It is recommended that the following credits be made mandatory for all developments which are required to conduct a Code assessment. Evidence of compliance should be demonstrated at the pre-assessment stage for large strategic sites and can be met through a design stage assessment. Their requirements should be aligned with other Code-related planning policies.

Ref	Code name	Credits
Sur 1	Management of Surface Water Run-off from Developments	(already mandatory)
Sur 2	Flood Risk	1
Wat 1	Indoor Water Use	3
Wat 2	External Water Use	1
Eco 2	Ecological Enhancement	1

To achieve the mandatory standards required by Sur 1, surface water drainage systems must avoid, reduce and delay the discharge of rainfall run-off to watercourses and public sewers using sustainable drainage techniques.

Sur 2 promotes development in low flood risk areas. Where development is located in flood zone 2 or 3 measures to reduce the impact are required. In practice, this means locating the habitable parts of dwellings and access routes above the level of flood water. The Environment Agency requires that an allowance of 20-30% be made in drainage systems for new developments as a precautionary allowance for climate change. Emerging research is aiming to develop local flood protection standards influenced by spatial climate projections and the characteristics of individual

catchments. Local planning policy requirements should be reviewed periodically and should consider incorporating the requirements of new guidance.

Wat 1 and Wat 2 aim to reduce water consumption through the specification of water efficient fittings, appliances and water butts. The requirement to achieve 3 Wat 1 credits encourages water demand reductions while not requiring more expensive interventions such water recycling systems. This level of water saving is now included in the Building Regulations.

Eco 2 can be achieved where an ecologist is appointed and recommendations for enhancing site ecology are met. This credit has been selected because its criteria can be achieved on all development sites and because it promotes site-specific enhancements.

5.2.2. Overheating

Building Regulations compliance includes a requirement for new buildings to avoid overheating. The calculation is relatively simplistic, assessing only monthly thresholds, and takes no account of a warming climate. Overheating risk is also not dealt with sufficiently through the Code or BREEAM. New development proposals should therefore explain the measures taken to manage the risk of internal overheating, today and in the future. The following design features could be considered:

- Openable windows
- Dual aspect homes for cross-ventilation
- Consideration of orientation and shading
- Thermal mass
- Facilitating retrofit for thermal comfort
- Increasing green infrastructure with street trees, water features, green roofs and walls

5.2.3. Subsidence

The risk of subsidence from soils with a high shrink-swell potential was identified in section 4.6 and the implications for new developments are discussed in 5.1.2. Reference to and encouraging a response to the risks could be included in policy but because of the level of uncertainty it is not sufficient to require higher standards. However, proposals in vulnerable areas should be asked to include a subsidence risk assessment and for the development to respond accordingly.

5.2.4. Natural environment

Delivery of new green infrastructure and maintenance of the size and ecological quality of existing resources should continue to be a local priority as should recognition of its ability to contribute to wider climate change resilience and carbon reduction. New development may be able to contribute to this through planning conditions and Community Infrastructure Levy (CIL) contributions. Policy should consider how this might be achieved – potentially related to delivery of elements of the green infrastructure network.

5.2.6. Design guidance

Design guidance in an SPD could be helpful in advising applicants on the availability and use of proven adaptation measures in complying with policy. It would also be support development managers in pre-assessment discussions and determining applications.

A range of published guidance documents could be used to help identify adaptation measures. Climate change adaptation by design: a guide for sustainable communities[xxv], published by the TCPA provides a non-technical overview of measures at the building, neighbourhood and strategic scales.

5.3. Advice and recommendations for the Council's Climate Change Adaptation Plan

The Council's Climate Change Strategy acknowledges the risks of climate change to Central Bedfordshire and sets out strategic goals and targets for reducing carbon emissions and for increasing preparedness.

> *"The Council's vision is to deliver a robust, cohesive and actionable response to mitigating and adapting to climate change across the authority and Central Bedfordshire area."*

The strategy sets out the Council's strategic goals and sets out important ideas and themes which will need to be carried through into the Climate Change Adaptation Plan:

- Governance and ownership – a management board should oversee the Climate Change Strategy and must be responsible for creating the institutional structures which will develop and drive forward the Plan
- Integration with wider objectives – work to deliver other core strategies and plans should exploit any opportunities to deliver adaptation measures. Adaptation actions should prioritise infrastructure which delivers multi-functional benefits or improved prospects for sustainable growth, e.g. green infrastructure
- Working in partnership – engaging with partner organisations in the public and private sectors to mainstream adaptation in decision-making and to identify how projects can be delivered together
- Climate change is a cross-cutting issue – all departments should use this evidence base to explore the potential consequences of climate change to their service

The advice and recommendation for corporate policy below could be used to help ensure the Adaptation Plan is effectively implemented.

