Oxfordshire County Council - Climate resilience

Current and future climate risk and vulnerability and health impacts assessments in Oxfordshire

Oxfordshire County Council

April 2024

Deliverable 2

River Thames at Abingdon Lock

Notice

This document and its contents have been prepared and are intended solely as information for Oxfordshire County Council and use in relation to this Report on findings from current and future climate vulnerability of key thematic areas and health impacts assessments in Oxfordshire

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Client signoff

Client	Oxfordshire County Council
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Contents

Acronyms

CARO	Climate Adaptation and Resilience in Oxfordshire
CCC	Climate Change Committee
CCRA3	UK 3rd Climate Change Risk Assessment
CRI	Climate Risk Indicators
CSGM	Countywide Steering Group Members
EAD	Expected Annual Damage
ETL	Electricity Transmission Lines
GIS	Geographical Information System
LSOA	Lower Super Output Area
MO	Met Office
MSOA	Medium Super Output Area
OCC	Oxfordshire County Council
ONS	Office for National Statistics
RCP	Representative Concentration Pathways
TVERC	Thames Valley Environmental Records Centre
UKCP18	UK Climate Projections 2018

Executive Summary

Preamble

Oxfordshire County Council (OCC), Oxford City Council and the four Oxfordshire District Councils declared a Climate Emergency in 2019, making significant commitments towards Net-zero before 2050[1] as well as climate action to improve climate resilience. Climate change is already impacting on Oxfordshire, increasing the chances of extreme heatwaves, flooding from rivers and surface water and putting pressure on infrastructure systems and environment. Since 2007, the county has experienced 18 significant flood events, 10 named storms, 8 cold snaps, 4 major heatwaves and 3 periods of drought[2]. According to the Climate Change Risk Assessment, direct and indirect impacts from river flooding cause an average of approximately £114 million of damages each year in Oxfordshire[3]. In recent years, heatwaves have emerged as a significant risk with impacts on schools, hospitals and care home settings, as well as on water, energy and transport infrastructure systems. Urgent action is needed to manage the risks of climate change and respond to opportunities to deliver climate action alongside nature recovery, improved infrastructure and service delivery and improvements in health and wellbeing.

Purpose of this report

The purpose of this report is to provide OCC with an understanding of the current and future risks posed by climate-related hazards with regards to four key thematic areas; 1) critical infrastructure, 2) health, communities and the built environment, 3) natural environment and assets and 4) business and industry.

The report provides an overall characterisation of the county and a baseline assessment of the climate in recent years and a timeline of climate-related events since 2000 and impacts in Oxfordshire. Current risk from climate-related hazards is explored nationally and for Oxfordshire, investigating the current impact of heatwaves, flooding, drought, low temperatures and high winds and storms using bespoke risk mapping and existing quantitative and qualitative sources.

A future risk assessment follows, to explore a range of future climate change scenarios in 2050 on a pathway to +2°C and +4°C warming by 2100 and a high-end scenario to understand the potential risk of extreme temperatures in Oxfordshire. A health impact assessment is also completed as part of the future risk assessment to help identify the impact of climate on health and wellbeing. The assessment takes a vulnerability perspective and therefore focuses on the sensitivity of communities and infrastructure exposed to climate hazards and our current capacity to manage risks. It provides detailed mapping of flood risks and heatwave risks, as well as a synthesis of available evidence related to other risks.

Key findings

Current climate-related hazards

- **Average annual temperatures have steadily increased in Oxfordshire since the 19th century with the greatest warming occurring in the last 20 years** (Figure E-1). With one of the longest weather station records in the world at Radcliffe Observatory operated by the University of Oxford[4], the long term and local trends are clear, with average temperatures on the brink of exceeding 1.5°C above pre-industrial records (1851-1900). Our analysis of Met Office data for Oxfordshire and the Oxford record shows that maximum

[1] Enabling a net-zero county | Oxfordshire County Council
[2] Significance is based on incidence records provided by OCC as part of this study.
[3] Based on Expected Annual Damage (EAD) data for West Thames river basin which covers most of Oxfordshire, reported in the CCRA3 supporting research study by Sayers et al., Future-Flooding-Main-Report-Sayers-1.pdf (ukclimaterisk.org)
[4] Oxford Radcliffe Observatory https://www.geog.ox.ac.uk/research/climate/rms/reports.html.

temperatures have increased at a greater rate (+2.3°C) than average temperatures (+1.2°C) since the 19th century. The risks of very high temperatures have already increased significantly due to climate change.

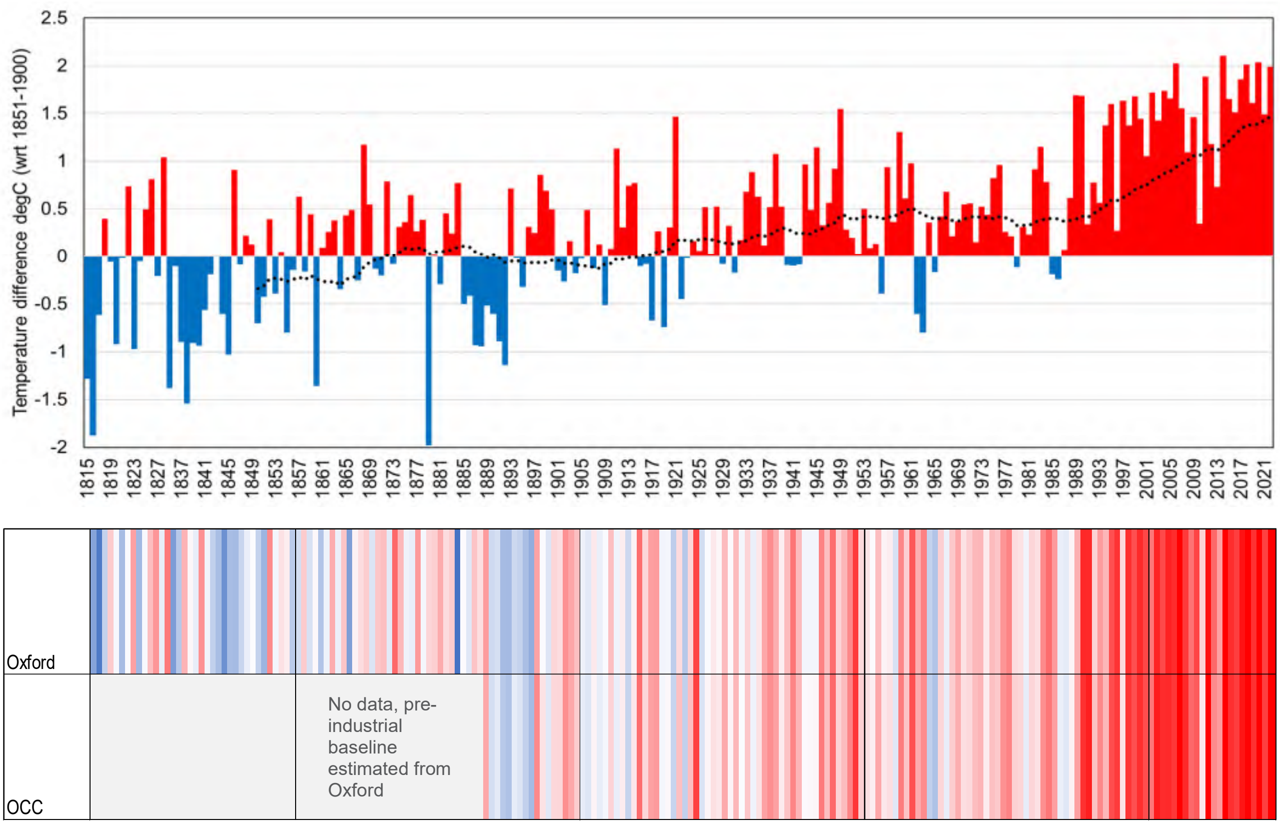

Figure E-1 – Average annual mean temperature anomalies for Oxford (top) and climate stripes (bottom) for Oxford and across Oxfordshire (OCC) relative to a pre-industrial 1851-1900 baseline (data from OUCE Radcliffe Observatory and Met Office HadUK)

- **Heatwaves are becoming more frequent in the county but the overall impacts of extreme heat are less well understood compared to floods.** Heatwave risk is greatest in built up areas such as Oxford and parts of Abingdon. This has led to adverse impacts such as 44 excess deaths in Oxfordshire due to heat in 2022. In July 2022, maximum temperatures exceeded 38°C in Oxford in an extensive heatwave that affected most of the south and east of England. High temperatures particularly impact vulnerable groups such as the elderly, children and those chronically ill. Our assessment identified 51 care homes, 4 hospitals and 40 healthcare and GP facilities that are currently at high risk of heat related impacts. Heatwaves are already impacting the ability of water companies to maintain secure supplies to a growing population during peak summer demand. Recently we have seen water companies forced to implement more stringent adaptation measures from the drought plans including a hosepipe ban over the Thames Valley region in the summer of 2022. Thames Water offer various resources for households and businesses to reduce their water use such as school engagement activities and free water-saving devices. OCC can help promote efficiency to residents and businesses across its region to support the sustainability of supplies, particularly during periods of dry and hot weather.
- **Flooding has occurred frequently in Oxfordshire and has presented the most significant climate risk in recent years**. Since 2007 there have been 18 separate significant flood events recorded. Flood risk remains high especially along rivers and flood plains and where people and buildings are exposed, notably in Witney, Oxford, and Abingdon. Areas with a high proportion of low rise single storey buildings or basements are particularly vulnerable. Flooding in July 2007 resulted in a cost of £4.5 million in direct costs to Oxfordshire County Council alone, but the total direct and indirect costs of individual flood events

are far greater, due to damage of properties and disruption to a wide range of services. Our assessment identified that around 27% of the population are exposed to high risks related to flooding from rivers and surface water. The high risk category includes 139 school and university buildings, as well as critical infrastructure related to water supply, transport and telecommunications. Fluvial and pluvial flooding has impacted the delivery of essential water services across the Oxfordshire region. The risk has recently been assessed within Thames Water's 25-year Drainage and Wastewater Management Plan which was developed with customers and stakeholders. Investment plans have been developed to adapt to these risks and deliver a sustainable and resilient service[5]. However, it is a complex risk that is shared across multiple organisations and collaboration in promoting and implementing adaptation actions will be essential to the region's successful management of this risk.

- **Drought, high winds and storms and low temperatures are still important climate-hazards in Oxfordshire**, posing risks to people's health, critical infrastructure such as transport and energy networks, business and industry and the natural environment and assets. The south east of England is one of the UK's driest regions. Without further adaptation, water companies in England are facing short-term water supply shortfalls even before climate change is considered. Thames Water predicts a shortfall of 372 million litres of water per day by 2035 and 1059 million litres per day by 2050[6]. They are working together with neighbouring water companies to develop shared solutions for resilient water supplies, environmental protection and to support economic growth[7] and preparing for extreme drought. Thames Water is working to reduce leakage by over a half by 2050 and to encourage customers to reduce their household demand in the region. The OCC can support the reduction in water demand by helping to promote water efficiency to the people and businesses within their region.
- **Compound risks where multiple climate hazards and other factors combine to cause an impact are more prevalent,** for example recent fish kills in Oxfordshire's rivers and canals have been linked to high temperatures combined with heavy rainfall events and pollution[8]. Similarly systemic and cascading risks are becoming more important, for example, a resilient power supply into and across Oxfordshire is essential to maintain water supplies and transport systems.
- **Current climate risks are not evenly spread across the county and at the same time local communities are facing high risks from both floods and heatwaves**. Flood hazards are largely confined to existing river floodplains and areas affected by surface water flooding and exposure to extreme heat is greater in urban areas and communities in high rise or low quality housing. Social vulnerability is high in more deprived areas with poorer access to services and larger proportions of vulnerable people. Our assessment has mapped flooding and heatwave risks locally, showing the variation across the county and correlation between flood and heat related risks across Oxfordshire. The highest risk wards are located in specific areas of Abingdon, Witney and Oxford City (Figure E-2), with the highest heat related scores in Oxford and highest flood related scores in Abingdon, Witney and parts of Oxford due to their locations on the Thames, Ock and Stert in Abingdon and River Windrush in Witney.

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[5] https://www.thameswater.co.uk/about-us/regulation/drainage-and-wastewater-management
[6] https://thames-wrmp.co.uk/
[7] https://www.wrse.org.uk/
[8] For example, see Oxford canal: Weather blamed after fish found dead - BBC News

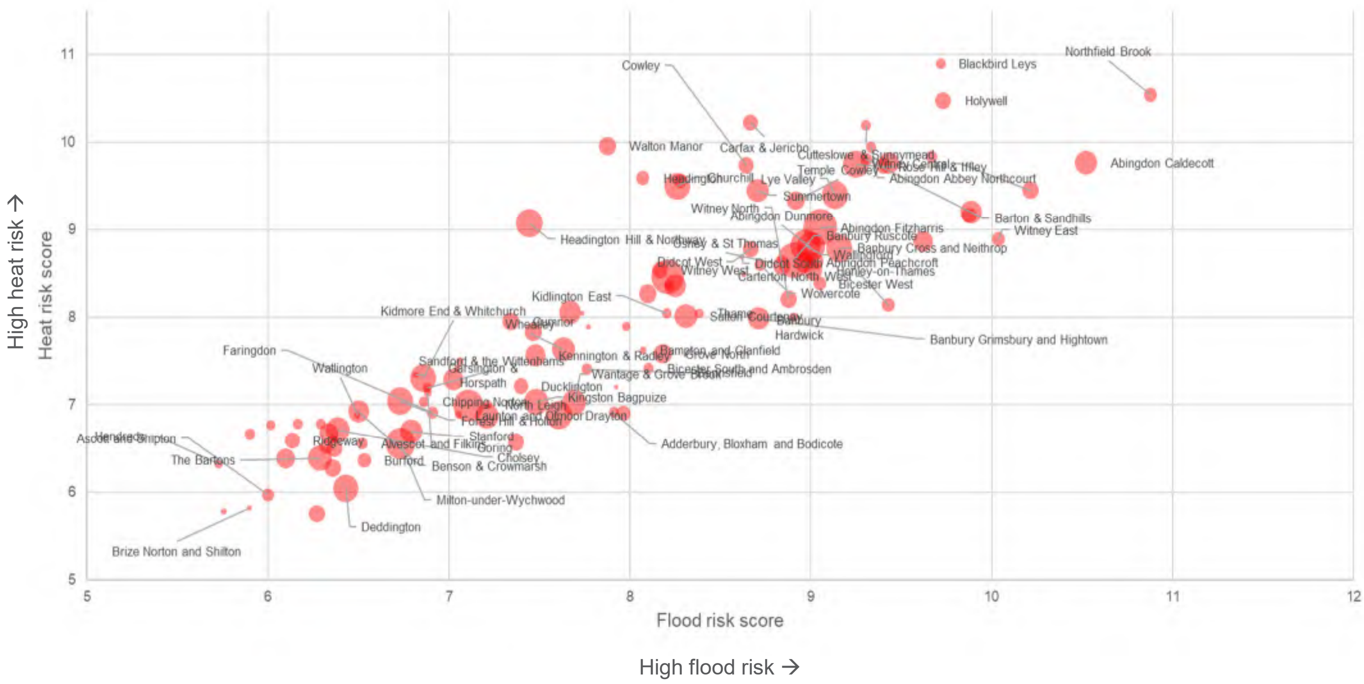

Figure E-2 – Current heatwave and flooding risk score at a ward level with bubble size by combined risk score

- **Climate variability and anxiety about future changes have a notable impact on both physical and mental health.** A health impact assessment highlighted 88 excess deaths due to heat in Oxfordshire from 2021 to 2022. Not only is physical health impacted by climate change through increased mortality and morbidity due to climate-related hazards such as heatwaves and flooding, but so is mental health. Eco-anxiety, anxiety driven by climate change, is impacting communities in Oxfordshire, as evidenced by the establishment of Climate Cafes in Oxford North, to allow for open spaces for people to share their thoughts and feelings on climate change.
- **Although some progress has been made on climate change adaptation, more climate adaptation action is needed to keep pace with inevitable climate change.** For example, Oxfordshire has plans and policies in place to target the impacts of climate-related hazards such as preparing against flooding and habitat protection, through the Oxfordshire Local Flood Risk Management Strategy and Oxfordshire Biodiversity and Planning guidance. However, insufficient policies and plans and slow implementation of plans are notable at the national and county scales, especially for some areas of critical infrastructure and health, communities, and the built environment.

Future risk from climate-related hazards

- **Heatwaves, flooding, and drought are expected to pose the greatest future risks in Oxfordshire without further adaptation action.** Risks increase under both 2°C and 4°C scenarios assuming the current levels of climate adaptation action, with the risk of heatwaves increasing at a greater rate than other hazards. In the medium term, by the 2050s, most climate risks increase at a similar rate under all climate change scenarios. Therefore, increases in risks locally are almost certain whatever the pace and ambition of global mitigation efforts. After the 2050s, risks increase more significantly under the 4°C pathway and further still under more extreme high impact scenarios, particularly for flood risks. While flood risk and water resources drought risk are already subject to medium and long term investment plans by the Environment Agency, other flood management authorities and Thames Water, there is an urgent need for further adaptation plans for heat-related risks and to improve community preparedness for climate change.

- **The risk of cold snaps is projected to decrease under all scenarios.** There is an upside to the reduction in low temperatures in winter months that are very likely to reduce cold weather impacts, such as cold morbidity and mortality, reduce household heating costs and the number of cold-related pipe bursts and associated water leakage. Our analysis shows that the number of cold weather alerts annually and heating degree days (HDD), a measure of the demand for heating, will both reduce significantly by the 2050s under all scenarios. However, occasional cold snaps and the associated impacts cannot be ruled out, and it will be important to continue improving building insulation and performance for both winter and much hotter summer conditions.
- **Heatwaves are expected to have the biggest impact on built up areas, with the largest increases in heatwave risk projected for Oxford, Abingdon, Witney, and Banbury** (Figure E-3). Heat-related hazards and risks will extend spatially to impact on the whole of Oxfordshire, and on all sectors. Under the +4°C pathway the majority of healthcare facilities will have moved from moderate risk into the high heat risk categories. Four of the region's hospitals were categorised as high risk in the baseline scenario and this rises to 12 hospitals at high risk by 2050 under the +4°C pathway. As heatwave risks become more prominent for health infrastructure, a range of climate adaptation measures will be needed to retrofit hospitals, provide new services and develop more comprehensive contingency plans.
- **The risks of flooding from rivers and surface water is very likely to increase as outlined in the UK CCRA3.** The Expected Annual Damage due to fluvial flooding is projected to increase by 25%-30% by the 2050s under +2°C pathway and 30%-40% under +4°C pathway assuming current levels of adaptation, and the damage due to surface water flooding is projected to increase by 30%-36% by the 2050s under +2°C pathway and 48%-56% under +4°C pathway assuming current levels of adaptation. Our vulnerability model indicates that flood risk remains very high in 2050s under all scenarios, particularly in Oxford, Abingdon, Witney and Banbury. Under a +4°C scenario, 64% of the population will be within a high risk flood area compared to 27% of the population currently. The frequency of flooding is projected to increase by +90% and +101% for fluvial flooding under +2°C and +4°C scenarios respectively and +29% and 46% for surface water flooding under the same scenarios. However, further analysis is needed to fully quantify the impacts of these changes.
- **Key transport infrastructure will be impacted by flooding and heatwaves as defined by future hazard mapping.** Approximately 1,600km of road length, 200km of the rail network, 100km of National Cycle Networks in Oxfordshire will be located in areas with a high heatwave hazard. This may increase the likelihood of damage to road and cycle path surfaces and lead to buckling of rail tracks. Likewise, flooding hazard will also increase for much of the transport network, with approximately 1,500km of the road network and 121km of the rail network located in areas of high flood hazard, which may lead to inundation of infrastructure and disruption to services.
- **The natural environment will be faced by increased heatwave events, a higher chance of wildfires, and increase livestock heat stress due to future climate change**. This will have a profound effect on the natural environment, leading to biodiversity loss, wildfire destroying habitats, an adverse impact on crop yields and the ability for ecosystems to function.