5.3.1. Management Board

A new or existing (such as the Risk Matters group) management board made up of key managers with specific expertise or responsibility for delivering the Climate Change Strategy should be given responsibility for delivering the Adaptation Plan and the actions that are recommended. It should have responsibility for ensuring that:

- The Climate Change Adaptation Plan is prepared and endorsed by the Council. It should include a prioritised list of adaptation measures and the appropriate routes for delivery
- The risks identified are acknowledges and communicated to each department, communities and strategic partners
- The local evidence base is kept up to date following publication of the Economics of Climate Resilience, National Adaptation Plan and future editions of the CCRA

- Records of weather related incidents and impacts on local authority services should be maintained and used to supplement the local evidence base
- The local evidence base is taken into account when the Council is designing projects, programmes and plans across all services, strategic partners and the Local Resilience Forum
- Each department considers and responds to the consequences for service delivery internally. Departments should be required to report back to the management board throughout this process, for support and for critical scrutiny

5.3.2. Working in partnership

The Central Bedfordshire Carbon Reduction Working Group (CRed WG) brings together a range of key organisations to act on and oversee the commitments made on climate change mitigation. A parallel Adaptation Working Group could be a useful forum for implementing the Adaptation Plan. It would focus on reducing risks while the Local Resilience Forum (BLLRF) would continue to plan for emergencies. A number of existing relationships will be influential in managing climate change risks, including utility, environment and transport partners.

Below, the importance of strong relationships with the Environment Agency and water utilities are highlighted.

5.3.2.1 The Environment Agency

The Environment Agency has changed the funding model and criteria by which it establishes how much funding will be allocate to specific flood management schemes. The Flood Defence Grant in Aid (FDGiA) grants funding according to the number of households protected, the damages avoided, and crucially, the wider environmental benefits from the project; including habitat creating and river restoration. In addition, the Environment Agency has a Catchment Restoration Fund* for England which supports projects that reduces pollution and improves the landscape around rivers.

These funding opportunities can help meet the new obligations on local authorities under the Flood and Water Management Act and offer the potential to link flood management with environmental projects that could deliver the ambitions of the Green Infrastructure Plan and the Biodiversity Strategy. The benefit of these schemes could also benefit other organisations who might be able to provide funding in support of their own objectives. For instance, flood defences which also protect energy infrastructure or green infrastructure that improves water quality and reduces costs for water companies. Consideration should be given to how public (including CIL), private and community funding sources can be combined to maximise resilience to flood risk.

5.3.2.2 Water utilities

Regional drought plans are being prepared by utilities across the country. The plans set out a framework for dealing with droughts of different types and severity, outlining how the impacts of drought should be managed and the triggers actions. The plan for the Anglian region is being finalised and will be published soon. The Council should work with the utilities to identify water resource management projects which deliver on common objectives. Where possible, multiple benefits should be sought, for example by combining water resource management with green infrastructure or sustainable drainage schemes.

* More information on the Catchment Restoration Fund can be viewed here: http://www.environment-agency.gov.uk/research/planning/136182.aspx

5.3.3. A tree policy

Trees in and around urban areas provide significant co-benefits, supporting a range of adaptation and other corporate objectives. Existing urban green and blue infrastructure should be protected and maintained. In addition, new street trees and other green features should be actively encouraged and should be integrated into urban areas where possible.

The London Borough of Islington has a policy which has been highlighted as a model for promoting trees in urban areas*. The policies cover the maintenance and protection of existing trees and the planting of new trees in appropriate areas. In addition, it provides clear advice to officers in implementing the policy and for managing tree related liabilities, such as subsidence. An alternative example is the Mayor of London's RE:LEAF programme† which is proactively seeking to increase tree cover through dialogue with new development and through provision of grants to community groups. A dialogue approach, supported by planning policy, could be taken to encourage businesses to increase the amount of green space, green roofs and the number of trees within their curtilages.

Planting news trees in appropriate areas is a practical and cost-effective way of introducing green infrastructure to urban areas but there are many other options which can deliver similar benefits. While opportunities may be more limited, the potential for new urban forests, parks, ponds and green roofs could also be explored. The Council should consider the benefits that a tree policy for Central Bedfordshire could bring and use policy and other delivery mechanisms to support implementation.

5.3.4. The Community Infrastructure Levy and infrastructure

CIL can be used to raise a proportion of the funds needed to deliver local infrastructure. It could be used to contribute towards flood defences, the green infrastructure network, a retrofit programme or urban greening projects which would increase the resilience of Central Bedfordshire to climate change. To do so, the development vision used for setting the CIL should include the Council's climate change objectives and a prioritised list of infrastructure that needs funding should be identified on the CIL charging schedule.

Where new development sites are allocated that will require new flood defences, these should be added to the schedule. Since it is likely that the list of infrastructure projects requiring funding in Central Bedfordshire will far exceed the available money, opportunities for using other sources of private and community-based funding should be explored.

Infrastructure projects on the CIL charging schedule should aim to deliver on multiple council objectives, thereby increasing value for money. Providing surface water flood storage capacity through a park redevelopment scheme is a good example of this. The Council might go further by thinking about how different types of infrastructure, such as revenue generating renewable energy, could be used to subsidise others. Rather than being a cost, infrastructure needed to improve resilience to climate change could be used to unlock stalled or less viable development projects. It is recommended that these opportunities be considered as part of the CIL and infrastructure delivery process (see also section 6.0).

* The policies contained in the Tree Policy for Islington are available at:
http://www.islington.gov.uk/DownloadableDocuments/Environment/Pdf/greenspace/tree_policy_2011.pdf
More information on the policy and its evidence base is available here:
http://www.islington.gov.uk/DownloadableDocuments/Environment/Pdf/greenspace/a_policy_for_trees_in_islington.pdf

† More information on the RE:LEAF programme can be found at:
http://www.london.gov.uk/priorities/environment/greening-london/releaf-london

The costs of infrastructure which are not currently known may become clearer when the Economics of Climate Resilience report due later this year and the National Adaptation Plan are published.

5.3.5. Risks and opportunities by local authority departments

Each local authority department will need to consider how the impacts and opportunities identified in this report could affect the service they provide. A comprehensive assessment of those consequences should be undertaken with the outcomes used to inform an adaptation action plan which identifies priority issues and the resources required for managing them.

UKCIP provide a number of decision making support tools* that can support this process. The *Adaptation Wizard* can be used to structure these assessments and to develop a climate change action plan. The *AdaptME toolkit* can be used to understand decision-making under uncertainty and to evaluate adaptation activities.

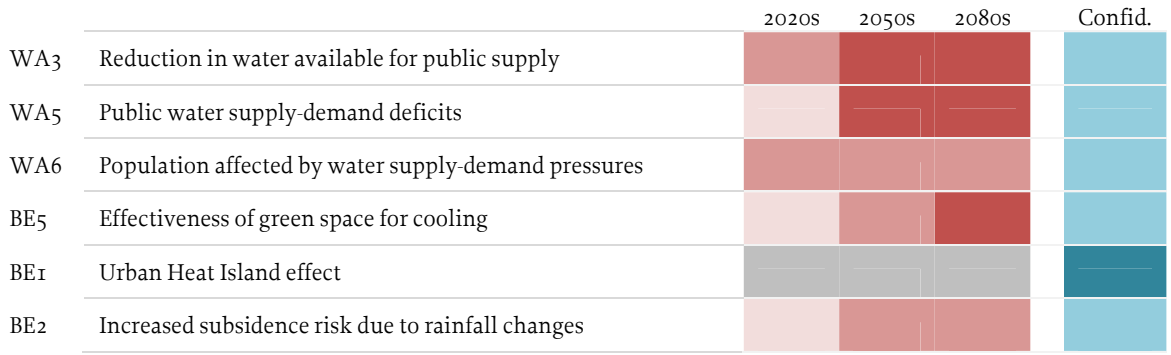
The selected risks identified in the CCRA presented in section 4.1 should be used as the basis for the departmental risk assessments. The tables below identify which of the CCRA risks and opportunities are considered to be most relevant to each department.