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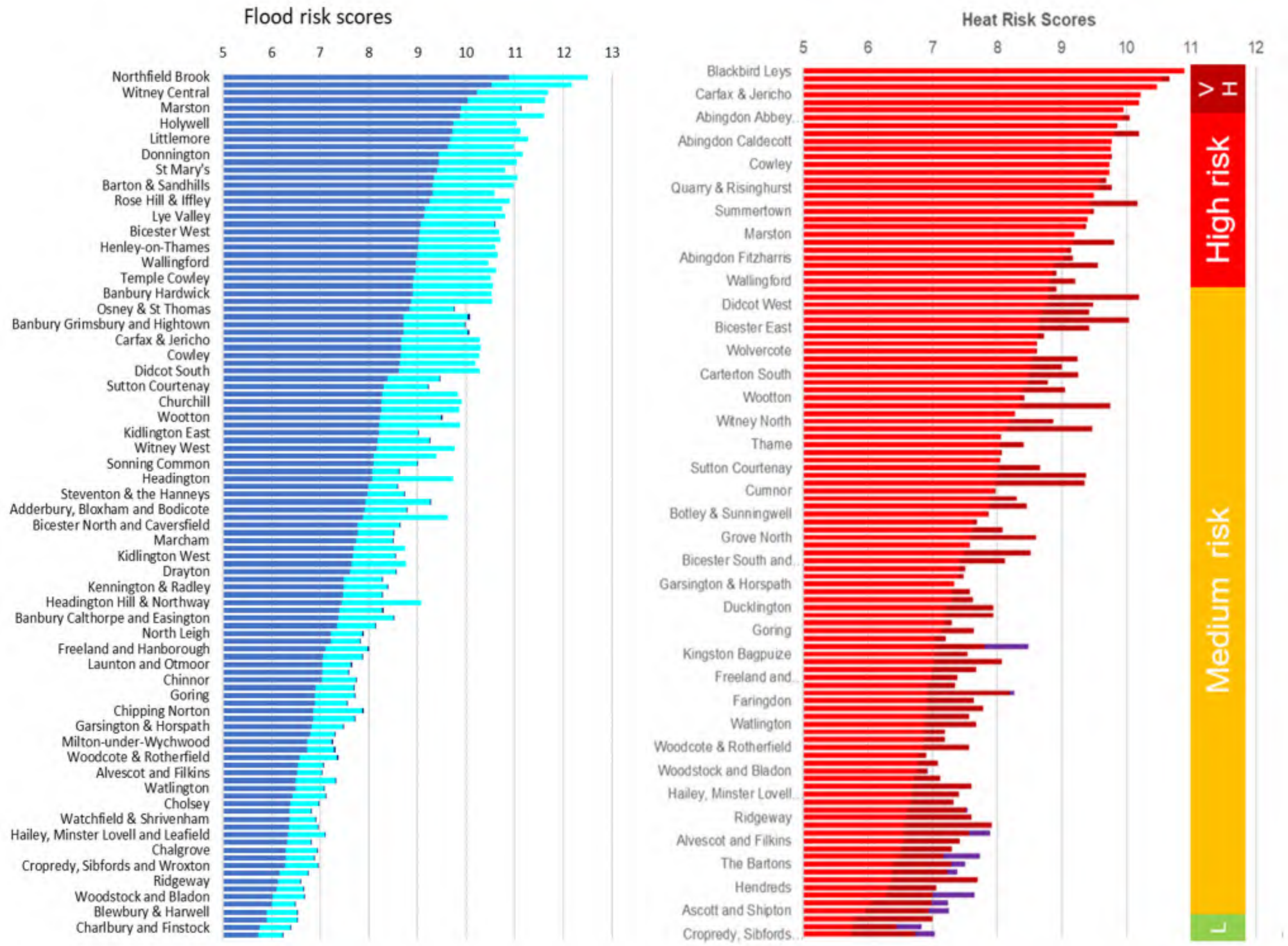

KEY	Current flooding risk score	2050 flooding risk score on a pathway to +2°C warming by 2100	2050 flooding risk score on a pathway to +4°C warming by 2100	Current heatwave risk score	2050 heatwave risk score on a pathway to +2°C warming by 2100	2050 heatwave risk score on a pathway to +4°C warming by 2100

Figure E-3 – Current versus future (2050) flooding risk (left) and heatwave risk (right) score at ward level (future flood risk scores are under review).

- **Future changes in climate change risks are likely to exacerbate existing inequalities that exist across Oxfordshire.** Extreme heat and flooding will especially affect vulnerable groups such as the elderly, children and those who work outside, with potential impacts on mental health, mortality, morbidity and healthcare services buildings and operations. Without targeted climate action to improve housing and community services, provide greater access to greenspace, continue to improve air quality and address interactions between climate and health risks, the gap between the lowest and highest risk communities will continue to grow.
- **The recent heatwaves across Europe and impacts including wildfires, heat morbidity, transport disruptions and environmental impacts, provide insights into the wide ranging impacts of extreme heat due to climate change.** Based on our analysis, there is now a 1% chance of exceeding 38.7°C in Oxford City and around 0.5% chance of exceeding 40°C in any year[9], and this risk will increase significantly under all future scenarios. According to Met Office climate modelling studies (Figure E-4) and more recent

[9] Based on observations of Oxford Radcliffe Observatory (1815-2022) and a recorded a maximum temperature of 38.1°C on 19th July 2022.

weather attribution studies, the risk of very high temperatures is likely to increase by 2 to 5-fold by the 2050s under +4°C pathway. (See the main text for further details).

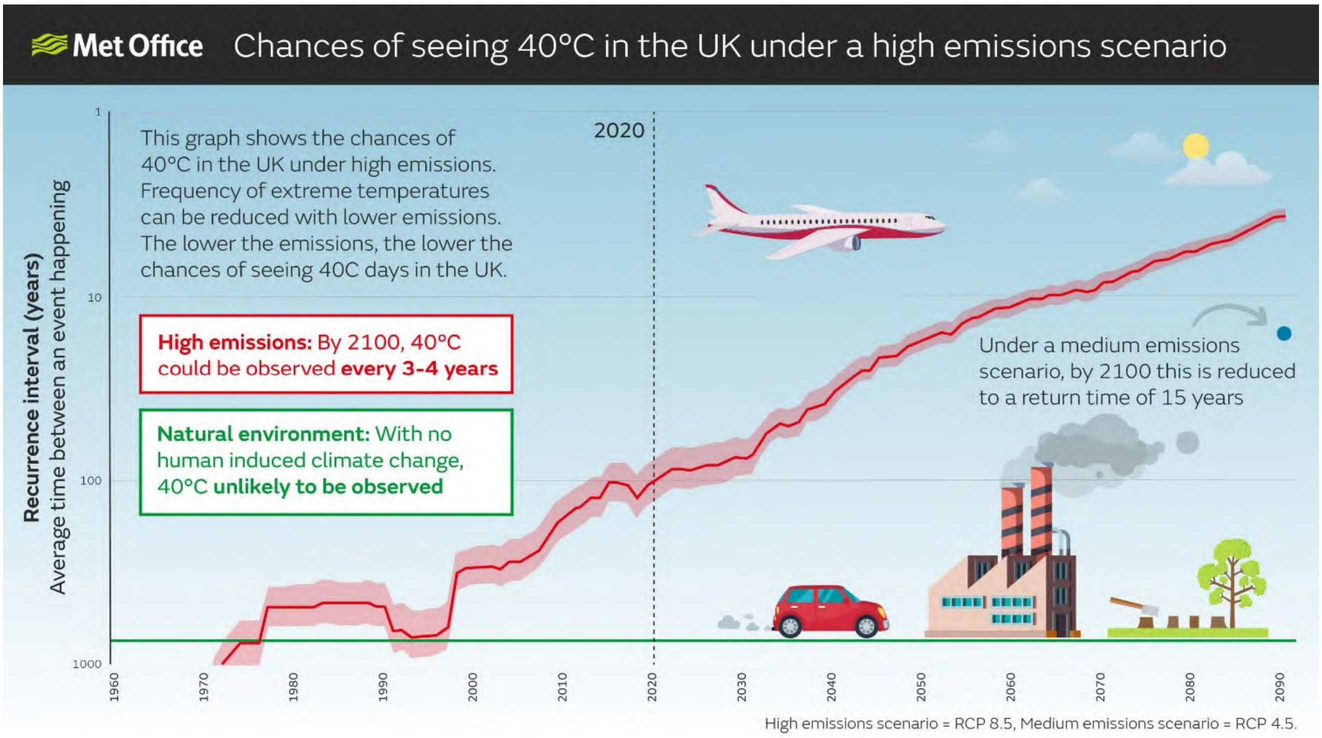

Figure E-4 – Met Office assessment of the likelihood of seeing 40°C in the UK under High and Medium Emissions scenarios.

1. Introduction

1.1. Background

"Global climate is changing due to human alterations of the composition of the atmosphere and the character of the land surface."[10] Global average surface temperature has increased by at least 1.1°C above pre-industrial average temperatures and, with current global commitments to cut greenhouse gas emissions, this could increase by another +2°C or +4°C (or even higher) by the end of this century.

This global change in climate is affecting local weather patterns and increasing the likelihood of extreme weather events. Such changes are affecting ecosystems and habitats and posing more weather-related risks to communities in the UK such as flooding, storms, and heatwaves[10].

With rising concerns over the impacts of climate change, Oxfordshire County Council (OCC) and the four district and one city councils – Cherwell, Oxford City, South Oxfordshire, Vale of White Horse, West Oxfordshire –declared a Climate Emergency in 2019[11]. In doing so, they have publicly committed to dedicating more resources and efforts towards climate change mitigation and adaptation. This involves enabling a low carbon transition, supporting infrastructure and zero-carbon developments to be fit for 21st century living and working, and funding sustainability initiatives targeted at building adaptation and resilience on the ground.

In terms of climate change mitigation, all councils have now set their own net-zero targets (Table 1-1) and a range of initiatives and projects to help reduce greenhouse gas emissions have been pursued and implemented in recent years (see section 3).

Table 1-1 - Net-zero targets for Oxfordshire County, City and District councils

Council	Targets	
	Carbon neutral council operations	**Area wide net-zero**
Oxfordshire County Council	2030	2050
Cherwell District Council	2030	2030
Oxford City Council	2030	2040
South Oxfordshire District Council	2025	2030
Vale of White Horse District Council	2030*	2045**
West Oxfordshire District Council	2030	2050

** With an interim target of 75% reduction by 2025.*
*** With an interim target of 75% reduction by 2030.*

However, less efforts have focused on supporting and advancing climate change adaptation and resilience initiatives across Oxfordshire. To address this gap and in the wider context of the climate change emergency declaration, OCC has commissioned Atkins to support their efforts - as well as of other key stakeholders in the county - towards a more adapted and resilient Oxfordshire in light of a changing climate. The project, entitled Climate adaptation and resilience in Oxfordshire is described below.

1.2. About this project

The main aim of the Climate Adaptation and Resilience in Oxfordshire (CARO) project is to provide an evidence base to inform a climate adaptation strategy to support a resilient Oxfordshire. This has been achieved by working with OCC and key stakeholders to assess the current and future risk of climate change to

[10] Betts, R.A. and Brown, K.(2021) Introduction. In: The Third UK Climate Change Risk Assessment Technical Report [Betts, R.A.,Haward, A.B. and Pearson, K.V.(eds.)]. Prepared for the Climate Change Committee, London
[11] Net-zero by 2030 | Oxfordshire County Council [Accessed online: 29/06/2023]

Oxfordshire and supporting the development of an adaptation strategy for Oxfordshire and an action plan for the county key service areas.

The project is underpinned by several high-level aims reflecting some of the already understood challenges around climate change, including:

- Protect the health and wellbeing of Oxfordshire residents, enabling them to build long term resilience to a changing climate.
- Improve the resilience of council services and key stakeholder operations across Oxfordshire to a changing climate.
- Minimise financial cost to the council and Oxfordshire stakeholders from future adverse and extreme weather events.
- Realise added benefit from Oxfordshire's natural environment improvement programmes and support its improved resilience to a changing climate.
- The project will be developed in close collaboration with the Countywide Steering Group[12] (CSGM) which will inform, contribute, and agree on best options at key stages in the project.

The project is composed of two work packages:

- **Work package 1** – Assessment of climate risk and climate-related health impacts to act as an evidence base
  - Gathering available information and knowledge on climate hazards and key thematic areas
  - Assessment of current risk of key thematic areas to climate hazards
  - Assessment of future risk of key thematic areas to climate change
- **Work package 2** – Towards a climate resilient Oxfordshire
  - Develop a county wide climate adaptation and resilience strategy
  - Oxfordshire County Council action plan

1.2.1. Risk assessment

The focus of the Oxfordshire risk assessment is on key thematic areas of relevance to OCC and other key stakeholders, including:

- **Critical Infrastructure:** including energy, transport, telecommunications, and water infrastructure.
- **Natural Environment and Assets**: including terrestrial and freshwater environments, and agriculture and forestry, landscape, and associated assets such as ecosystem services.
- **Health, Communities and Built Environment**: focusing on specific climate hazards (for example heat or flooding) that affect multiple sectors as well as specific policy areas (for example health systems).
- **Business and Industry**: Domestic risks to business and industry.

[12] Countywide Steering Group Members (CSGM) include the County, City and District Councils, University of Oxford, Oxfordshire Local Enterprise Partnership (OxLEP), NHS Foundation Trusts, Local Nature Partnership, and Oxford Brookes University.

In this project, the risk assessment was pursued from a vulnerability perspective where risk is conceptualised as a function of climate hazards, exposure to such hazards and the vulnerability of communities and ecological systems to those hazards (Figure 1-1). In this report, the following definitions have been used[13]:

- **Risk** – risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or natural system to the hazards.
- **Impacts** - the consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards, exposure, and vulnerability**.**
- **Vulnerability** - The predisposition to be adversely affected. Vulnerability encompasses a variety of elements, including sensitivity to harm and lack of capacity to cope and adapt (i.e., adaptive capacity of communities and groups).
- **Exposure** - The physical presence of people; ecosystems; services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

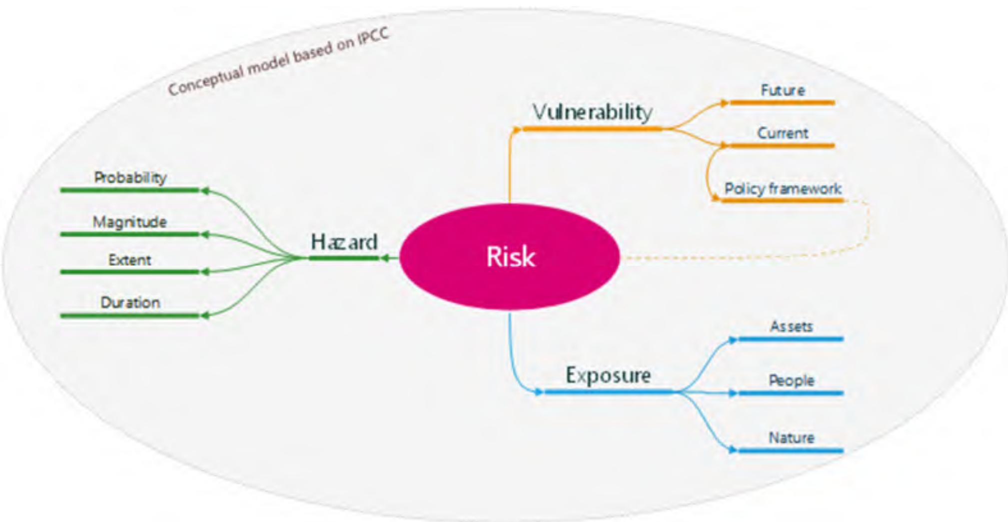

Figure 1-1 - Risk as a function of hazard, exposure, and vulnerability

The assessment of current and future risks from climate-related hazards in Oxfordshire has been completed for each of the four key thematic areas: critical infrastructure; health, communities, and the built environment; natural environment and assets; and business and industry (Figure 1-2). Current risk assessment of climate-related hazards includes an overview of national risks and adaptation-related policies, followed by a local assessment of OCC evidence and risk assessment data, supported by risk assessment mapping and quantitative and qualitative evidence. A future risk assessment explores the impact of a +2°C and +4°C[14] pathway to warming by 2100 in the year 2050 and a high-impact scenario to understand the impact of extreme events on the county, as is good practice in risk assessment[15] and climate change adaptation to consider the

[13] Definitions adapted from IPCC, 2022: Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A. Reisinger (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029
[14] Scenarios with global average temperature approximately +2°C and +4°C above pre-industrial levels in 2100.
[15] Preparing for extreme risks: Lords committee report - House of Lords Library (parliament.uk)

implications of ‘unpredictable extremes[16]. These low-likelihood high-impact scenarios are plausible but extreme outcomes that are associated with the ‘high-end’ of RCP8.5 scenarios.

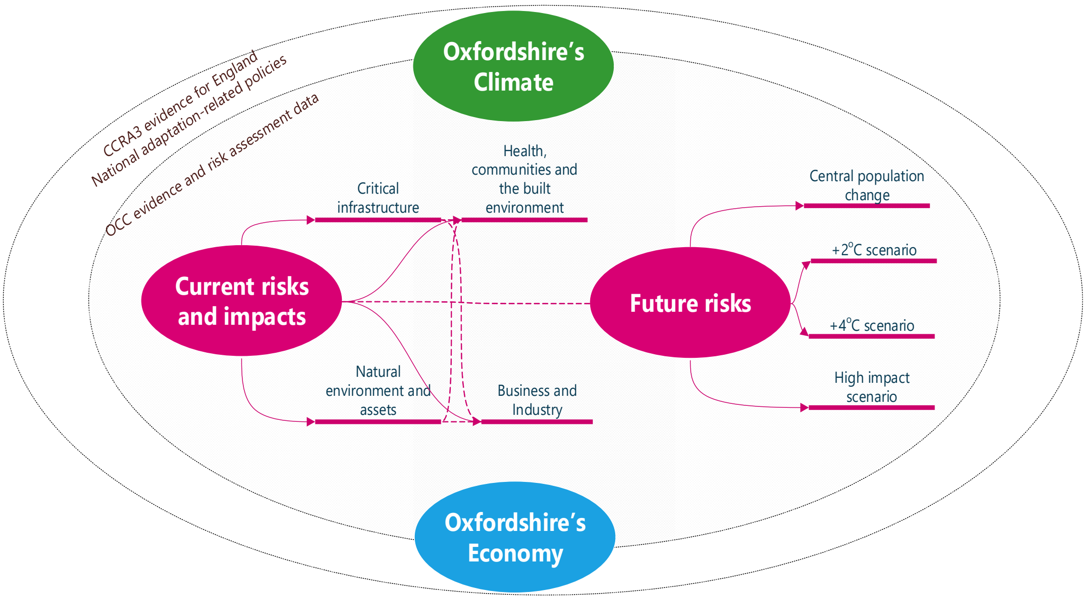

Figure 1-2 – Current and future risk assessment methodology

The methodology used to pursue the analysis of current and future risk to climate hazards is described in Appendix A.

1.3. Purpose of this report

This report is the second deliverable in WP1 and provides the assessment of current and future risk to climate hazards in Oxfordshire as well as a health impacts assessment. It builds upon the first deliverable which described the underlying layers of information that have been used to assess current risk of the key thematic areas to key climate hazards in Oxfordshire.

This report is divided into four main sections:

- **Section 2** provides an overall characterisation of Oxfordshire socio-economic aspects as well as an overview of the changes in climate and related impacts in the county over the last few years.
- **Section 3** presents the assessment of current risk to climate-related hazards in Oxfordshire based on the four key thematic areas of interest (critical infrastructure; natural environment and assets; health, communities and built environment; and business and industry).
- **Section 4** provides the assessment of future risk based on the key hazards and key thematic areas in Oxfordshire (as identified in section 3) using climate change scenarios for 2050 on a pathway to +2°C, +4°C by 2100 and selected high impact scenarios.
- **Section 5** concludes the report with key findings and conclusions from this study.

[16] ‘Prepare for unpredictable extremes’ is one of the Climate Changes Committee’s Ten Principles of Good Adaptation presented in the CCRA3.

2. The Oxfordshire region

2.1. General characterisation

Oxfordshire county is located in the south-east of England, comprised of OCC, four district councils and one city council: Cherwell, Oxford City, South Oxfordshire, Vale of White Horse and West Oxfordshire.

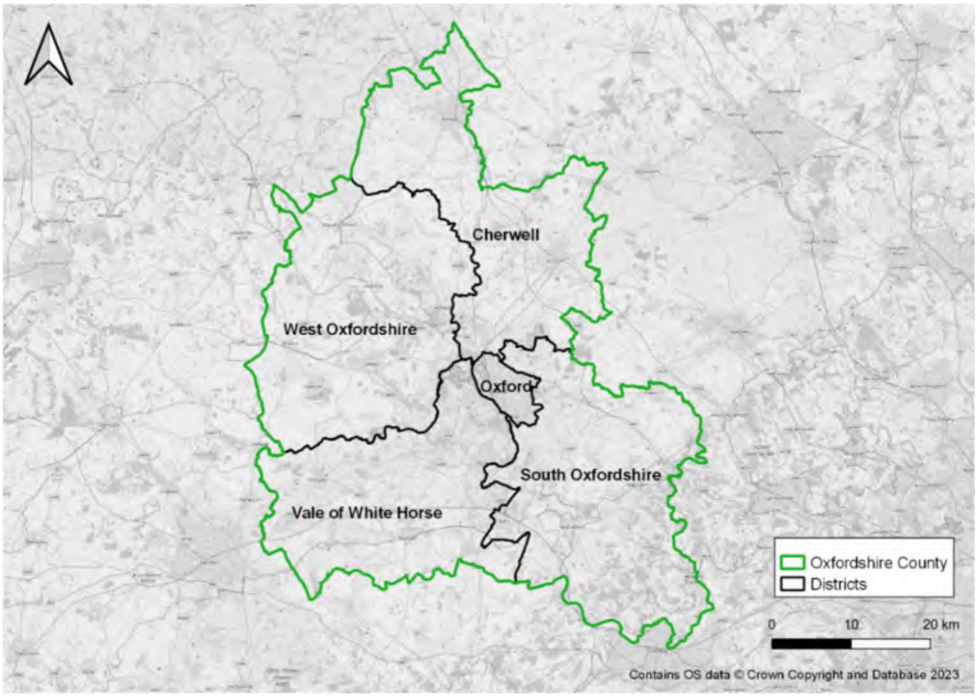

Figure 2-1 - Oxfordshire County, Districts and City Councils

Oxfordshire has a total area of around 1,000 square miles characterised by rural countryside with considerable agricultural land, the Thames valley, canals, historic villages, market towns and the City of Oxford (Figure 2-2). Oxfordshire has several environmentally protected areas including 3 Areas of Outstanding Natural Beauty (AONB) (the North Wessex Downs, Cotswolds and Chilterns[17]), 7 Special Area of Conservation (SACs), three National Nature Reserves and 154 Sites of Special Scientific Interest (SSSIs). There are also 12,204 listed buildings and world heritage sites such as Blenheim Palace.

[17] Review of Environmental Sensitivity in Oxfordshire

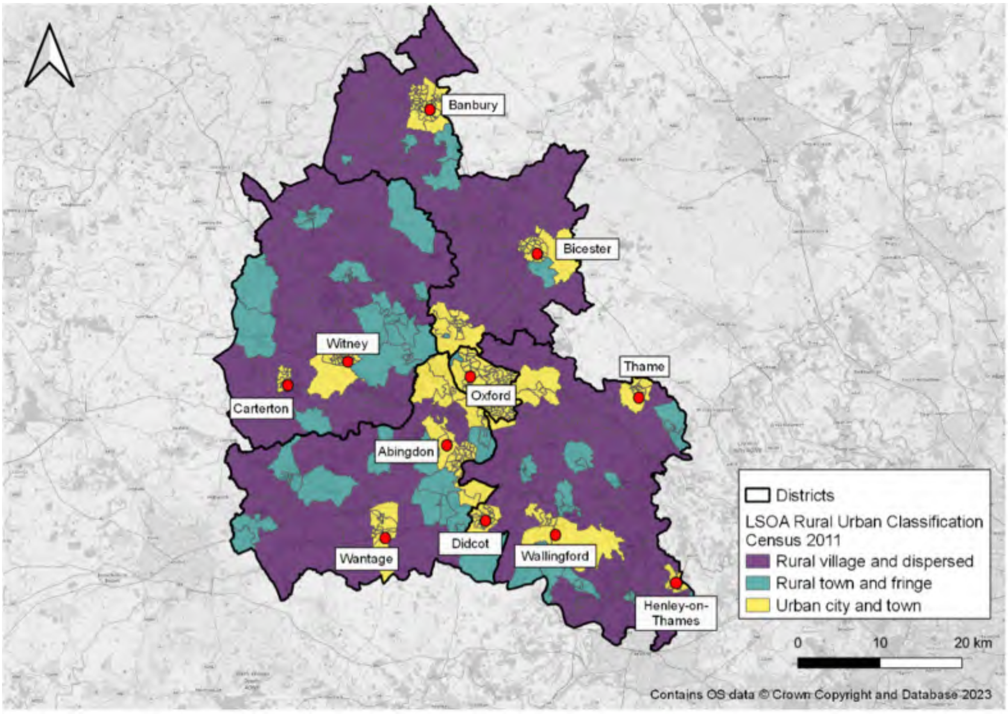

Figure 2-2 - Urban and rural classifications in Oxfordshire[18]

In the latest Census of 2021, Oxfordshire had a population of 726,500, with the greatest district level population based in Cherwell (161,800 people), closely followed by Oxford City (160,000 people)[19]. Within Oxfordshire 64% of the population are of a working age (16-64), compared to 63% in England[19]. Further socio-economic characteristics of Oxfordshire are outlined in Figure 2-3.

Population grew by 71,500 from the 2011 to the 2021 Census (+10.9%)

Largest ethnic group is White: English, Welsh, Scottish, Northern Irish or British" (76.8%)

Followed by "Indian or British Indian" (7.5%)

"European mixed" (7.4%)

"Pakistani or British Pakistani" (6.6%)

Oxfordshire has strong employment with 80% aged 16-64 in employment (349,900)

Since 2011, Oxfordshire saw significant increases in the resident population of:

Young people aged 5 to 14 (+15%)

Working aged people in their 30s (+15%) and 50s (+27%)

Older people aged 65+ (+25%)

Most common occupations in Oxfordshire are Professional Occupations which include:

- Science, Research, Engineering and Technology Professionals

- Teaching and Educational Professionals

Oxfordshire is the tenth least deprived local authority in England.

There are 12 LSOAs in the 20% most deprived LSOAs nationally in Oxford and Banbury.

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[18] 2011 rural/urban classification - Office for National Statistics (ons.gov.uk)

[19] Labour Market Profile - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)

Figure 2-3 - Socio-economic characteristics of Oxfordshire[20]

2.2. Oxfordshire's changing climate

2.2.1. Past climate

In this report, most observed climate data has been sourced from the Met Office UCKP18 User Interface[21] and analysed using a 30-year baseline period of 1981-2010. A much longer climate record (1815-2023) is available at the University of Oxford's Radcliffe Observatory, and this has been used for the assessment of temperatures since the pre-industrial period and for extreme value analysis in Section 4.5.1.

For the period 1981-2010, the highest average monthly mean and maximum temperatures were in July, at approximately 17°C and 22°C, respectively. Peak monthly rainfall occurs from October to January with greatest totals in October with an average of 73 mm of precipitation, and least in February at 45 mm.

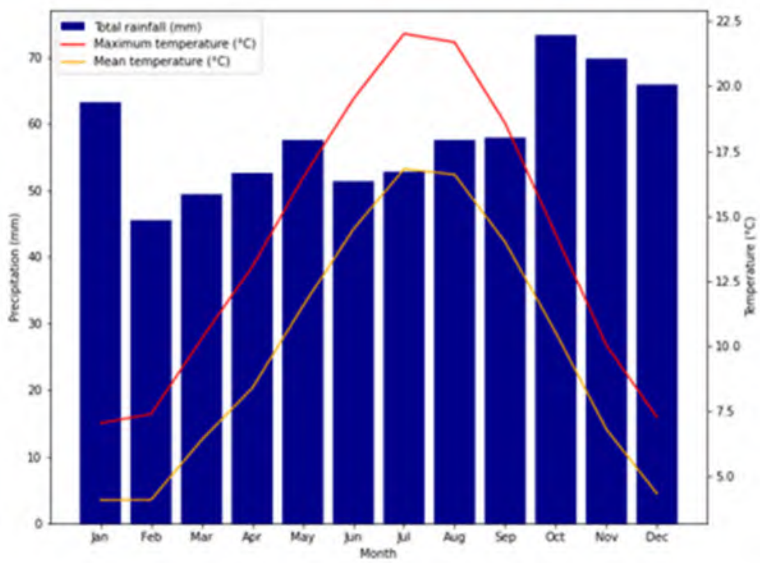

Figure 2-4 - Average monthly maximum and mean temperature, and rainfall across Oxfordshire from 1981-2010[21]

Average annual temperatures have steadily increased since the 19th century with the greatest warming occurring in the last 20 years. Figure 2-5 illustrates how the average mean temperature each year across Oxfordshire has changed over time with respect to the 1981-2010 baseline annual average of 9.8°C.

[20] Census 2021 results highlight Oxfordshire's growing population | Oxfordshire Insight, Workbook: Oxfordshire Local Skills Dashboard (tableau.com), Census 2021 - Ethnic groups in Oxfordshire | Oxfordshire Insight

[21] Data sourced from: UCKP User Interface Version: v2.8.0 (WPS-2.8.0-DP-2.8.0-CV-1.0.10). The UKCP18 datasets are all available under Open Government Licence v3.0: Open Government Licence (nationalarchives.gov.uk). Available from: https://ukclimateprojections-ui.metoffice.gov.uk/ui/home. Accessed: [15/03/2023]

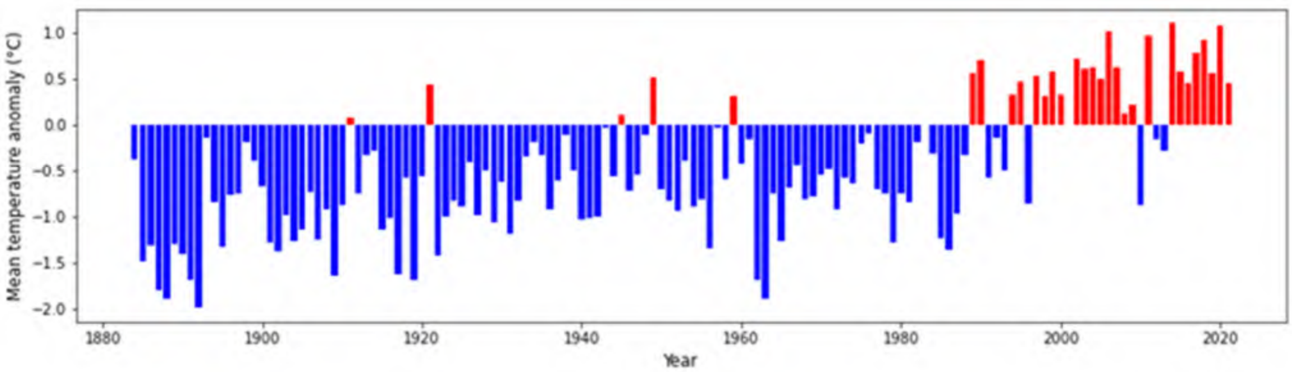

Figure 2-5 - Average annual mean temperature anomaly across Oxfordshire relative to the 1981-2010 baseline average[21]

As illustrated by Figure 2-6, winter and summer seasonal rainfall in Oxfordshire has not changed much over time relative to the baseline period. The figure shows large year-to-year interannual variability of seasonal rainfall which makes trends difficult to detect.

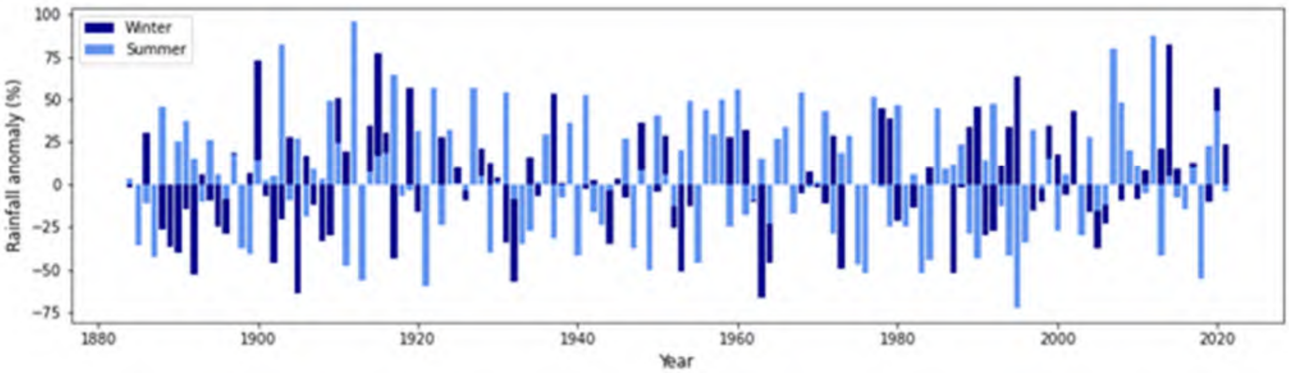

Figure 2-6 - Average summer and winter rainfall anomalies across Oxfordshire relative to the 1981-2010 baseline averages[21]

Wind speed in Oxfordshire does not vary greatly throughout the year. From 1981 to 2010, average wind speeds in August were observed at approximately 3.3 ms^{-1}, whilst in February average wind speeds were observed at approximately 4.5 ms^{-1}. Whilst Figure 2-7 illustrates that average wind speeds across Oxfordshire have decreased since 1969, wind speed varies spatially and there is uncertainty in trends of wind speeds.

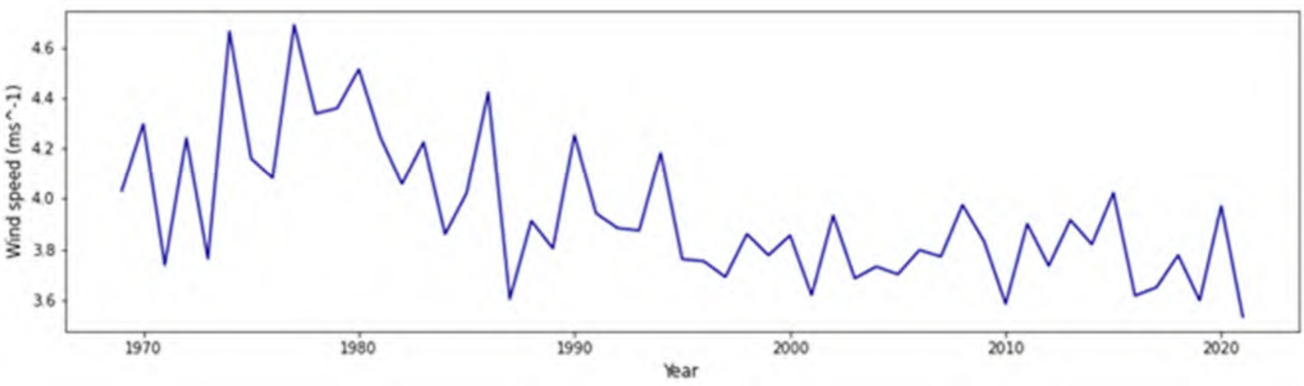

Figure 2-7 - Average annual wind speed across Oxfordshire[21]

An analysis of the Oxford Radcliffe Observatory data and climate model attribution studies shows that the chance of very high temperatures in Oxfordshire is much higher than previously assumed.

- Maximum temperatures are increasing at a greater rate than average temperatures in Oxford; our analysis shows an increase of 2.3°C in maximum temperatures between 19th century and last decade compared to around 1.2°C in average temperatures[22].
- In any given year, there is now a 1% chance of exceeding 38.7°C in Oxford and around 0.5% chance of exceeding 40°C (based on observations).

2.2.2. Climate-related events and impacts

Since 2000 there has been several key hazardous events in Oxfordshire, notably, flooding, heatwaves, droughts, and storms adversely impacting on the county. Information on key past hazardous climate and weather events have been collected from a review of historical newspaper articles, Met Office Weather Observations (Met Office WOW) and based on lived experience from Countywide Steering Group Members.

A timeline of key hazards and impacts in Oxfordshire since 2000 is outlined in Table 2-1.

Overall, the timeline of key past climatic hazardous events since 2000 illustrates the continuous weather and climatic events adversely impacting the county. Of note is the number of flooding events, heatwaves, droughts, and storms, which have been prevalent. Past events with the greatest impact on the county include the July-August 2022 heatwave, June-August 2022 drought, July 2007 flooding and January 2014 flooding with impacts felt across the county impacting schools, agriculture, health services, power supply and damage to homes and businesses.

Table 2-1 - Timeline of key climate hazards and impacts in Oxfordshire since 2000

Drought[23]	*Heatwave[24]*	*Flood*	*Storm/Wind[25]*	*Snow/Cold spell[26]*

[22] Atkins analysis of ORO time series based on differences between 2003-2022 and 1891-1900 periods (20 year blocks), using trends analysis to focus on the climate change signal rather than natural variability.
[23] There are different definitions of drought but in this study we use the notion of meteorological drought which occurs when rainfall in an area is below average for the region UK and Global extreme events – Drought - Met Office
[24] A heatwave is defined as a period of at least three consecutive days with daily maximum temperatures meeting or exceeding the heatwave temperature threshold. The threshold for Oxfordshire is 27°C What is a heatwave? - Met Office
[25] A storm can be understood as a deep and active area of low pressure with associated strong winds and precipitation Storms - Met Office
[26] Cold spells occur when mean temperature falls below 2°C for 48 hours or longer and/or heavy snow and/or widespread ice Cold Weather Alerts - Met Office

Year	Event	Impacts
2007	January - Storm[27]	• Several injuries, 7000 households left without power and 160 businesses affected in Oxfordshire.
	July - Flooding	• 3-5 inches of rain per day and £4.5 million in costs to the council (OCC)[28]. • In West Oxfordshire 1,631 homes and 72 businesses flooded[29] and 40-50 schools and council buildings damaged. • Several electricity transmission stations flooded[30] • Arterial roads closed[30] • Radcliffe Infirmary hospital, Abingdon hospital and Abingdon fire station flooded[31]
2008	January - Flooding[30]	• Localised power loss, flooded properties, and bottled water activation
	June - Flooding[30]	• 62 properties flooded across the county
2009	February - Snow[30]	• 60 schools closed and four reception centres opened
	July - Heatwave[32]	• 31st July >28°C temperatures recorded. • £5000 cost to OCC to adjust for staff working conditions.
2010	January – Snow[33]	• Snow disruption across the UK and Thames Valley area including school closures and power outages. • Strategic roads closed.
	December - Snow[30]	• A34 closed.
2011	December - Snow[30]	• Chilterns and M40 impacted.
2012	February – Snow[30]	• Vehicles stranded on the M40.
	March-April – Drought [34,35]	• Dry soils from October to March 2011-2012 followed by extreme rainfall in April 2012 impacted on agriculture, leading to limited access to farmland and damaged crops. • Hosepipe bans – April 2012.
	April - Flooding[30]	• 23 properties flooded and road closures countywide. • Water treatment works at Banbury lost.
	July - Flooding[30]	• Sandbags activated countywide, road closures and five roads of properties flooded (fluvial and pluvial).
	November - Flooding[36,37]	• 40-50mm of rainfall within a 12-hour period across the Southwest of England. • Road and railway closures in the City of Oxford.

27 Storms battering county | Oxford Mail
28 Flooding (West Oxfordshire) - Hansard - UK Parliament
29 Fears of flooding fail to recede | Oxford Mail
30 Oxfordshire County Council records
31 Oxfordshire County Council records
32 Oxfordshire County Council Local Climate Impacts Profile 2007- 09
33 Tvlrf risk register oct 2016.pdf (thamesvalleylrf.org.uk)
34 2012_Drought_Transformation_FINAL.pdf (nerc.ac.uk)
35 England-and-wales-drought-2010-to-2012---met-office.pdf (metoffice.gov.uk)

36 November 2012 flooding - Met Office
37 Oxfordshire homes flooded due to heavy rain - BBC News

		• Residents re-homed in Witney after deploying more than 1,000 sandbags. • School closures, sandbag sites activated and localised power and water disruption.
2013	January – Flooding[30]	• School closures and roads impacted.
	October - Wind[30]	• 1000 properties without power in Cherwell for 12+ hours.
	December - Storm[30]	• 6,251 properties without power.
2014	January - Flooding[38,39]	• 1,400 homes across Oxfordshire without power and 3,300 sandbags issued across the county. • Major transport routes (Botley Road, Abingdon Road) in the City of Oxford are disrupted. • Railways services halted. • Farmers lose tens of thousands of pounds as land is inundated. • Water pumping station and electricity sub stations impacted.
2016	September - Flooding[30]	• 43 properties and Wallingford hospital flooded. • Road closed and barriers put in place.
2017	December - Storm[30]	• Storm Caroline - countywide wide power disruption.
	December – Snow/flood[30]	• M40 impacted, school closures and care homes without power.
2018	February-March – 'Beast from the East' – Snow[40]	• Cold spells causing heavy snowfall, widespread transport disruption and school closures. • Roads blocked or closed such as the A424, A361 and A338.
	May - Flooding[30]	• Countywide impacts with Oxford and Banbury impacted in particular. • Properties flooded in Farmoor and Botley Road.
	July-August - Drought[41,42]	• Reduced opening times and closures on Oxford Canal.
	July - Heatwave[43]	• "Amber" weather warning issued in Oxfordshire.
2019	February - Snow[30]	• 220 schools closed, traffic disruption and multiple power cuts.
	July - Heatwave[44]	• 30th July 36.5°C recorded in Oxford, a new record high at the time.
	November - Flooding[30]	• Properties flooded in Kidlington, Islip, Bloxham, Wendlebury, Kings Sutton, Banbury, Cropredy school, two care homes and Bablock Hythe mobile home park. • Road closures countywide and sandbag sites in place.
2020	February – Storm Ciara[45]	• Amber weather warning issued. Power outages across Oxfordshire, damage to properties and roads blocked by fallen trees.