5.3.5.1 Economic Growth & Regeneration

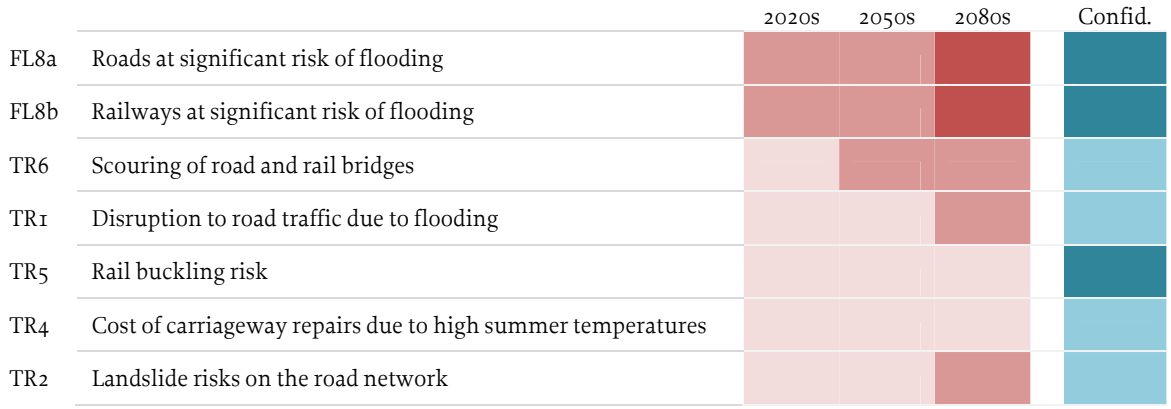
	Opportunities	2020s	2050s	2080s	Confid.
BE9	Reduction in energy demand for heating				
	Threats				
EN1	Energy infrastructure at significant risk of flooding				
FL11b	Sub-stations at significant risk of flooding				
FL13	Ability to obtain flood insurance for residential properties				
FL7a	Non-residential properties at significant risk of flooding				
FL7b	Expected Annual Damage (EAD) to non-residential property due to flooding				
FL6b	Expected Annual Damage (EAD) to residential property due to flooding				
BU2	Monetary losses due to tourist assets at risk from flooding				
TR1	Disruption to road traffic due to flooding				
WA3	Reduction in water available for public supply				
WA5	Public water supply-demand deficits				
AG5	Increases in water demand for irrigation of crops				
BE3	Overheating of buildings				
BU10	Loss of staff hours due to high internal building temperatures				
BU5	Loss of productivity due to ICT disruption				