[38] Flood-damaged road to remain closed for foreseeable future (oxfordshire.gov.uk)
[39] Berkshire and Oxfordshire flooding timeline - BBC News
[40] SNOW: Travel latest in Oxfordshire as roads blocked and public transport cancelled | The Argus
[41] https://www.bbc.co.uk/news/uk-england-berkshire-62524215
[42] Water situation: national monthly reports for England 2018 - GOV.UK (www.gov.uk)
[43] Heatwave warning - take action (oxfordshire.gov.uk)
[44] Oxford: Heatwave likely to smash city's record temperature | Oxford Mail
[45] Destruction as Storm Ciara batters Oxfordshire | Oxford Mail

	July - Heatwave[46]	• 31st July 36°C daily max temperature recorded. • Failure of water pumping stations and power cuts.
	November - Flooding[30]	• Road closures and properties impacted in Bicester.
	December - Flooding[47]	• 10 flood alerts. • Road closures across Oxfordshire. • Drains overflow after heavy rainfall and raw sewage fills homes. • Properties flooded in Yarnton, Bucknell and Launton.
2021	January - Flooding[30]	• 71+ properties flooded countywide, road closures and impact on public transport.
	February - Flooding[30]	• Road closures countywide and Murcott flooded.
	March - Wind[30]	• Hangar roof blown off at RAF Brize Norton, Oxford Eastern bypass closed due to roof blown off block of flats and 154 postcodes without power.
	July - Heatwave[48]	• “Amber” weather warning. • Widespread power cuts, multiple care homes off power, melting road surfaces and buckling train lines.
	November - Flooding[30]	• Countywide impacts to roads.
	November – Storm Arwen[30]	• Countywide impacts including damage to trees and power cuts.
	November – Storm Barra[30]	• Countywide impacts including damage to trees and power cuts.
2022	February - Storm Eunice[49,30]	• Closures on the M40, damage to Grove Business Park, 165 fallen trees attended to and wind gusts of more than 60mph. • Brize Norton hangar roof blown off. • School closures, power cuts and public transport impacts.
	June-August - Drought	• 3-month Thames Water hosepipe ban in August-November 2022[50]. • Water shortages – Northend village without running water[51]. • Stressed terrestrial habitats – ‘Autumn’ leaf fall in August 2022[52]. • 246 Wildfires tackled by Oxfordshire fire-fighting services June to August 2022[53].
	July–August - Heatwave	• 38.4°C RAF Benson, near Wallingford (19th July)[54]. • “Red” weather warning in northern and eastern parts of Oxfordshire and “Amber” health warning for the rest of Oxfordshire[55].

[46] Microsoft Word - 2020_05_july_temperature.docx (metoffice.gov.uk)

[47] Flood Investigation Reports - Oxfordshire County Council - Flood Toolkit (oxfordshirefloodtoolkit.com), Oxford flooding: Gardens fill up with raw sewage after rain - BBC News, Christmas flooding in Witney following heavy rainfall - BBC News, Flash flooding in Oxfordshire after torrential downpours - BBC News

[48] Amber warning issued for extreme heat as temperatures soar in parts of Oxfordshire | Oxford Mail

[49] Storm Eunice: Pictures show damage storm has caused across Oxfordshire from fallen trees to overturned lorries - Oxfordshire Live

[50] UK heatwave: Berkshire and Oxfordshire officially in drought - BBC News

[51] ‘This is the future’: the Oxfordshire village living without running water | Drought | The Guardian

[52] UK drought: Why do the trees think it's autumn already? - BBC News

[53] Oxfordshire firefighters tackled nearly 250 wildfires during summer | Oxford Mail

[54] Last week's heatwave in Oxford was made worse by climate change | Oxford Mail

[55] Hot weather across England - warnings and advice issued (oxfordshire.gov.uk)

		• Over 9 different school closures[56]. • Chiltern railway speed restrictions within Oxfordshire and "Do not travel" notice issued by Chiltern railway[57]. • Household and waste recycling centres reduced hours and COVID-19 vaccination centres closed[58]. • Fire frequency stated to nearly double (↑78%) in Jul-Sep 2022 compared to same period in 2021. • Water disruption to 200+ properties, 24 water abstraction licenses constrained and water disruption to 200+ properties in Burford and Carterton. [30]
2023	January - Flooding[30]	• Countywide flooding, Great Western Rail network flooded and city barriers deployed.
	March - Flooding[30]	• Countywide flooding and property flooding in Sunningwell.
	November – Storm Ciaran[59][60]	• Flood alerts in place on the River Cherwell, River Thames and River Ock. Sewer discharge into River Thames in Oxfordshire.
2024	January – Storm Henk[61]	• 32 flood alerts issued for Oxfordshire. • Widespread flooding across Oxfordshire and transport disruption at Didcot Parkway Station due to platform closure due to flooding. Vehicles were submerged in part of the county.

3. Current risk from climate-related hazards

Current risk to climate-related hazards has been pursued based on key hazards identified in section 2 and focusing on four key thematic areas of interest in Oxfordshire:

- Critical infrastructure,
- Natural assets and environment,
- Health, communities, and the built environment,
- Business and industry.

The assessment of current risk from climate-related hazards was conducted based on available sources of information and relevant data available for Oxfordshire. Thus, included georeferenced data, statistical data, academic literature and reports and documents from key sources such as Census 2021, Defra, Environment Agency, NHS, Ordnance Survey, Insight Oxfordshire, OCC and city and district councils, Met Office and the UK Climate Resilience Programme. Insights and feedback from the Countywide Steering Group Members was also captured at different points in the assessment.

[56] Schools in Oxfordshire closed due to the heatwave | Oxford Mail
[57] Chiltern Railways warns commuters not to travel due to heatwave | Oxford Mail
[58] Hot weather across England - warnings and advice issued (oxfordshire.gov.uk)
[59] Storm Ciarán: Scores of Oxfordshire flood alerts in place | Oxford Mail
[60] Raw sewage discharged in Thames again after Storm Ciarán - BBC News
[61] Oxfordshire flood warnings in place following Storm Henk | Oxford Mail, Pictures: Oxfordshire flooded in wake of Storm Henk | thisisoxfordshire

To note that, whilst the mapping produced for Health, Communities and the Built Environment provide an overall assessment of current **climate risk** (as a function of hazard, exposure, and vulnerability) for flooding and heatwaves, this was not possible for the themes of Critical Infrastructure and Natural Environment and Assets as the quantification of vulnerability was not possible. Instead, the focus of the current risk assessment for these themes is on **climate hazard** (as a function of hazard and exposure).

Additional current climate-related hazards are explored for each theme using Climate Risk Indicators[62] and relevant sources of information.

For more detail on the methodology utilised please refer to Appendix A.

3.1. Critical infrastructure

In this study, critical infrastructure includes transport networks, energy production and supply, water infrastructure, public water supplies, etc. An assessment of critical infrastructure has been completed spatially where there is open data available. Open and accessible data included in this section includes the locations of bus stops, rail stations, roads, mobile phone masts, electric vehicle charging points and electricity transmission lines. Spatial data such as the locations of petrol stations, water/sewage treatment works, electricity distribution lines and gas networks were not publicly available, due to national security restrictions or licensing restrictions.

An assessment of current risks and impacts to critical infrastructure in England and Oxfordshire, current policies addressing such risks and overall risk to critical infrastructure across the county are provided in the sections below.

3.1.1. Current risks and impacts to critical infrastructure at a national level

The UK's Third Climate Change Risk Assessment (CCRA3) recognises the risks posed by climate change to the UK and has been created to ensure the UK is and remains resilient to the climate change[63,64]. National risks to critical infrastructure include high temperatures, low temperatures, flooding, drought, and cascading failures. In addition, high winds and lightning also pose risks to critical infrastructure.

The impacts of these climate risks may be greater in urban areas than rural areas because there is a higher population in towns and cities and a greater number of assets that are exposed to hazards. In addition, the urban landscape can contribute to increased risks, for example, due to development in the floodplain, an increase in impermeable surfaces that increase the risk of surface water flooding[65] and due to the Urban Heat Island (UHI) effect in more densely urbanised areas, which typically increase maximum daytime and nighttime temperatures by around 2 and 4 degrees. A more comprehensive analysis of these risks and impacts on critical infrastructure are provided in Appendix B.

3.1.2. Critical infrastructure in Oxfordshire

An inclusive, integrated, and sustainable transport network is a strategic priority for Oxfordshire[66]. Transport in Oxfordshire comprises of both public transport (trains, buses and coaches), active modes (walking and cycling) and private vehicle use. Oxfordshire's rail network connects key settlements such as Oxford city, Didcot and Bicester to London, Swindon, Bristol and Birmingham[67]. Train stations in Oxfordshire include Oxford, Oxford Parkway, Didcot Parkway, Banbury, Bicester Village and Henley-on-Thames. A number of park and ride

[62] Climate Risk Indicators (uk-cri.org)
[63] https://www.gov.uk/government/news/government-publishes-uks-third-climate-change-risk-assessment
[64] https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2022
[65] https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf
[66] OCC Strategic Plan 2022 to 2025 (oxfordshire.gov.uk)
[67] Oxfordshire Local Industry Strategy

facilities are located across the county, five outside of Oxford City and one outside of Bicester[68]. Oxfordshire has a high local bus usage, including a substantial network in Oxford City and Banbury, premium routes between cities and towns across Oxfordshire including Didcot to Oxford and Bicester to Oxford[68] and many other local routes. Key road links in the county include the A40/M40 linking to Cheltenham, London and Birmingham and the A34 to Southampton (Figure 3-1). National Cycle Network also have routes throughout the county.

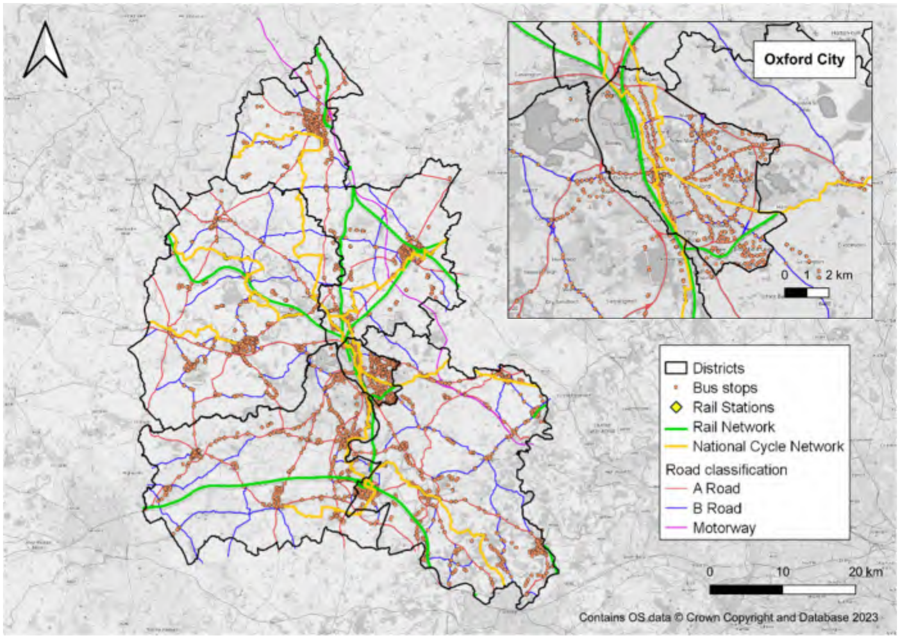

Figure 3-1 - Transport links within Oxfordshire for road and public transport[69]

Energy networks in Oxfordshire include a number of substations including Cowley, Didcot, Moulsford Down and Hinksey[70] that are critical nodes for the transmission of electricity across the county. Electricity transmission lines are concentrated to the south of the county surrounding Oxford City (Figure 3-2). Masts are located across the county and are primarily concentrated in urban settlements. Total energy use in Oxfordshire in 2018 was primarily petroleum products (45%), followed by gas (32%), electricity (19%), bioenergy and waste (3%), manufactured fuels (1%) and coal (0.6%)[71]. National grid gas pipelines are located in Oxfordshire to the east of Oxford and runs southward to the east of Abingdon-on-Thames and Didcot[72].

[68] Bsip (oxfordshire.gov.uk)
[69] Data | PBCC (carbon.place) and OS Open Roads | Vector Map Data for GIS | Free OS Data downloads and National Cycle Network

[70] Network route maps | National Grid ET
[71] Mapping Oxfordshire's Energy Transition (arcgis.com)
[72] Network route maps | National Gas: download (nationalgas.com) and download (nationalgas.com)

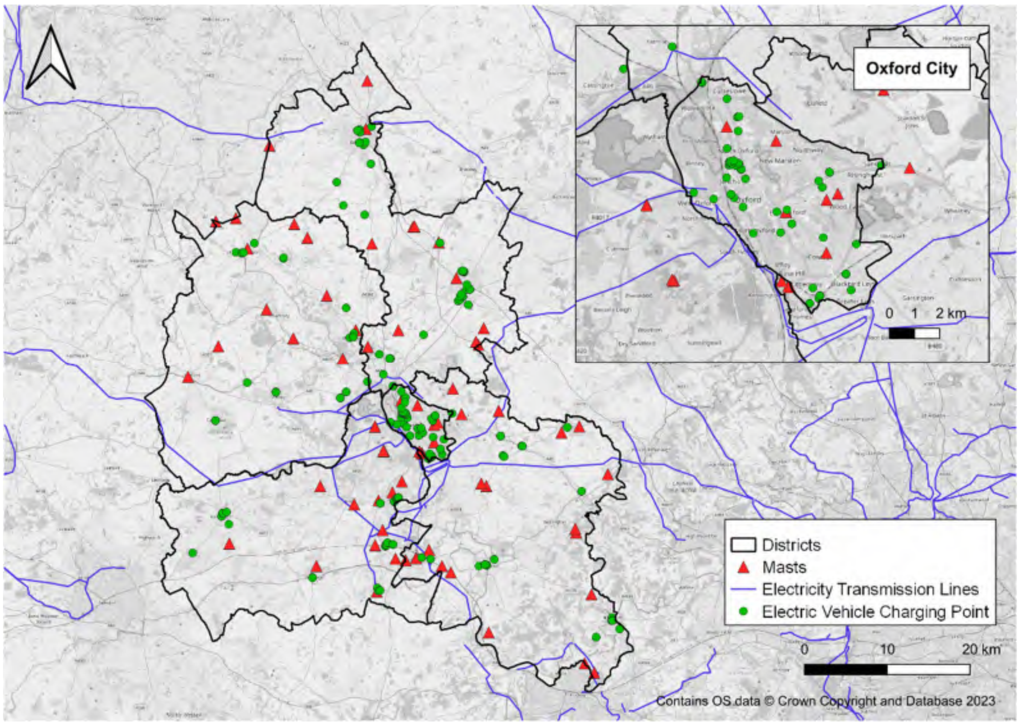

Figure 3-2 – Electricity Transmission Lines, electric vehicle charging points and mobile phone masts in Oxfordshire[73]

Water is provided by Thames Water to Oxfordshire. The Swindon and Oxfordshire (SWOX) water resource zone is primarily supplied by groundwater and supplemented by surface water abstraction and the Farmoor Reservoir (Figure 3-3). River flows, groundwater and reservoir water levels are regularly monitored by Thames Water[74] and are used to forecast the impact of drought and to plan ahead to minimise the need for emergency measures[75]. On average household water consumption in Thames Water is 127 l/h/d. which is marginally below the national average for England and Wales; leakage from the distribution network is high but has declined significantly in line with industry performance targets[76]. Water resources, including water discharges returned to the River Thames, are important for London's water supply. The water resources system in Oxfordshire is part of a larger system of inter-connected supplies covering the South East of England.

There is also a navigable canal network which starts in Oxford City and runs north towards Banbury and onwards to Birmingham. The canal network is managed by the Canal and River Trust[77]. In future the canal network may be important for transferring water supplies as well as for recreation, amenity and nature.

[73] OS Open Zoomstack | OS Products (ordnancesurvey.co.uk) and OSM Tag:man_made=mast - OpenStreetMap Wiki

[74] Reservoir levels | Performance | About us | Thames Water
[75] Final Draft Drought Plan (thameswater.co.uk)
[76] DiscoverWater (en-GB)
[77] Canal & River Trust | Wellbeing for everyone (canalrivertrust.org.uk)

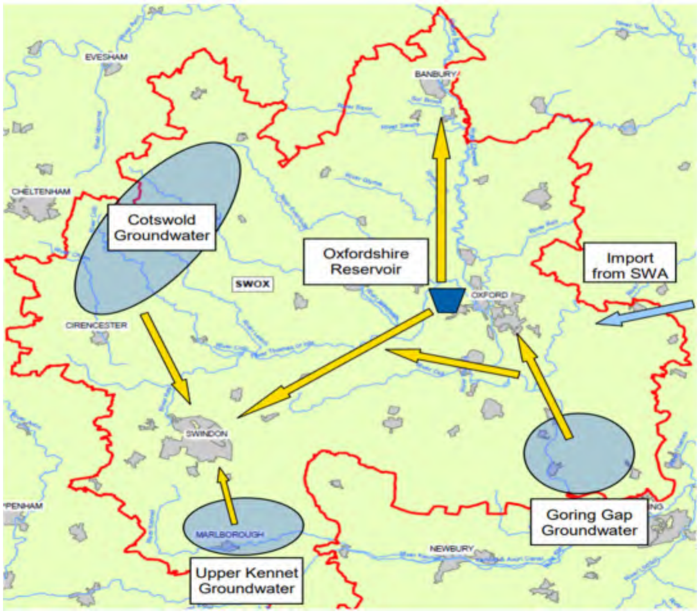

Figure 3-3 – Principal features of the Swindon and Oxfordshire Water Resource Zone[78]

3.1.3. Current risk from climate-related hazards to critical infrastructure

Critical infrastructure such as roads[79], railway lines[80] and energy networks[81] are vulnerable to climate-related hazards (based on their location in relation to climate-related hazards), such as flooding, heatwaves and high winds and storms. To visualise the risk to key critical infrastructure, hazard maps were created for flooding and heatwaves, comprised of 500m hex grids across Oxfordshire.

3.1.3.1. Flooding

The current flood hazard was based on Expected Annual Damage (EAD) from surface water flooding and fluvial flooding[82] and return periods of surface water flooding[83] and risk of flooding from rivers[84]. High current flood hazard suggests a greater return period of fluvial flooding, surface flooding and greater EAD from fluvial and surface flooding. Further information is available on the hazard mapping methodology in Appendix A.

Figure 3-4 demonstrates the current flood hazard (surface water and fluvial flooding) across Oxfordshire. Fluvial water flood hazard mapping is available in Appendix E. High current flood hazard is visible along river channels including the River Thames in Abingdon and Oxford City, River Ock in Vale of White Horse district, River Evenlode in West Oxfordshire district and River Cherwell and River Ray in Cherwell district. Low current flood hazard is recorded to the south-east of Oxfordshire in South Oxfordshire district in the Chilterns AONB which has higher elevations, likewise to the east of Oxford City where Beckley Hill and Shotover Hill are located.

Critical infrastructures are located in areas of high current flood hazard, including electricity transmission lines located along the River Thames path to the west of Oxford and to the east and west of Abingdon, south of Oxford City.

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78 Appendix-d-water-resource-zone-integrity.pdf (thameswater.co.uk)
79 https://www.ordnancesurvey.co.uk/business-government/products/open-map-roads
80 network-rail-gis/network-model/VectorLinks at main · openraildata/network-rail-gis · GitHub
81 OS Open Zoomstack | Data Products | Ordnance Survey
82 https://www.ukclimaterisk.org/wp-content/uploads/2020/09/CCRA3-Results-Summary-External-02Sept2020.xlsx
83 Defra Risk of Flooding from Surface Water Data Download
84 Risk of Flooding from Rivers and Sea - data.gov.uk

The railway line from Oxford City to the Cotswolds in West Oxfordshire lies on an area of high flood hazard, as it lies in proximity to the River Evenlode. This is also true of the Oxford to Banbury rail line which is located in parallel to the channel of the River Cherwell. All other main rail lines in Oxfordshire are located at least partially within an area of high current flood hazard.

OCC have identified a Resilient Highways Network, defined as the 'portion of the highway network that is absolutely vital to maintaining economic activity and enabling access to key services during extreme weather emergencies (snow, ice or flooding) and other major incidents'[85]. This includes roads connecting towns and cities, strategic diversion routes and key operational services requiring emergency public access such as hospitals and police stations. The M40 in Cherwell district is located in high current flood hazard in proximity to the River Ray. A roads and B roads in Oxford City and Abingdon such as the A34, A420 and A4144 are located within areas of high current flood hazard. This Resilient Highways Network also highlights a greater number of roads in urban areas which are of the greatest importance for accessibility during extreme weather emergencies in areas of high current flood hazard, such as west of Oxford City and Abingdon.

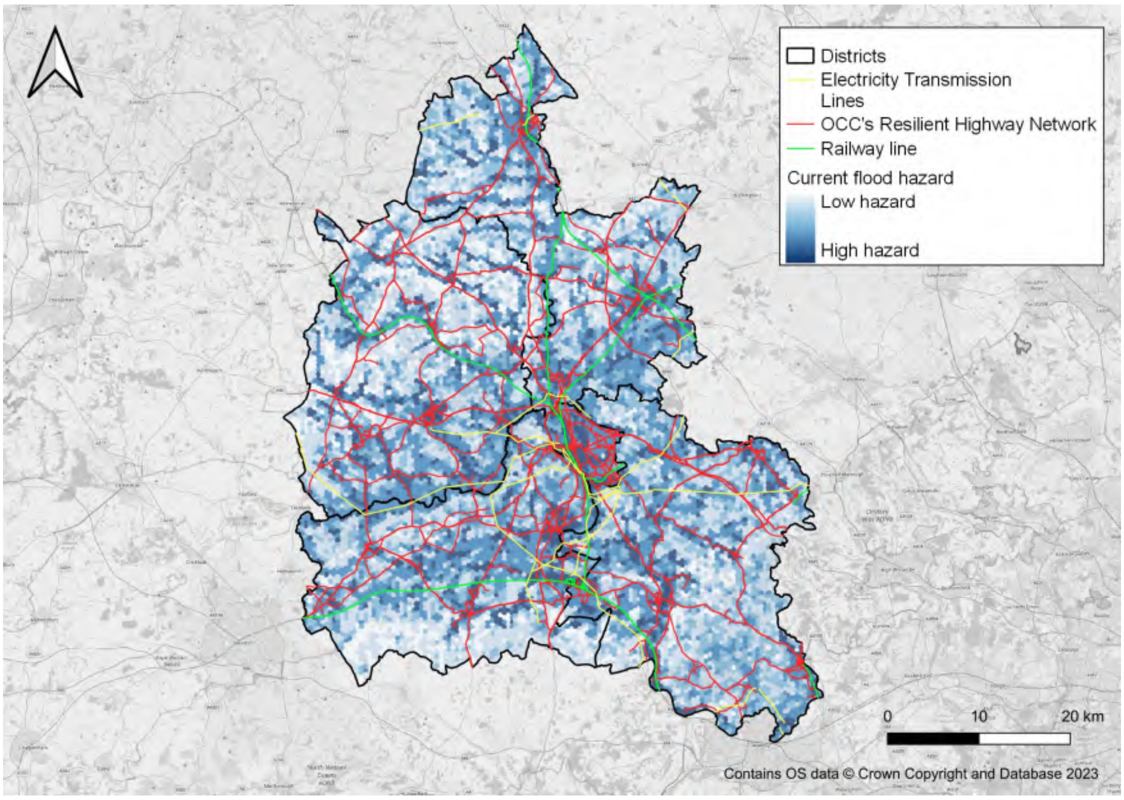

Figure 3-4 – Current flood hazard in Oxfordshire and critical infrastructure[85]

Key critical infrastructure by current flooding risk score (fluvial and surface flooding) is presented in Table 3-1, demonstrating the large proportion of the Oxfordshire resilient highway, rail network and national cycle network which are within areas of high current flood hazard. Likewise, key infrastructure such as mobile phone masts,

85 [ResilientNetworkDefinition (oxfordshire.gov.uk)]

electric charging points and electricity transmission lines tend to be located where there is a higher current flood hazard.

Table 3-1 – Key critical infrastructure and current flooding (fluvial and surface) risk scoring

Key critical infrastructure	Key infrastructure and current flooding hazard score				
	Lowest hazard (0-1)	*1-2*	*2-3*	*3-4*	*Highest hazard (4-5)*
ETLs (length in km)	15	48	48	70	30
Roads (length in km)	396	718	1,162	1,342	992
Rail network (length in km)	4	63	75	164	168
National cycle network (length in km)	24	38	55	77	66
Mobile phone masts (count)	6	9	19	22	13
Electric charging points (count)	-	2	34	98	160

3.1.3.2. Heatwaves

Current heatwave hazard and critical infrastructure are presented in Figure 3-5. The current heatwave hazard is calculated based on the number of cooling degree days[86,87], urban heat island effect (the proportion of urban and suburban land use)[88] and proportion of green space[89]. Further information on the methodology is available in Appendix A. There is an evident higher current heatwave hazard in urban areas such as Oxford City, Abingdon, Kidlington and Henley-on-Thames due to greater urban and suburban areas, higher cooling degree days and lower proportion of green space.

Electricity transmission lines are located primarily in areas of lower current heatwave hazard, in more rural areas. However, rising temperatures pose a hazard to electricity transmission lines even rurally as higher ambient temperatures overall require electrical current to be reduced to prevent overheating of equipment, and hotter power lines are less efficient due to de-rating[90]. The changing nature of energy demand, with less requirement for heating in winter and a growing demand for cooling in summer, may exacerbate these risks.

Railway lines are located primarily in areas of lower heatwave hazard. However, key railway stations and routes are located in Oxford City, Didcot and Bicester which have a high heatwave hazard.

OCC's Resilient Highways Network, as explained in section 3.1.3.1, identifies roads which are vital to maintain economic activity and access to essential services during extreme weather[85]. These strategic roads are concentrated within built up urban areas which have a high current heatwave hazard, primarily Oxford City and Abingdon including the A34, A4144, A420, A4165, A4142 and B480. The Resilient Highways Network demonstrated a greater number of local roads in urban areas such as Oxford City and Abingdon which are located with high current heatwave hazard.

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[86] Cooling degree days are a measure of the severity and duration of hot weather, using a threshold temperature of 22° C. Source: Arnell, N.W., Kay, A.L., Freeman, A., Rudd, A.C., Lowe, J.A. (2021) Changing climate risk in the UK: A multi-sectoral analysis using policy-relevant indicators, *Climate Risk Management*, Volume 31, Available at: https://doi.org/10.1016/j.crm.2020.100265
[87] Climate Risk Indicators (uk-cri.org)
[88] Marston, C., Rowland, C. S., O'Neil, A. W., & Morton, R. D. (2022). Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A
[89] OS Open Greenspace | OS Products (ordnancesurvey.co.uk)
[90] Adapting overhead lines in response to increasing temperatures in UK — English (europa.eu)

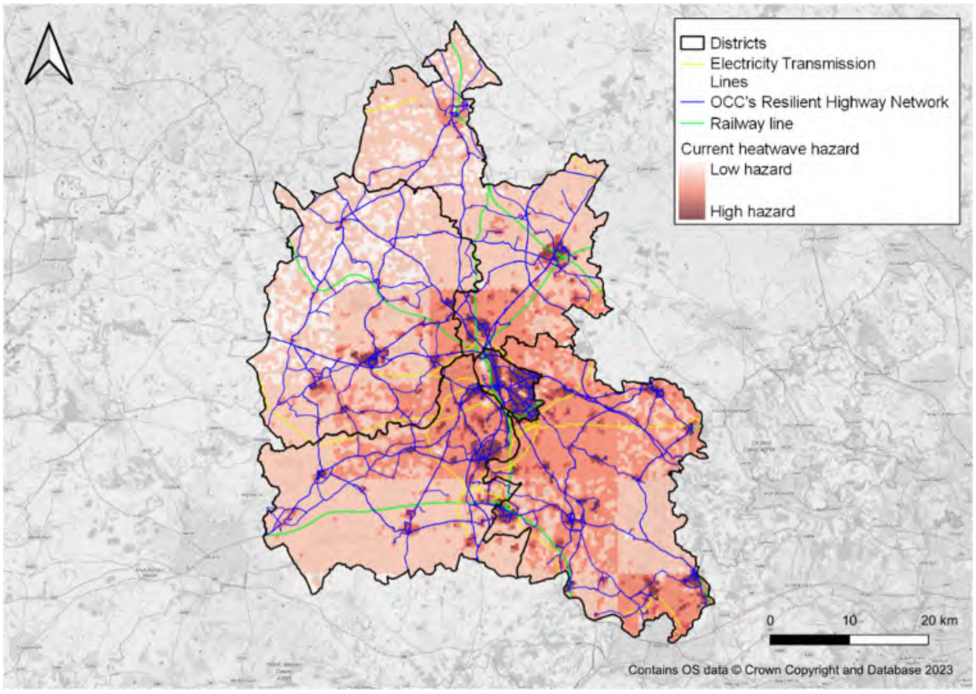

Figure 3-5 – Current heatwave hazard in Oxfordshire and critical infrastructure[85]

The length and count of key critical infrastructure and networks is presented in Table 3-2. The majority of the Oxfordshire Resilient Highway Network is located where there is a higher hazard score (hazard score of 3+), likewise with mobile phone masts and electric charging points.

Table 3-2 – Key critical infrastructure and current heatwave risk scoring

Key critical infrastructure	**Key infrastructure and current heatwave hazard score**				
	Lowest hazard (0-1)	*1-2*	*2-3*	*3-4*	*Highest hazard (4-5)*
ETLs (length in km)	-	3	64	136	8
Roads (length in km)	1	89	1,586	2,080	854
Rail network (length in km)	1	16	207	181	70
National cycle network (length in km)	-	9	109	94	48
Mobile phone masts (count)	-	-	1	45	23
Electric charging points (count)	-	2	15	122	155

The current risk of road melt, where days have a maximum temperature greater than 25°C is presented in Figure 3-6. Similarly to current heatwave hazard, road melt risk is centred in the south of the county around Oxfordshire and to the south-east in proximity to Henley-on-Thames where there are high concentrations of strategically important road network.

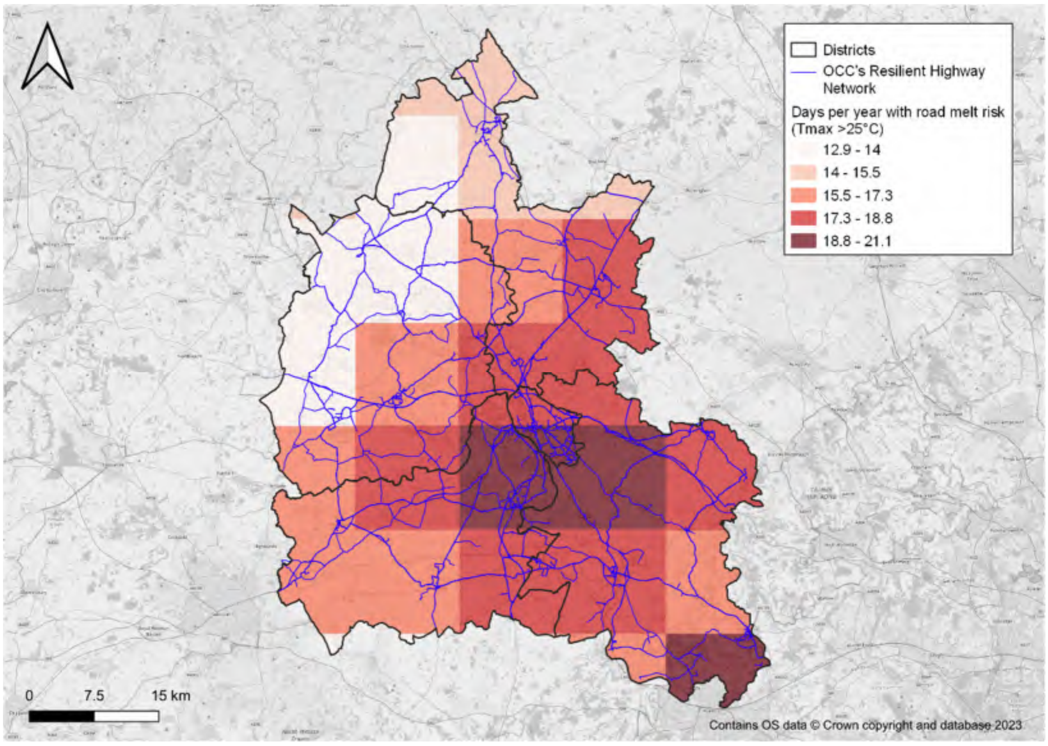

Figure 3-6 – Days per year with road melt risk (maximum temperature >25°C)[91]

3.1.3.3. Other key hazards and impacts

Other key hazards with impacts on Oxfordshire's critical infrastructure over the past years have been storms and cold snaps and snow. From available evidence around 9 storms/strong winds and 8 cold snaps/snow events have been registered in Oxfordshire since 2007 (see Table 2-1). Further information collected from OCC has indicated that the main impacts from storms and strong winds have been widespread across the county mainly with power cuts and disruption, felling of trees, and the occasional closure of roads and schools. Regarding cold snaps and snow events, these have mainly led to closure of roads and schools, disruptions to public transport and traffic and, in some instances, power cuts.

3.1.4. Policies and initiatives addressing risks and impacts on critical infrastructure

Figure 3-7 provides a summary of existing local and national[92] policies and plans that address climate impacts and adaptation on critical infrastructure within Oxfordshire. All four areas regarding critical infrastructure – water supply, energy, telecoms and transport – lack sufficient policies and/or there is a significant lack of data to help assess current situation on the ground particularly regarding interdependencies within and between these areas. However, water supply and transport policies seem to be more advanced compared to energy and telecoms in Oxfordshire. For more detail on the assessment of existing policies and plans, please refer to Appendix B, for which existing policies are assessed in the below categories of credible, partial, limited or insufficient policies and plans.

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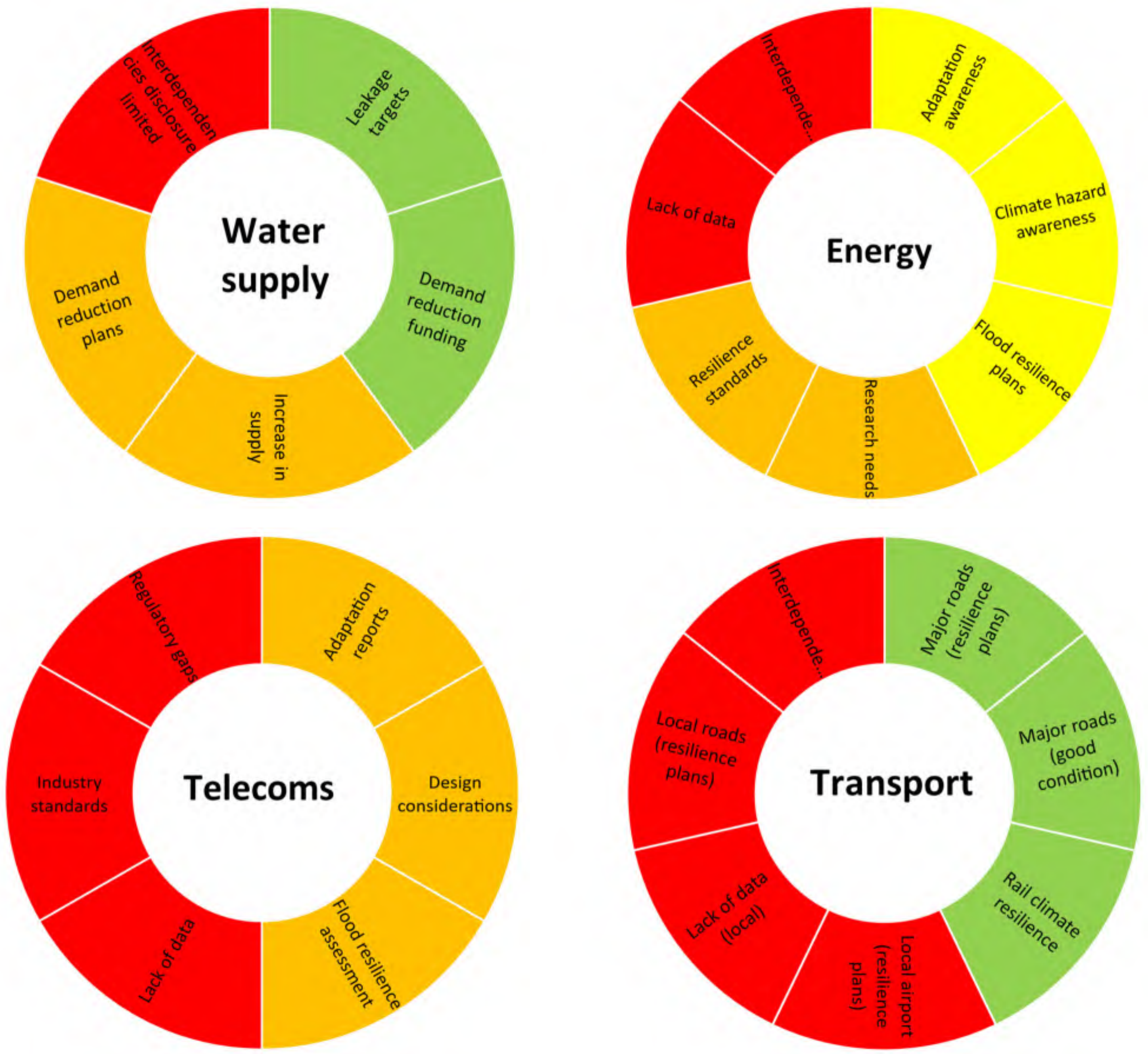
[91] Climate Risk Indicators (uk-cri.org)
[92] Information retrieved from https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf



Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans

Figure 3-7 – Local and national policies addressing impacts on critical infrastructure

3.2. Health, Communities, and the Built Environment

This theme considers the impact of climate change related-hazards on health including climate-related mortality and morbidity, healthcare facilities, and other health-related aspects affected by extreme weather conditions. It also covers elements of the built environment and the impacts of events such as flooding and heatwaves on communities and settlements, buildings, and cultural heritage.

3.2.1. Current risks and impacts to health, communities, and the built environment at national level

Over 80% of the UK population lives in urban areas[65,93]. Therefore, the built environment represents areas, such as towns and cities, where extensive communities are located and where exposure to climate risks is high. Oxfordshire is the most rural county in the South East region[95]. Built up areas are located at key urban settlements including Oxford City, Banbury, Bicester, Abingdon, Carterton, Witney, Didcot, Wallingford and Henley-on-Thames. Climate impacts affect both mental and physical health. Climate-related exposures, both direct (i.e. exposure to exposure to traumatic events) and indirect (social, political and economic determinants of mental health, such as poverty, unemployment, housing), have been associated with mental health disorders globally[94].

- Risks to the built environment also include those on cultural heritage such as archaeological sites can also be impacted. For example, warmer temperatures may result in additional pests that can metabolise building timbers, and drought may result in invisible deterioration of buried archaeological deposits.

A more comprehensive analysis of these risks and impacts at national level on health, communities and the built environment are provided in Appendix B.

3.2.2. Characterisation of health, communities and built environment in Oxfordshire

Prioritising the health and wellbeing of residents, supporting carers and the social care system, tackling inequalities in Oxfordshire are all strategic priorities outlined in the OCC Strategic Plan 2022[66]. Oxfordshire has a population of approximately 725,300 people. There is a higher than national and regional average life expectancy in Oxfordshire and an ageing population[95]. Population density is greatest in Oxford City and other urban settlements such as Bicester, Banbury and Abingdon (Figure 3-8). Oxfordshire was overall ranked the 10th least deprived of 151 local authorities in England[95]. However, there are notable concentrations of deprivation in Oxford City and Banbury (Figure 3-9).

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93 Surminski, S. (2021) Business and industry. In: The Third UK Climate Change Risk Assessment Technical Report [Betts, R.A., Haward, A.B. and Pearson, K.V. (eds.)]. Prepared for the Climate Change Committee, London

94 Charlson, F. et al. (2021) Climate Change and Mental Health: A Scoping Review, *Int. J. Environ. Res. Public Health*, 18(9), 4486; https://doi.org/10.3390/ijerph18094486, Available from: https://www.mdpi.com/1660-4601/18/9/4486.
The climate-related exposures listed in the article include heat, humidity, rainfall, drought, wildfires, and flooding. These have been linked with "psychological distress, worsened mental health, and higher mortality among people with pre-existing mental health conditions, increased psychiatric hospitalisations, and heightened suicide rates."