* A suite of UKCIP tools can be accessed free at: http://www.ukcip.org.uk/tools/

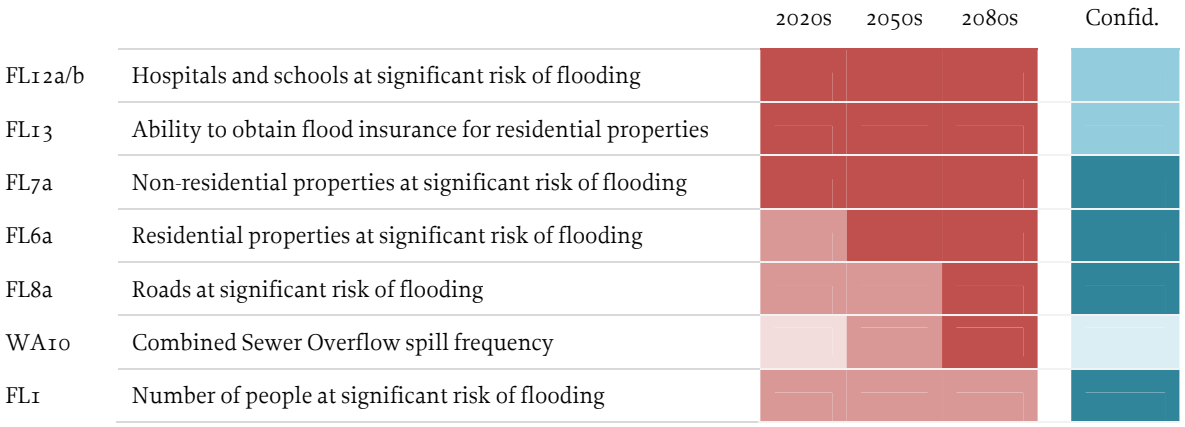
5.3.5.2 Planning



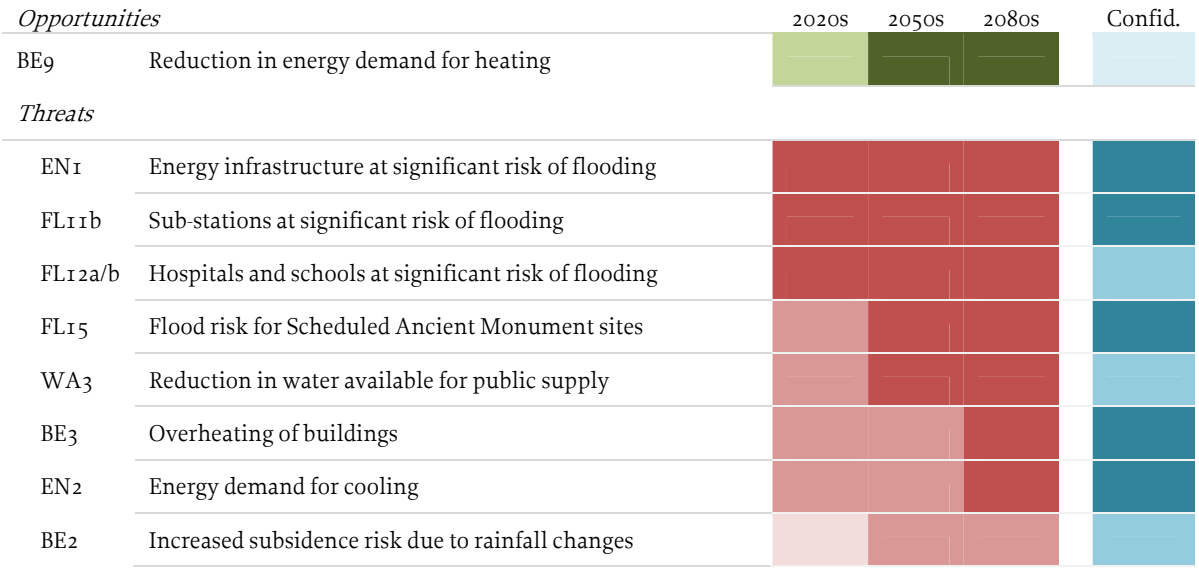
5.3.5.3 Highways & Transport



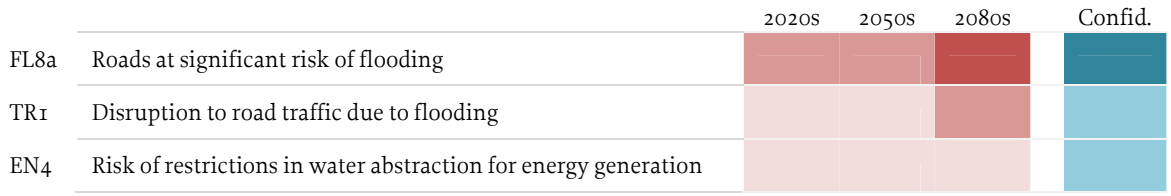
5.3.5.4 Community Safety & Public Protection