95 Oxfordshire JSNA 2022

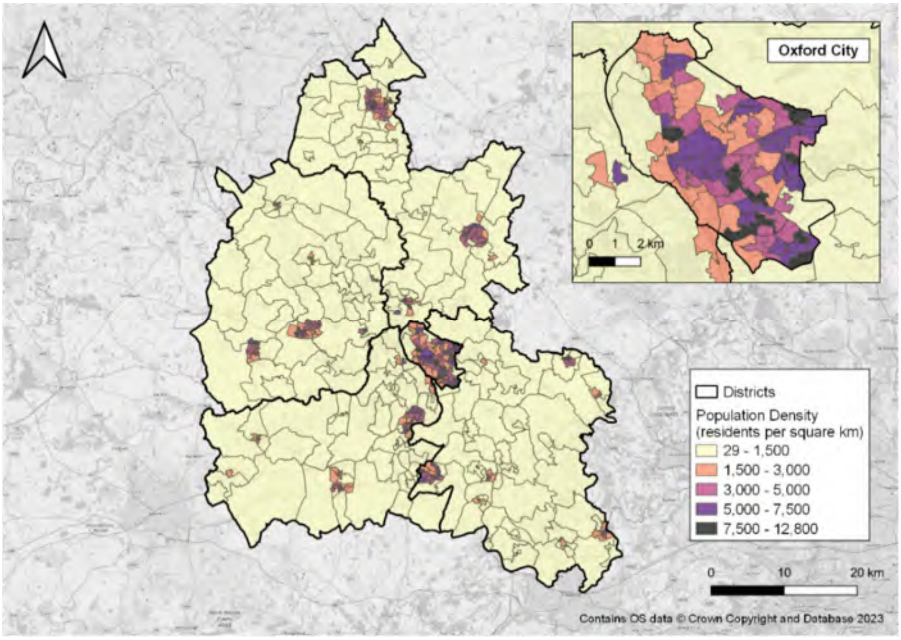

Figure 3-8 – Population density within Oxfordshire[96]

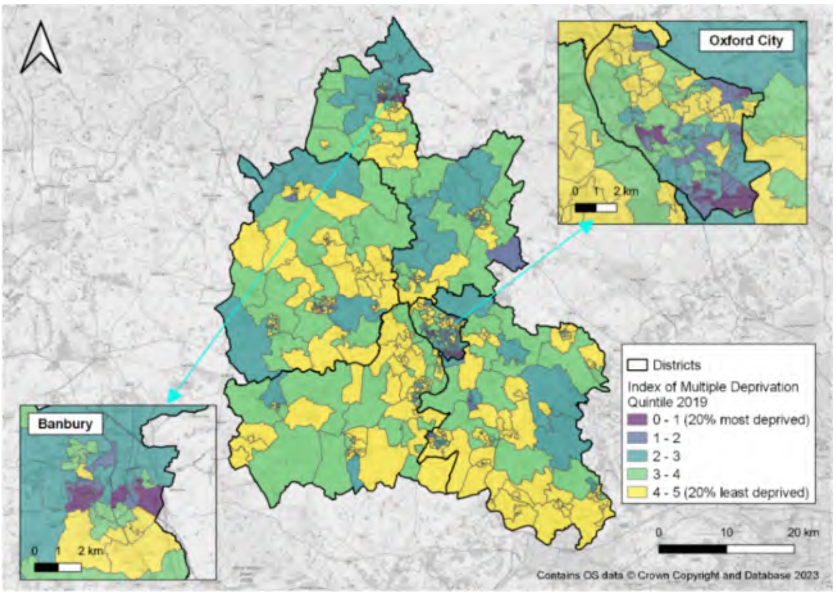

Figure 3-9 – Index of Multiple Deprivation within Oxfordshire[97]

The number of residents and households within Oxfordshire which are within a vulnerable group is outlined below in Table 3-3. Cherwell has the highest number of residents aged under 15 and Vale of White Horse has the highest number of residents aged 75 and over. Cherwell and Oxford have the highest number of residents identifying as disabled under the Equality Act 2010. The most deprived LSOAs in Oxfordshire, as noted previously, are located primarily in Oxford, Cherwell and a smaller number of the Vale of White Horse.

[96] Census 2021 TS006 - Population density - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)
[97] Census 2021 IMD 2019 | Lower Super Output Area (LSOA) | Ministry of Housing, Communities and Local Government (arcgis.com)

Table 3-3 - Vulnerable residents and households within Oxfordshire at district level

	Residents aged under 15 (Census 2021)	Residents aged 75 and over (Census 2021)	Residents identifying as disabled under Equality Act 2010 (Census 2021)	Households in 20% most deprived LSOAs nationally (IMD 2019)
Cherwell	28,550	12,962	23,388	4,179
Oxford	23,633	8,873	23,490	6,179
Vale of White Horse	25,845	15,085	20,898	517
West Oxfordshire	24,817	13,240	20,399	-
South Oxfordshire	19,164	12,058	17,294	-

Healthcare facilities such as hospitals, care homes and GPs are located across the county and are concentrated in urban areas such as Oxford City, Banbury and Bicester (Figure 3-10). Key hospitals include Witney Community Hospital in West Oxfordshire, Bicester Community Hospital and Horton General Hospital in Cherwell, Churchill Hospital and John Radcliffe Hospital in Oxford City, Thame Community Hospital and Wallingford Community Hospital in South Oxfordshire and Abingdon Community Hospital and Wantage Community Hospital in Vale of White Horse. Educational establishments are widespread across Oxfordshire and are particularly concentrated in towns and cities such as Oxford City, Banbury and Abingdon.

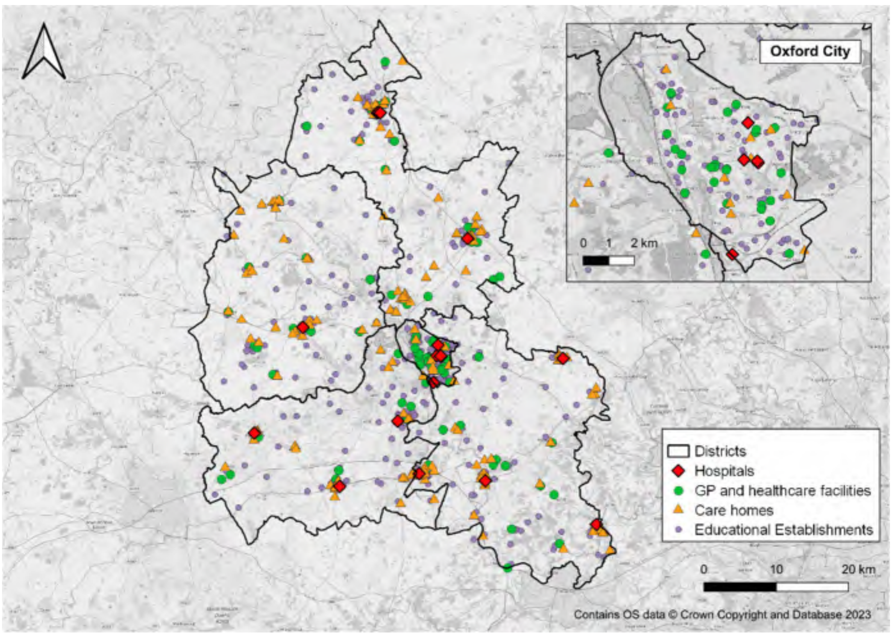

Figure 3-10 – Hospitals, care homes, educational establishments and GP and healthcare facilities[98]

98 The NHS website datasets - NHS (www.nhs.uk) for hospitals and GP and healthcare facilities and Google Earth for care homes and Downloads - GOV.UK (get-information-schools.service.gov.uk)

Listed buildings are spread evenly across the county in rural and urban areas and are especially concentrated in Oxford City, often in conservation areas[99].

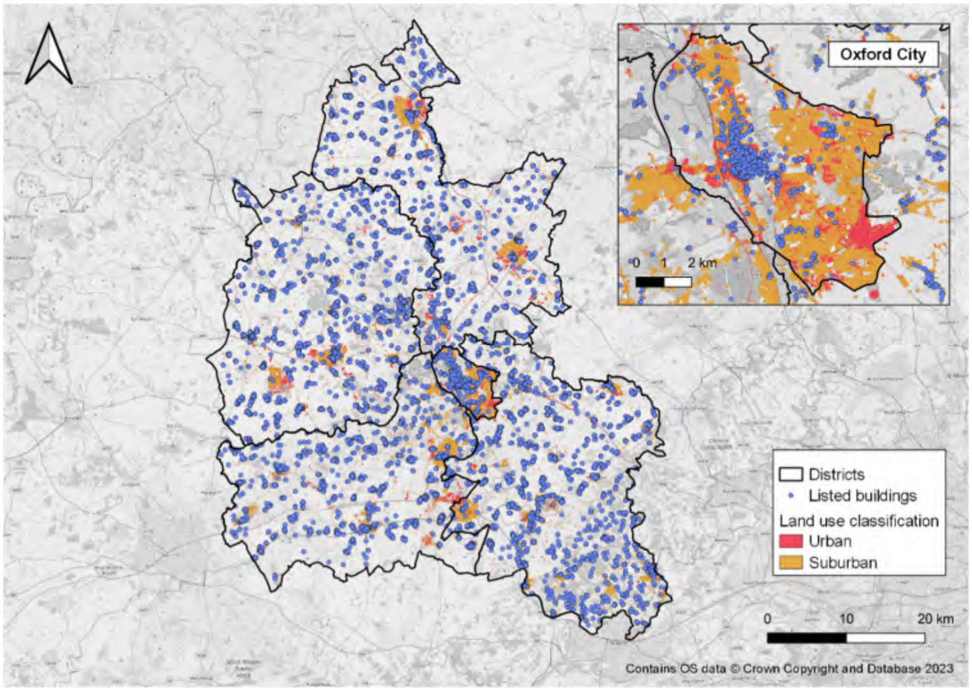

Figure 3-11 – Listed buildings[100] and built-up areas[101]

3.2.3. Current risk to health, communities and built environment from climate-related hazards

An assessment of current risk to health, communities and built environment was completed examining climate change risks as a function of vulnerability, exposure, and hazard in line with the IPCC approach[102]. Vulnerability, exposure and hazard are mapped to a 500m hex grid for both flooding and heatwaves for Oxfordshire to produce an overall current flood and heatwave risk. Further details on assumptions and the overall methodology are outlined in Appendix A.

3.2.3.1. Flooding

Current flood risk in Oxfordshire as a function of vulnerability, exposure and hazard is presented in Figure 3-12.

Vulnerability to flooding is derived from population characteristics including the proportion of the population which is elderly, children, disabled or renting properties and in combination with population density and index of multiple deprivation at a Lower Super Output Area (LSOA) level[103]. Higher vulnerability is notable throughout

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[99] Adopted Oxford Local Plan 2036 | Oxford City Council
[100] Listed Buildings (arcgis.com)
[101] Marston, C., Rowland, C. S., O'Neil, A. W., & Morton, R. D. (2022). Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A
[102] IPCC, 2022: Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A. Reisinger (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, doi:10.1017/9781009325844.029
[103] Census 2021 Topic Summaries - 2021 Census - Census of Population - Data Sources - home - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk) and Index of Multiple Deprivation from the Ministry of Housing, Communities and Local Government English indices of deprivation 2019 - GOV.UK (www.gov.uk)

Oxford, Banbury, Bicester, the Cotswolds in West Oxfordshire district and to the south-west of the Vale of White Horse district.

Exposure is assessed based on the number of buildings and how low building height is and are therefore more likely to be more exposed to flooding. There is fairly even exposure throughout Oxfordshire with some concentration of exposure in areas with greater housing concentration versus rural areas to the south-west in the Vale of White Horse district.

Current flood hazard, as aforementioned in section 3.1.3, was based on Expected Annual Damage (EAD) from surface water flooding and fluvial flooding[104] and return periods of surface water flooding[105] and risk of flooding from rivers[106]. High current flood hazard suggests a greater return period of fluvial flooding, surface flooding and greater EAD from fluvial and surface flooding. Mapping of fluvial flooding hazard and risk is presented in Appendix E.

Current flood risk as a function of vulnerability, exposure and hazard demonstrates high flood risk in the centre of Vale of White Horse District, Oxford City, Banbury and Witney. The ten wards with the highest current flood risk, as shown in Figure 3-12, are located in Oxford City (Blackbird Leys, Holywell, Hinksey Park, Littlemore, Marston and Northfield Brook), West Oxfordshire (Witney Central, Witney South and Witney East) and Vale of White Horse (Abingdon Caldecott) districts.

[104] https://www.ukclimaterisk.org/wp-content/uploads/2020/09/CCRA3-Results-Summary-External-02Sept2020.xlsx
[105] Defra Risk of Flooding from Surface Water Data Download
[106] Risk of Flooding from Rivers and Sea - data.gov.uk

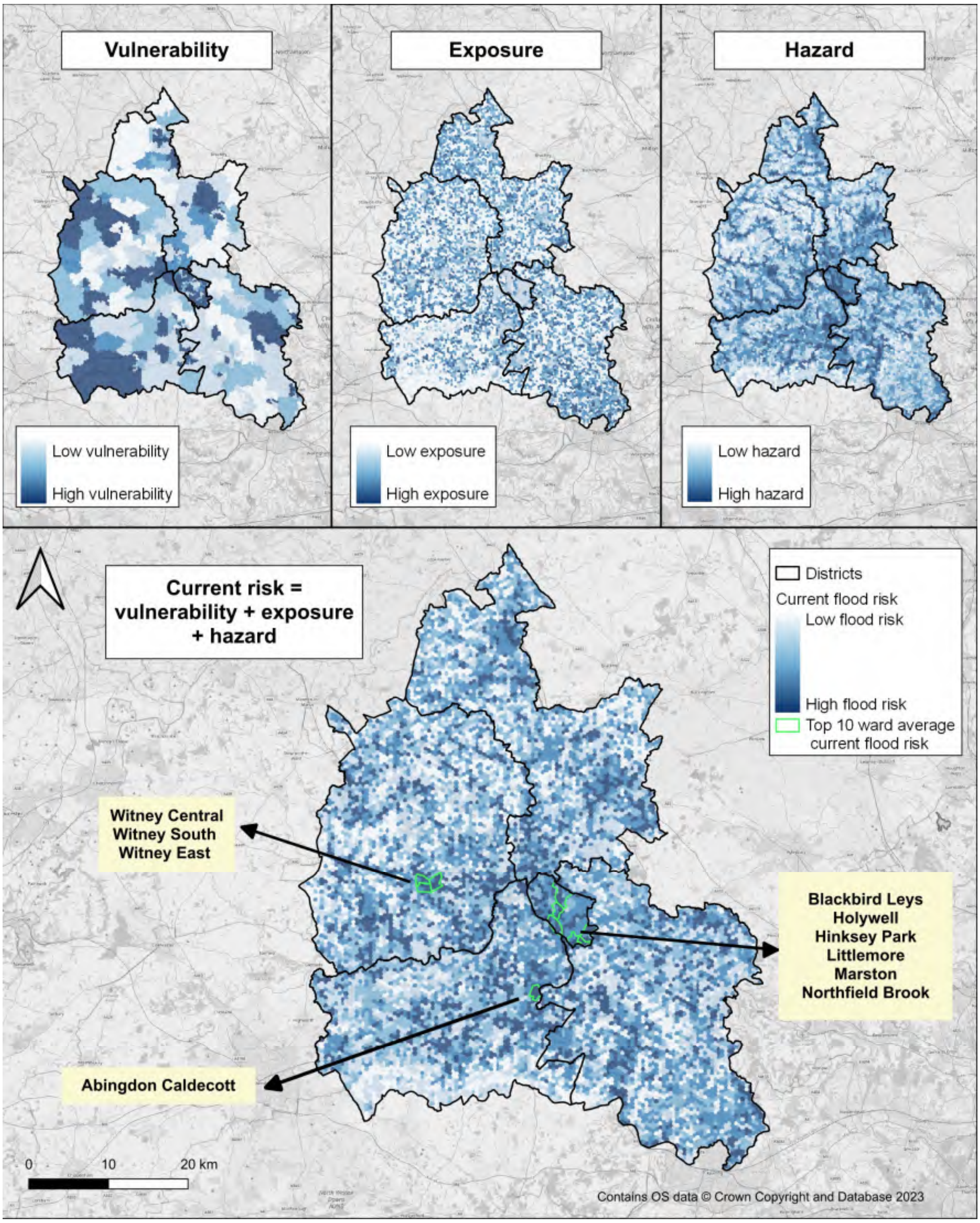


Figure 3-12 – Current surface and fluvial flood risk in Oxfordshire and ten wards with highest current flood risk

Approximately 193,101 people live within areas which have a high current flood risk (scoring 9+) (Table 3-4). Alongside substantial groups of children (31,495), elderly (14,614) and disabled residents (30,924). Population was not identified within the highest risk score category (12-15) due to the averaging of risk scoring to correspond with available LSOA level population data. 139 educational establishments, 63 care homes, 7 hospitals and 29 GP and healthcare facilities are located in areas of high current flood risk.

Table 3-4 – Key amenities and associated current flooding risk scoring

Key amenities and population	Key amenities and population groups within current flooding risk score				
	Lowest risk (0-3)	*3-6*	*6-9*	*9-12*	*Highest Risk (12-15)*
Aged under 15	-	5,084	83,913	31,495	-
Aged 75 and over	-	2,980	44,131	14,614	-
Total population	-	30,673	490,317	193,101	-
Disabled under Equality Act	-	4,033	68,939	30,924	-
Educational establishments (count)	-	6	231	139	-
Care homes (count)	-	3	101	63	-
Hospitals (count)	-	-	10	7	-
GP and healthcare facilities (count)	-	-	68	29	-
Buildings (count)	1	5,185	210,863	114,125	595

3.2.3.2. Heatwave

Current heatwave[107] risk in Oxfordshire as a function of vulnerability, exposure and hazard is presented in Figure 3-13.

Vulnerability to heatwaves is derived from the same population characteristics as the current flooding assessment, including the proportion of the population which is elderly, children, disabled or renting properties and in combination with population density and index of multiple deprivation at a Lower Super Output Area (LSOA) level[108].

Exposure is assessed based on the number of buildings and building height, the higher the buildings the more exposed to overheating[109]. There is fairly even exposure throughout Oxfordshire with some concentration of exposure in areas with greater housing concentration versus rural areas to the south-west in the Vale of White Horse district.

Current heatwave hazard, as aforementioned in section 3.1.3, is concentrated primarily in built up areas such as Oxford City, Henley-on-Thames, Abingdon, Witney and Bicester. Lower current hazard can be viewed where there is greater access to green space, lower cooling degree days and areas which are not built up.

Current heatwave risk as a function of vulnerability, exposure and hazard demonstrates high heatwave risk in Oxford City, Witney, Abingdon and Banbury. Eights of the ten wards with the highest current heatwave risk, as shown in Figure 3-13, are located in Oxford City (Barton and Sandhills, Blackbird Leys, Cutteslowe and Sunnymeade, Carfax and Jericho, Holywell, Littlemore, Northfield Brook and Walton Manor) and two wards in Vale of White Horse (Abingdon Caldecott and Abingdon Abbey Northcourt) districts.

[107] A heatwave is defined as a period of at least three consecutive days with daily maximum temperatures meeting or exceeding the heatwave temperature threshold. The threshold for Oxfordshire is 27°C What is a heatwave? - Met Office
[108] Census 2021 Topic Summaries - 2021 Census - Census of Population - Data Sources - home - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk) and Index of Multiple Deprivation from the Ministry of Housing, Communities and Local Government English indices of deprivation 2019 - GOV.UK (www.gov.uk)
[109] RecommendationsReport_CareHomeOverheatingAuditPilot_200713.docx (london.gov.uk)

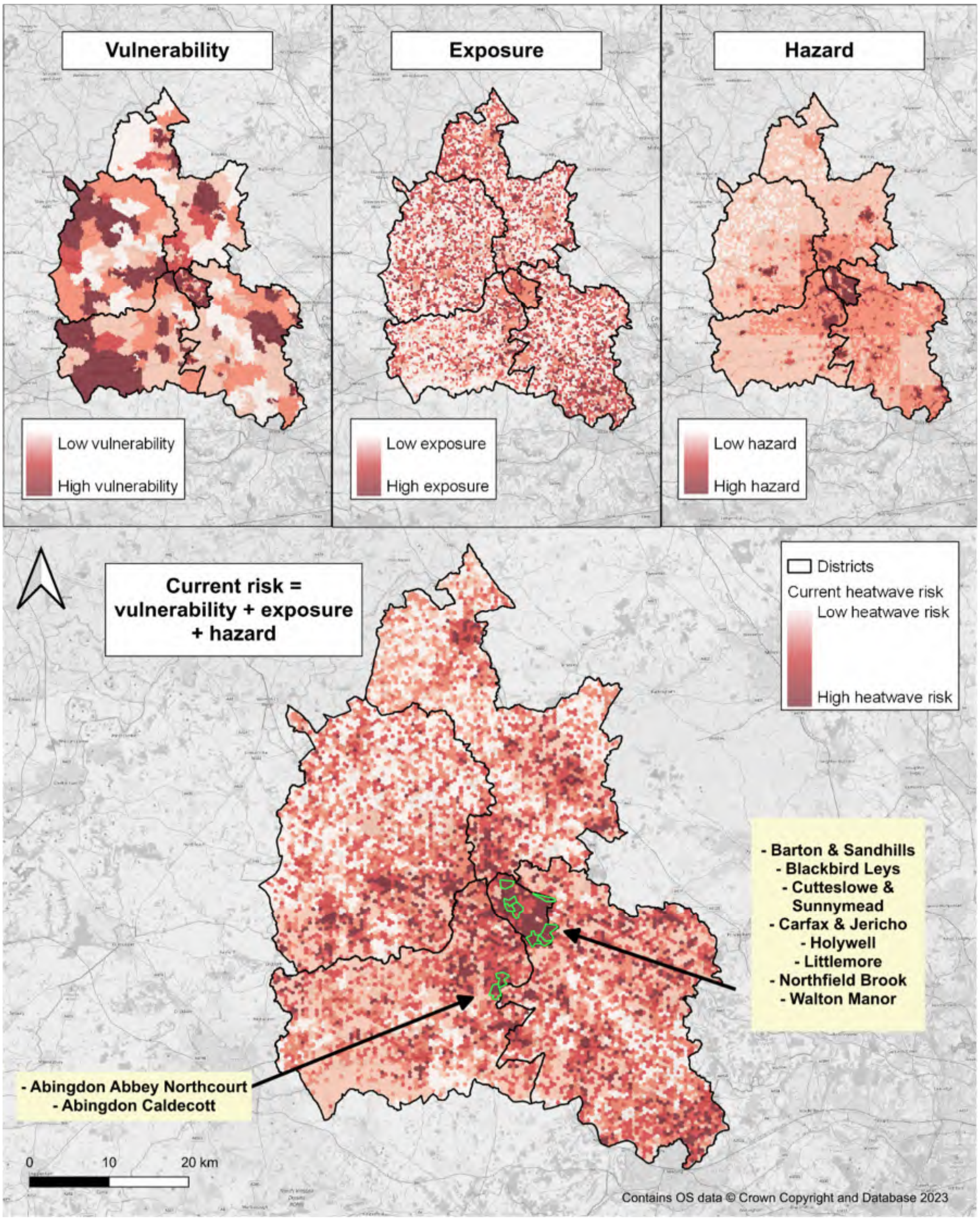


Figure 3-13 – Current heatwave risk in Oxfordshire and ten wards with the highest heatwave risk

Approximately 205,158 people live within areas which have a high current heatwave risk (scoring 9+) (Table 3-5). Alongside substantial groups of children (32,252), elderly (14,460) and disabled residents (32,493). Population was not identified within the highest risk score category (12-15) due to the averaging of risk scoring to correspond with available LSOA level population data. 130 educational establishments, 51 care homes, 4 hospitals and 40 GP and healthcare facilities are located in areas of high current heatwave risk.

Table 3-5 – Key amenities and associated current heatwave risk scoring

Key amenities and population	Key amenities and population groups within current heatwave risk score				
	Lowest risk (0-3)	*3-6*	*6-9*	*9-12*	*Highest Risk (12-15)*
Aged under 15	-	4,988	83,252	32,252	-
Aged 75 and over	-	2,859	44,406	14,460	-
Total population	-	31,342	477,591	205,158	-
Disabled under Equality Act	-	4,035	67,368	32,493	-
Educational establishments (count)	-	11	235	130	-
Care homes (count)	-	3	113	51	-
Hospitals (count)	-	-	13	4	-
GP and healthcare facilities (count)	-	1	56	40	-
Buildings (count)	-	7,087	238,481	85,112	89

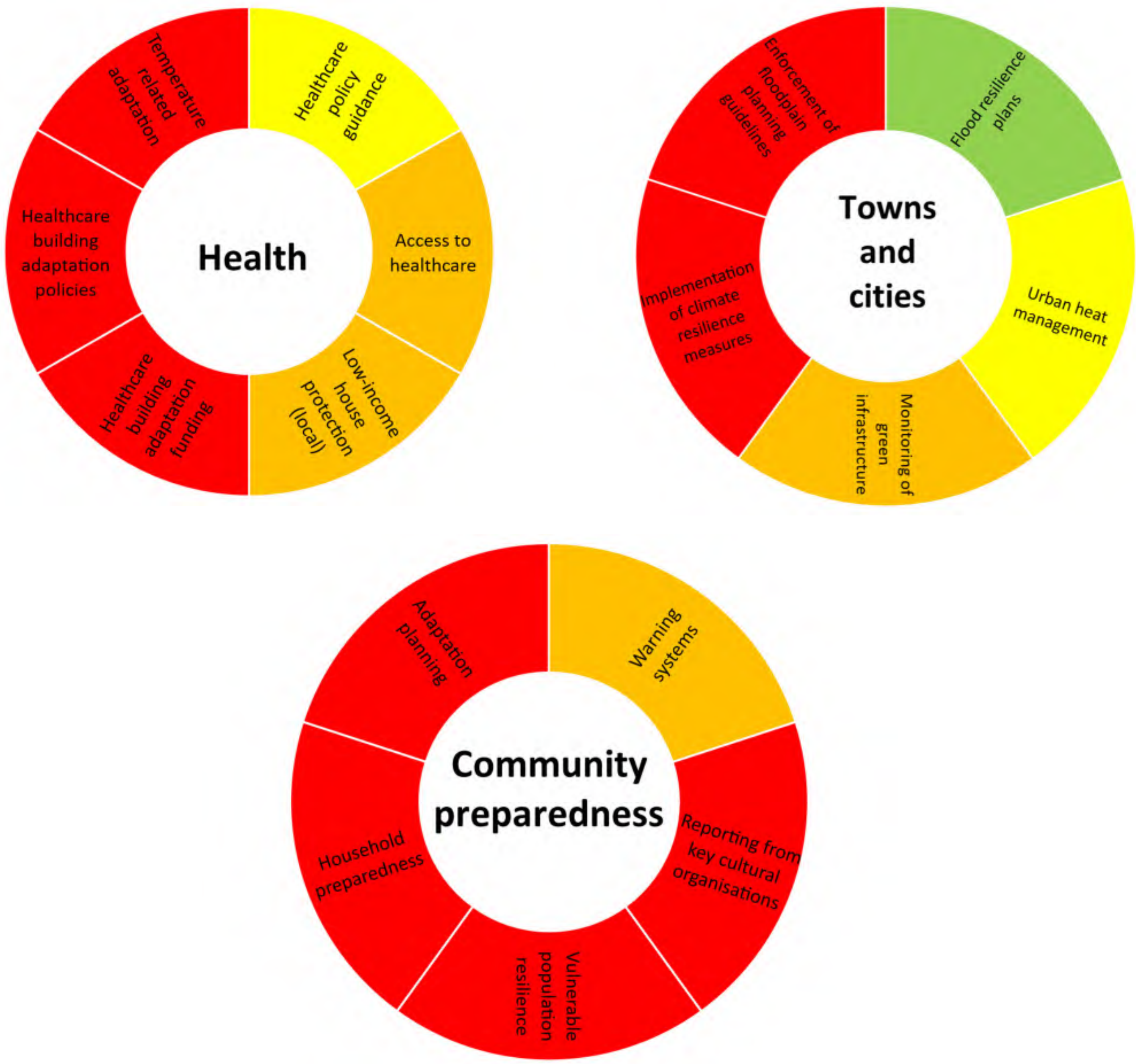
3.2.3.3. Other key hazards and impacts

Other key hazards that has impacted health, communities, and the built environment in Oxfordshire based on our findings since 2007 there have been storms and strong winds which have led to power cuts (including to care homes), felling of trees, as well as closure of schools (Table 2-1).

3.2.4. Policies and initiatives addressing known risks and impacts

Figure 3-14 provides a summary of the existing local and national[110] policies and plans that address climate impacts and adaptation on health, communities, and the built environment within Oxfordshire. Overall, all three areas – health, communities, and the built environment – are lacking policies in key areas in order to adequately address and adapt to the risk of climate change. There are, however, credible plans to reduce flood risk in Oxford, however further plans must be created for temperature-related adaptation measures and to improve community preparedness for climate change. For more detail on the assessment of existing policies and plans, please refer to Appendix B, for which existing and policies are assessed in the below categories of credible, partial, limited or insufficient policies and plans.

[110] Information retrieved from https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf



Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans

Figure 3-14 – Local and national policies addressing impacts on health, communities, and the built environment

3.3. Natural environment and assets

This theme encompasses aspects related to terrestrial and freshwater habitats and biodiversity as well as economic sectors such as agriculture and forestry sectors.

3.3.1. Current risks and impacts to natural environment and assets at national level

Agriculture practises and forestry activities may be impacted by flooding by limiting access to certain areas, reducing production, increased runoff and erosion and potential increase of pests and diseases. Higher temperatures can also contribute to an increase in pest and pathogen outbreaks and destabilise native habitats due to establishment of invasive/non-invasive species. However, higher temperature may also have benefits such as enhancing biodiversity and increase agricultural and forestry production. Drought can contribute to water scarcity which may impact agricultural and forestry activities as well as impact existing ecosystems.

A more comprehensive analysis of these risks and impacts at national on the natural environment and assets are provided in Appendix B.

3.3.2. Characterisation of natural environment and assets in Oxfordshire

Oxfordshire has a diverse geology, characterised by eight river systems and eight national character areas with diverse landscape, biodiversity and geodiversity (Figure 3-15). Low lying areas include Midvale Ridge, Berkshire and Marlborough Downs, Thames Valley and Chilterns[111]. Land use cover in Oxfordshire varies across the county, notably, a considerable contrast between Oxford City versus all other districts (Figure 3-16). In the county there is considerable arable land (44%), grassland (34%), smaller areas of woodland (9%) and suburban land use (9%) (

Table 3-6). Oxford City is primarily suburban (47%), grassland (30%) and urban (15%) land use.

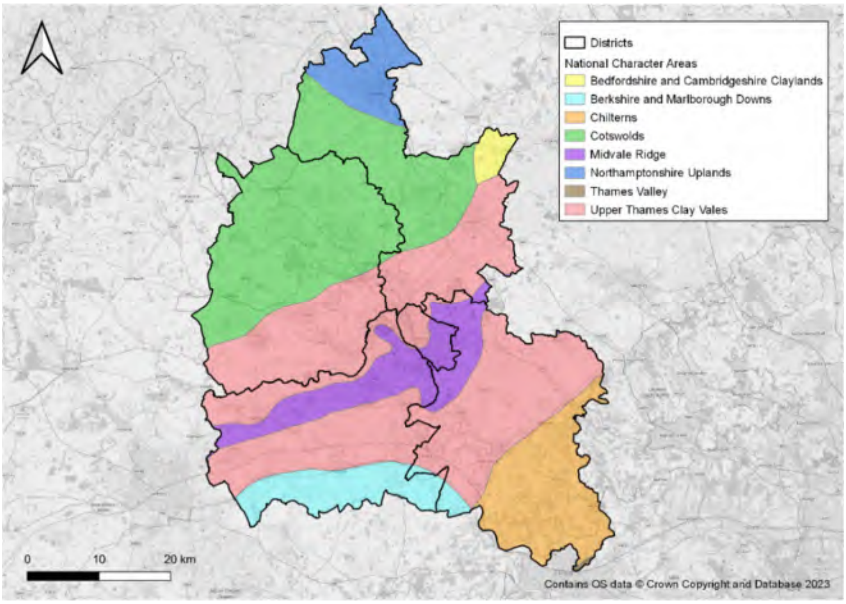


Figure 3-15 – National Character Areas in Oxfordshire[112]

[111] National Character Areas (wildoxfordshire.org.uk)
[112] National Character Areas (England) - data.gov.uk

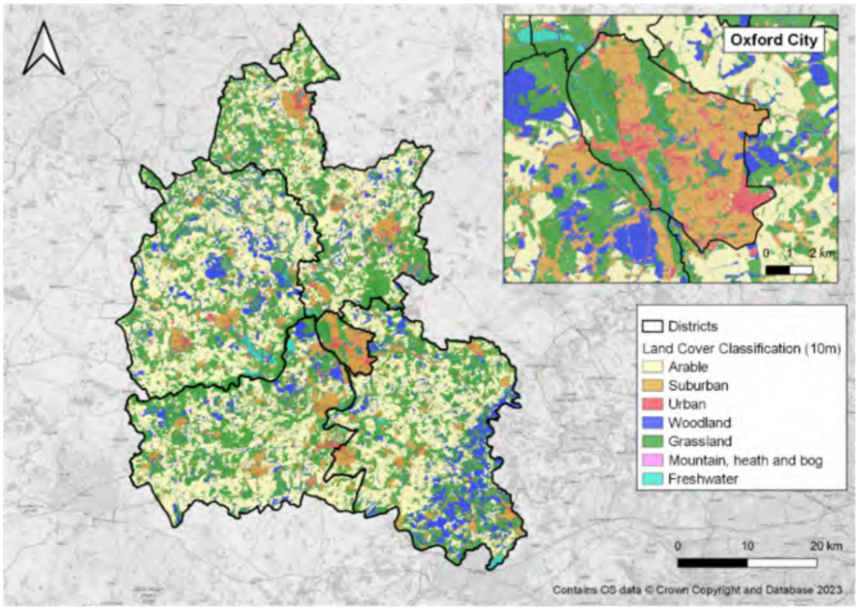


Figure 3-16 – Land use cover in Oxfordshire[113]

Table 3-6 - Proportion of land use cover by district[113]

Land cover	Land cover (%)					
	Oxfordshire county	Cherwell	Oxford City	South Oxfordshire	Vale of White Horse	West Oxfordshire
Arable	44%	45%	3%	41%	46%	49%
Grassland	34%	37%	30%	33%	35%	31%
Suburban	9%	9%	47%	9%	9%	7%
Woodland	9%	6%	3%	14%	7%	10%
Urban	2%	3%	15%	1%	2%	2%
Freshwater	1%	1%	2%	1%	1%	1%
Mountain, heath, and bog	0%	0%	0%	0%	1%	0%

Oxfordshire has considerable designated environmentally sensitive areas including 3 Areas of Outstanding Natural Beauty (AONB) namely the North Wessex Downs, the Cotswolds and the Chilterns[114], 154 Sites of Special Scientific Interest (SSSIs) and 4 national nature reserves. There are a substantial number of heritage designations also including 484 Conservation Areas such as the University of Oxford, Oxford city centre and Blenheim Palace World Heritage Site (Figure 3-17).

[113] Marston, C., Rowland, C. S., O'Neil, A. W., & Morton, R. D. (2022). Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A
[114] Review of Environmental Sensitivity in Oxfordshire

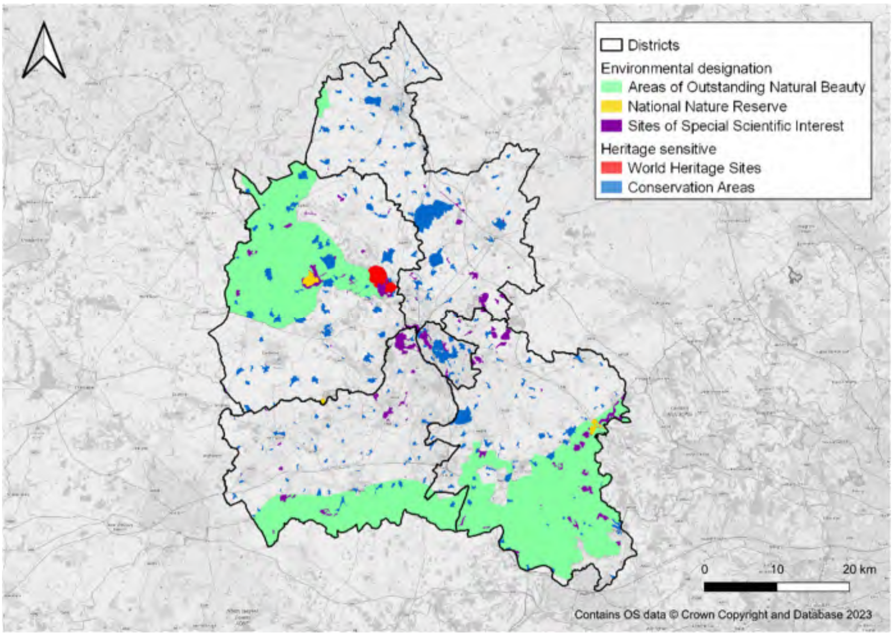


Figure 3-17 – Statutory designated environmentally and heritage sensitive areas[115]

Conservation Target Areas have been identified as part of the State of Nature in Oxfordshire 2017 report[116]. 37 Conservation Target Areas are the most important areas for wildlife conservation in Oxfordshire, where targeted conservation action is best placed[117]. These areas also overlap with Priority Local Wildlife sites, both existing and proposed sites. Biodiversity is supported by a large variety of habitats, including grasslands and woodlands for flora and damp reedy fen and acid grasslands to marshy meadows full of birds. Invasive Non-Native Species are present throughout the county, for example Himalayan Balsam, Butterfly-bush, Signal Crayfish and Ruddy Duck species.

3.3.3. Current risk to natural environment and assets from climate-related hazards

The natural environment can be impacted by climate-related hazards such as heatwaves which can contribute to drought and wildfire[118]. Conservation Target Areas and Local Wildlife Sites which are biodiversity hotspots and include important and rare habitats and species[119] are particularly vulnerable, and droughts especially grassland, woodland and arable land.

3.3.3.1. Heatwave

A maximum temperature greater than 27°C is established as a heatwave threshold for Oxfordshire[120]. The number of days per year (on average from 1990-2021) with a maximum temperature greater than 27°C[121]

[115] Areas of Outstanding Natural Beauty (England) - data.gov.uk, Natural England Open Data Geoportal (arcgis.com), GIS Open Data | Historic England, Sites of Special Scientific Interest (England) - data.gov.uk and World Heritage Sites GIS Data - data.gov.uk
[116] State_of_Nature_Oxfordshire_FINAL
[117] Conservation Target Areas (wildoxfordshire.org.uk)
[118] Oxfordshire firefighters tackled nearly 250 wildfires during summer | Oxford Mail
[119] Ecological networks | Thames Valley Environmental Records Centre (tverc.org) and Local Wildlife Sites | Thames Valley Environmental Records Centre (tverc.org)
[120] What is a heatwave? - Met Office A heatwave is defined as a period of at least three consecutive days with daily maximum temperatures meeting or exceeding the heatwave temperature threshold. The threshold for Oxfordshire is 27°C What is a heatwave? - Met Office

[121] HadUK observed maximum temperature data, 1990-2021 Product Form - UKCP (metoffice.gov.uk)

within Conservation Target Areas and Local Wildlife Sites is presented in Figure 3-18. In the past 30 years it can be viewed that there has been a greater number of days with a high maximum temperature within biodiversity hotspots across Oxford City, Abingdon and Otmoor to the north-east of Oxford City. It should be noted that certain habitats may be sensitive to other temperature thresholds, for example, freshwater environments can be impacted by temperatures in water reaching 17°C which are not assessed in this study[122]. For example, in recent hot weather in June dead fish were reported in the Oxford Canal due to a drop in oxygen levels associated with algal blooms in high temperatures[123].

The number of days per year from 1990-2021 with a maximum temperature greater than 27°C is also presented for woodland, arable and grassland land use in Oxfordshire, as these land uses are vulnerable to wildfires and drought (Figure 3-19). Woodland, arable and grassland land use around Oxford City, Abingdon, east of Abingdon and south of Henley-on-Thames have the greatest number of days per year greater than 27°C, indicative of heatwave conditions, creating conditions conducive to wildfires and drought. However, heatwaves, combined with other hazards such as drought or heavy summer rainfall that causes water pollution, are likely to have a greater impact on a range of habitats than heatwaves alone.