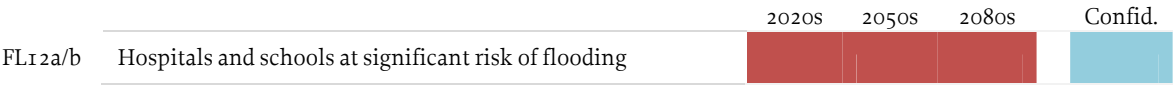
5.3.5.5 Assets



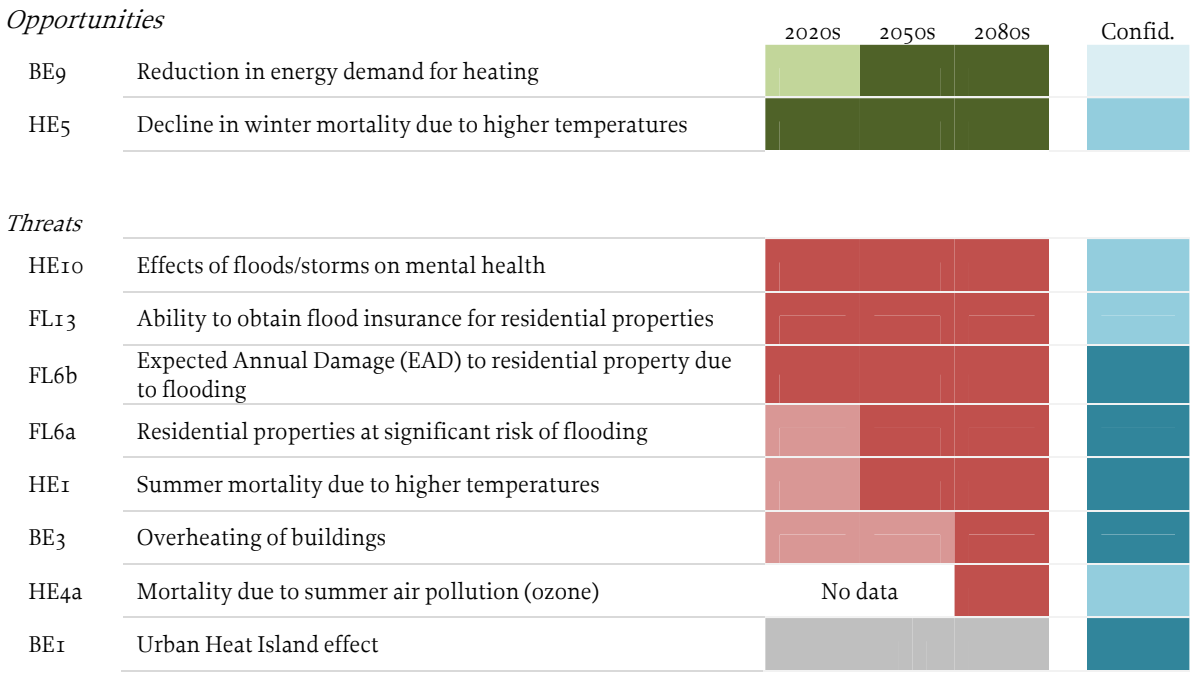
5.3.5.6 Waste services



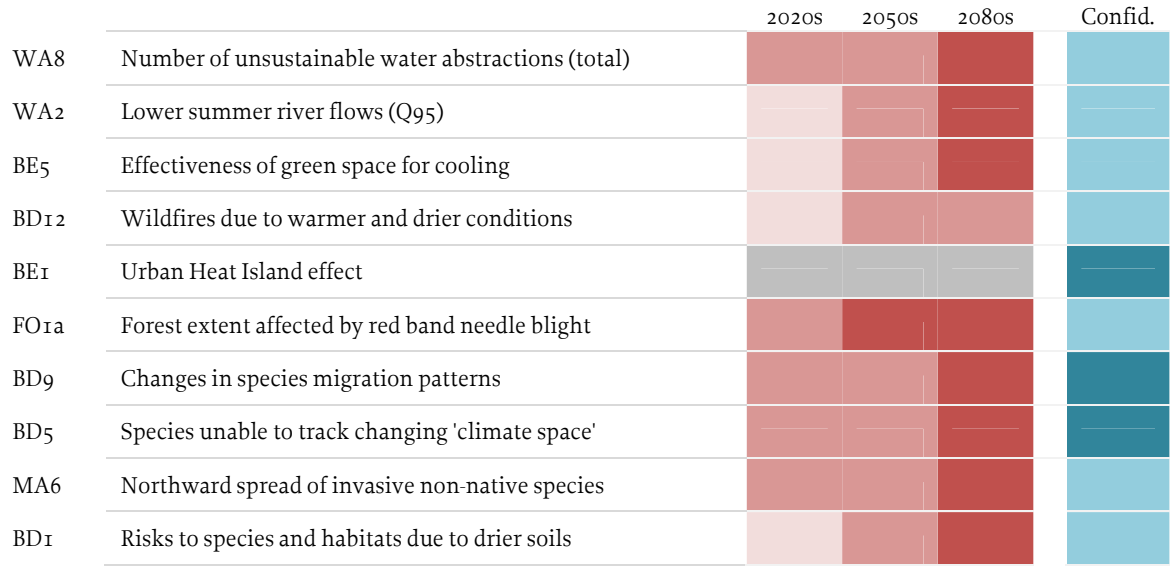
5.3.5.7 Children's services



5.3.5.8 Social care health & housing



5.3.5.9 Strategic planning and Countryside Access services



5.3.5.10 Leisure services

		2020s	2050s	2080s	Confid.
WA3	Reduction in water available for public supply				
FL15	Flood risk for Scheduled Ancient Monument sites				

5.4. Advice and recommendations for the Bedfordshire and Luton Local Resilience Forum

The Local Resilience Forum should make use of the evidence presented here when next updating the community risk register. The supporting spatial data which has been made available to the Council could also be used to help identify locations at particular risk, informing emergency planning and logistics. Future updates of the CCRA evidence base and the forthcoming NAP should be used to update the risk register periodically, ensuring the latest information on climate change is used to manage and prioritise the allocation of resources.

The table below includes the CCRA risks which are considered to be most relevant to the Local Resilience Forum:

		2020s	2050s	2080s	Confid.
EN1	Energy infrastructure at significant risk of flooding				
FL11b	Sub-stations at significant risk of flooding				
FL12a/b	Hospitals and schools at significant risk of flooding				
FL6a	Residential properties at significant risk of flooding				
FL11a	Power stations at significant risk of flooding				
FL8a	Roads at significant risk of flooding				
FL8b	Railways at significant risk of flooding				
FL1	Number of people at significant risk of flooding				
TR1	Disruption to road traffic due to flooding				
HE1	Summer mortality due to higher temperatures				
BE3	Overheating of buildings				
BD12	Wildfires due to warmer and drier conditions				
EN3	Heat related damage/disruption to energy infrastructure				
TR2	Landslide risks on the road network				

6.0 Delivering climate change adaptation

Although a detailed strategy for the delivery and funding of the response to the risks is outside the scope of this study, it is important to understand the range of constraints and opportunities that exist.

This study provides much of the evidence needed to enable the Development Strategy, the corporate Climate Change Strategy and the Local Resilience Forum to clarify what they actually want to achieve. The next stage is to find ways to make it happen. While the public sector finds itself constrained by funding cuts, a set of tools have been made available that can, if well-coordinated, enable local authorities and their partners to create a positive cycle of investment and delivery.

6.1. A shared vision for climate change

The three focal points for action (development planning, corporate activity and responses to emergencies) need to work together to develop a shared vision of how Central Bedfordshire will respond to the identified risks, using this study as the evidence base. The vision and the evidence base together will enable a set of priorities and actions to be confirmed that respond to the advice and recommendations presented in section 5.0 of this study.

6.2. Funding and delivery

The coalition government has put in place a number of tools and funding streams that can be used to fund delivery of adaptation measures. These include CIL (see section 5.3.4), New Homes Bonus and the anticipated Business Rates Retention. Individually and together these provide the means for the council and its partners to accumulate funds to deliver climate change related infrastructure in a coordinated way.

The mechanism by which flood defence schemes are agreed and funded has changed recently, with a focus on combining public and private funding to implement a wider number of schemes than has been possible previously. Similar thinking could be applied to other risks and could help to lever in additional funding from utilities or businesses affected by climate change: the shared vision might be the mechanism by which these opportunities are identified.

The financial tool, developed as part of this study, will help these options to be evaluated and funding gaps to be identified in much the same way as wider infrastructure gaps will be identified as part of the CIL process.

It will then be important to find the right vehicle to coordinate delivery and to maximise the benefits from the available money. The powers in the Localism Act provide a useful opportunity. They allow local authorities to set up companies, trusts and other investment funding bodies to deliver specific objectives, including the infrastructure needed to respond to climate change. Such special purpose vehicles could enable money from growth, regeneration, private and public sources to be spent on delivering the infrastructure identified as critical to dealing with the impacts of climate change. While we have focussed on climate change here, the same process can be used for all kinds of infrastructure, from road and public transport to low carbon energy.

Abbreviations

CCRA - Climate Change Risk Assessment

EA - The Environment Agency

ECR - Economics of Climate Resilience

FDGiA - Flood Defence Grant in Aid

IMD - Indices of Multiple Deprivation

LCLIP - Local Climate Impacts Profile

LSOA - Lower Super Output Area

NAP - National Adaptation Programme

TCPA – Town and Country Planning Association

UHI - Urban Heat Island

UKCIP - UK Climate Impacts Programme

UKCP09 - UK Climate Projections

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