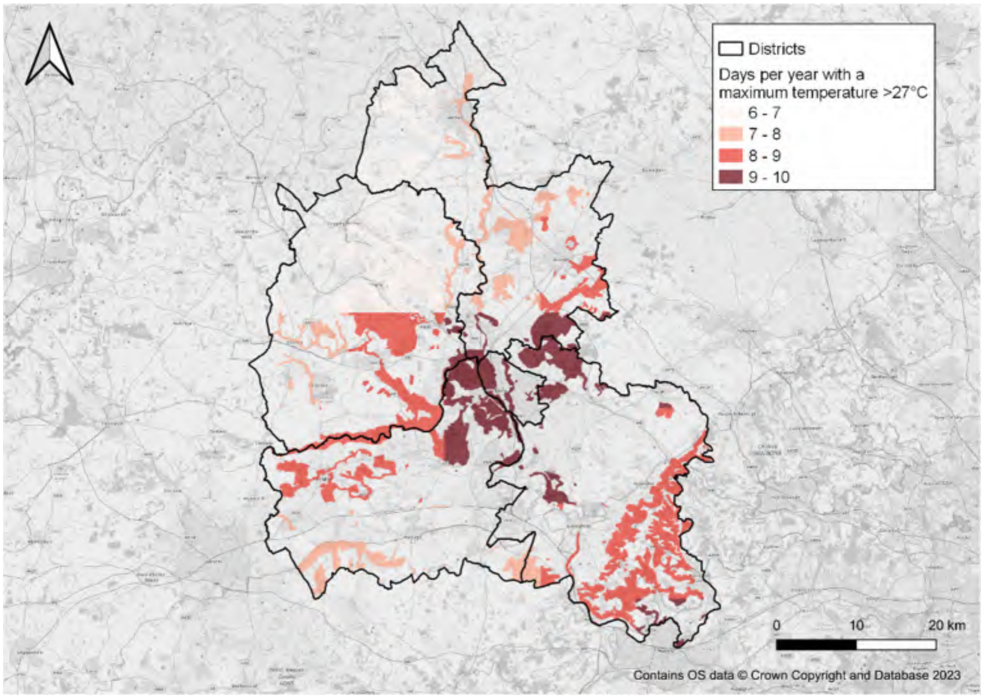


Figure 3-18 – Days per year with a maximum temperature >27°C, 1990-2021, within Local Wildlife Sites (existing and proposed) and Conservation Target Areas[124]

[122] Climate-driven-threshold-effects-in-the-natural-environment-UKCEH.pdf (ukclimaterisk.org)
[123] Oxford canal: Dead fish spotted as temperatures soar | thisisoxfordshire
[124] Product Form - UKCP (metoffice.gov.uk), Ecological networks | Thames Valley Environmental Records Centre (tverc.org) and Local Wildlife Sites | Thames Valley Environmental Records Centre (tverc.org) Product Form - UKCP (metoffice.gov.uk) 12x12km resolution, Ecological networks | Thames Valley Environmental Records Centre (tverc.org) and Local Wildlife Sites | Thames Valley Environmental Records Centre (tverc.org)

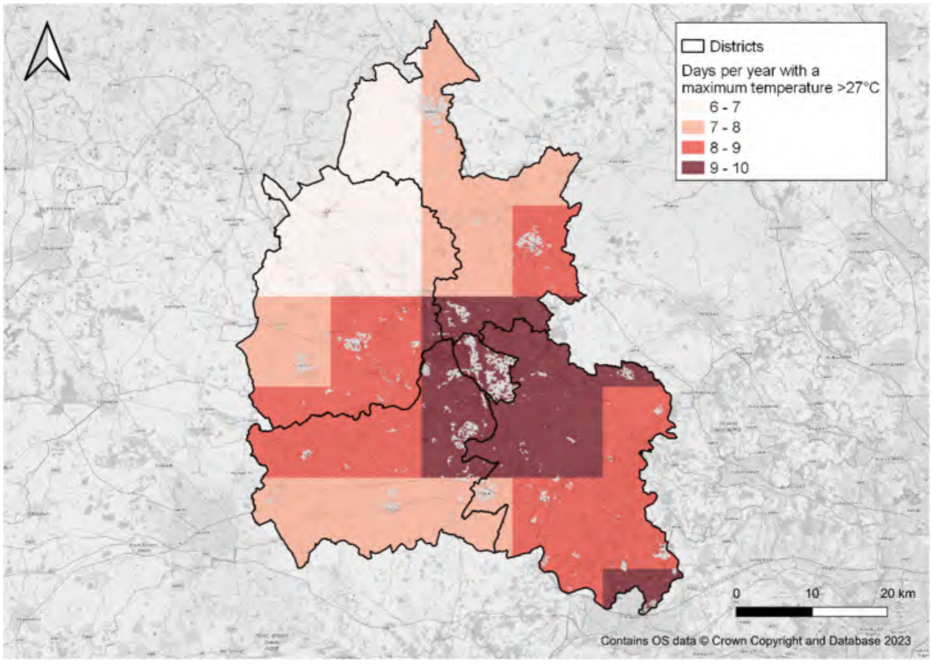


Figure 3-19 – Days per year with a maximum temperature >27°C, 1990-2021, within woodland, arable and grassland land use[125]

3.3.3.2. Other key hazards and impacts

Another key hazard that has been having an impact on the natural environment and assets in Oxfordshire is drought[126] (see Table 2-1). Since 2007, three drought events have been registered in 2012, 2018 and 2022 with impacts on agriculture (e.g. damaged crops), stress to terrestrial habitats, hosepipe bans and, more recently, an increase in wildfires (also associated to heatwaves).

3.3.4. Policies and initiatives addressing known risks and impacts

Figure 3-20 provides a summary of the existing local and national[127] policies and plans that address climate impacts on the natural environment and assets within Oxfordshire. Overall, there are credible and/or partial policies and plans towards adaptation of climate impacts such as plans to protect and enhance biodiversity within Oxfordshire. Whilst there are projects that aim to improve the resilience of agriculture and forestry to climate change, there are insufficient plans to mitigate the impacts of climate change on food supply. For more detail on the existing policies and plans assessment please refer to Appendix B, for which existing and policies are assessed in the below categories of credible, partial, limited or insufficient policies and plans.

[125] Product Form - UKCP (metoffice.gov.uk) and Marston, C., Rowland, C. S., O'Neil, A. W., & Morton, R. D. (2022). Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A
[126] Meteorological drought occurs when rainfall in an area is below average for the region UK and Global extreme events – Drought - Met Office.
[127] Information retrieved from https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

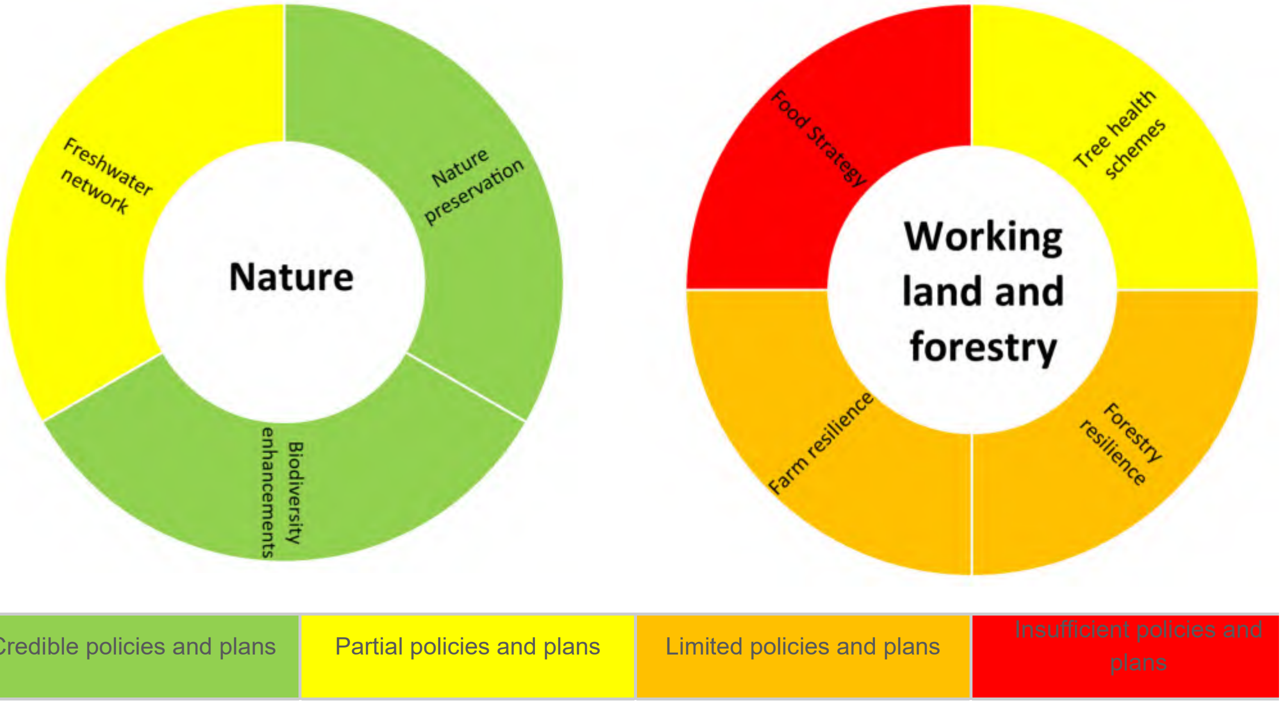


Figure 3-20 – Local and national policies addressing impacts on the natural environment and assets

3.4. Business and industry

This theme covers aspects related to business and industry including the location and infrastructure, production and processes, productivity in business, disruption to business supply chain and distribution networks.

3.4.1. Current risks and impacts to business and industry at national level

Climate can impact business and industry, from supply chains and goods distribution networks interruptions to direct impacts from extreme weather events. For example, flooding can directly impact business sites leading to loss of production/sales. Higher temperatures can also impact productivity, for example, decreased thermal comfort can particularly affect those working in outdoor labour.

Heatwaves in the past have affected economic productivity, for example, the 2003 heatwave in the UK resulted in £41 million in health-related costs and productivity losses[128] and in 2010, five million staff days across all sectors were lost due to overheating, resulting in an economic loss of £770 million[129]. Heatwave events have occurred in Oxfordshire in 2009,2018, 2019, 2020, 2021, 2022. The 2009 heatwaves resulted in a £5000 cost to OCC to adjust for staff working conditions (Table 2-1).

Storm and high winds may also affect business and industry through cascading impacts e.g. by affecting transport networks and/or energy supply, telecoms which in turn can impact supply chains and the type of infrastructure that they depend on[254]. A more comprehensive analysis of these risks and impacts at national level on business and industry are provided in Appendix B.

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128 PPP-climate-crisis-and-its-healh-impacts.pdf (publicpolicyprojects.com)
129 Heatwaves: adapting to climate change - Environmental Audit Committee - House of Commons (parliament.uk)

3.4.2. Current risk to business and industry from climate-related hazards

Current risk to business and industry from climate-related hazards could not be captured as currently there is no available data or evidence on this. An assessment of future impacts from climate-related hazards on business and industry in Oxfordshire is provided in section 4.4. below.

3.4.3. Policies and initiatives addressing known risks and impacts

Figure 3-21 provides a summary of the existing local and national[130] policies and plans that address climate impacts on business and industry within Oxfordshire. Credible net-zero and carbon neutral plans have been made in Oxfordshire, with OCC securing funding to decarbonise their assets. Further plans must be made to address the impact of extreme temperatures on staff productivity, and the impact of climate change on supply chains. For more detail on the existing policies and plans assessment please refer to Appendix B, for which existing and policies are assessed in the below categories of credible, partial, limited or insufficient policies and plans.

Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans

Figure 3-21 – Local and national policies addressing impacts on business and industry

[130] Information retrieved from https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

4. Future risk from climate-related hazards

Future risk to climate-related hazards in Oxfordshire has been assessed through hex grid mapping for 2050[131], based on increases in global mean temperature of +2°C and +4°C by 2100 scenarios[132]. This provides an understanding of two potential future scenarios, for which uplifts have been applied to the current flooding and heatwave hazards and vulnerability to derive future risk scoring.

To note that, whilst the mapping for Health, Communities and the Built Environment provide an overall assessment of **climate risk** (as a function of hazard, exposure, and vulnerability) for flooding and heatwaves this was not possible for the themes of Critical Infrastructure and Natural Environment and Assets as the quantification of vulnerability was not possible. Instead, the focus of the assessment for these themes is on the **climate hazard** (as a function of hazard and exposure).

A high-end scenario is explored for future scenarios for extreme temperatures, analysing the Oxford Radcliffe Observatory data and climate model attribution to analyse the chance of very high temperatures occurring in Oxfordshire. This differs from the +2°C and +4°C by 2100 scenarios as it considers the implications of 'unpredictable extremes[133].' These low-likelihood high-impact scenarios are plausible but extreme outcomes that are associated with the 'high-end' of RCP8.5 scenarios.

Additional climate-related hazards are explored for each theme using Climate Risk Indicators[134] and relevant sources of information.

For more detail on the methodology utilised please refer to Appendix A.

4.1. Critical infrastructure

To understand future risk of climate change on critical infrastructure in Oxfordshire identified in section 3, an assessment of future risk was completed for key climate-related hazards.

4.1.1. Flooding

Current flooding impacts identified in section 3, highlighted the impact of flooding particularly for settlements along the course of rivers in Oxfordshire, such as the River Thames in Abingdon and Oxford City, River Ock in the Vale of White Horse district council, River Evenlode in West Oxfordshire district council, and River Cherwell and River Ray in Cherwell district council.

Future flooding hazard was assessed for 2050 on a pathway to +2°C and +4°C warming by 2100. Overall, there is an increased risk of fluvial flooding and surface water flooding across Oxfordshire, which is determined by climate change, rates of population growth and the level of adaptation. According to the UK CCRA3 results for the region:

- Expected Annual Damage due to fluvial flooding is projected to increase by 25%-30% by the 2050s under +2°C pathway and 30%-40% under +4°C pathway assuming current levels of adaptation.
- Expected Annual Damage due to surface water flooding is projected to increase by 30%-36% by the 2050s under +2°C pathway and 48%-56% under +4°C pathway assuming current levels of adaptation.

[131] 2030 scenarios were not used as the assessment of current risk (in section 3) already covers part of that time period.
[132] Scenarios with global average temperatures approximately +2°C and +4°C above pre-industrial levels in 2100.
[133] 'Prepare for unpredictable extremes' is one of the Climate Changes Committee's Ten Principles of Good Adaptation presented in the CCRA3.
[134] Climate Risk Indicators (uk-cri.org)

In our risk model, uplifts to future flooding hazard were defined based on the UK CCRA3 future flood risk calculations[135], using the Expected Annual Damage (EAD) metric and changes due to climate change only for 2050 under pathways to 2°C and +4°C by 2100 scenarios weighted by the number of buildings within each 500m hex. This metric was then combined with uplifts in the return period of surface and fluvial flood frequency, based on UK CCRA3 future flood risk EAD uplifts. The frequency uplifts use +90% and +101% for fluvial flooding under +2°C and +4°C scenarios respectively and +29% and 46% for surface water flooding under the same scenarios. Further information on the future flood risk methodology is outlined in Appendix A (section A3).

The pathway to a +4°C scenario by 2100 is presented in Figure 4-1 (pathway to +2°C scenario by 2100 is presented in appendix E). Future fluvial flood hazard mapping is available in Appendix E. It can be viewed that there is expected to be increased flood hazard in proximity to rivers such as in the Thames, Ock, Ray, Evelode floodplains will impact on critical infrastructure increasing the likelihood of damage and interruptions to transport and utilities.

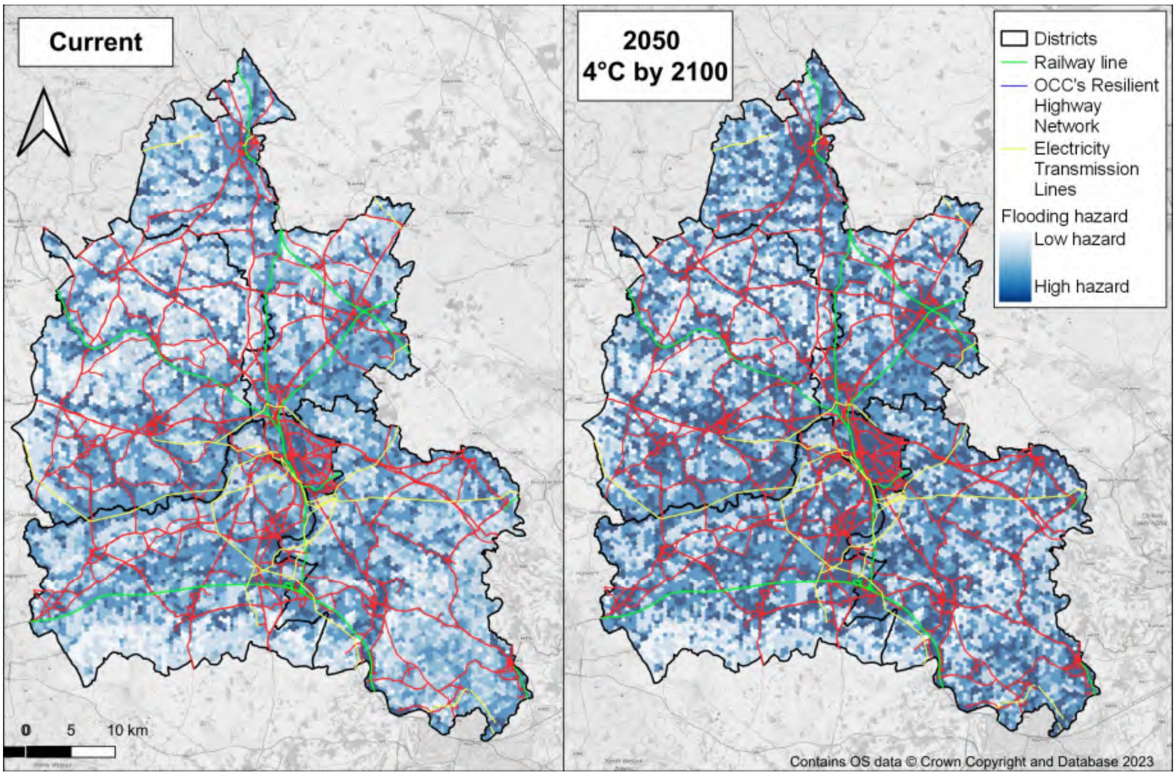


Figure 4-1 - 2050 flood hazard[136] versus current flood hazard and critical infrastructure in Oxfordshire

Table 4-1 shows the length of key networks and counts of critical infrastructure and their associated future hazard level for fluvial and surface flooding. There is a marginal increase in infrastructure exposed to a higher flooding hazard level by 2050 compared to current flood hazard levels, especially the OCC's resilient highway network and electric charging points.

[135] Future-Flooding-Main-Report-Sayers-1.pdf (ukclimaterisk.org)
[136] The change in flood hazard by 2050 for the +2°C and +4°C by 2100 scenarios is the same. Flood hazard map for +2°C by 2100 is displayed in Appendix E

Table 4-1 – Key critical infrastructure and current versus 2050 surface and water flooding hazard scoring

Key critical infrastructure	Key infrastructure within future flooding hazard score (2050 on pathway to 4°C by 2100) and change from current flooding hazard				
	Lowest hazard (0-1)	*1-2*	*2-3*	*3-4*	*Highest hazard (4-5)*
ETLs (length in km)	13 (-2)	38 (-10)	29 (-20)	60 (-10)	71 (+42)
Roads (OCC's resilient highway network) (length in km)	245 (-150)	499 (-218)	548 (-613)	828 (-514)	2,488 (+1,496)
Rail network (length in km)	4 (-1)	43 (-20)	50 (-25)	89 (-75)	290 (+121)
National cycle network (length in km)	17 (-7)	28 (-10)	23 (-31)	43 (-34)	148 (+82)
Mobile phone masts (count)	3 (-3)	6 (-3)	10 (-9)	10 (-12)	40 (+27)
Electric charging points (count)	-	- (-2)	5 (-29)	8 (-90)	281 (+121)

4.1.2. Heatwave

In the current risk assessment, the greatest heatwave hazard was evident in areas such as Oxford City, Abingdon, Kidlington and Henley-on-Thames due to the concentration of urban and suburban areas, higher cooling degree days and lower proportion of green space.

To understand the future heatwave hazard in Oxfordshire, uplifts to heatwave hazard were obtained for cooling degree days from the UK Climate Risk Indicators for 2050 on a pathway to +2°C and +4°C by 2100 scenarios[137]. Future changes in the urban heat island effect (based on area of urban and suburban land use) and green space were applied based on CCRA3's socioeconomic metrics which outlines future changes in land use across England[138]. Further information on the future heatwave risk methodology is outlined in Appendix A.

Heatwave hazard increases across the majority of Oxfordshire under both scenarios (Figure 4-2, Figure 4-3). Changes in land use (urban heat island effect and green space) remain the same for both scenarios.

The greatest increase in 2050 under a +2°C by 2100 scenario is projected in the south and north-east of Oxfordshire, whereas in 2050 under a +4°C by 2100 scenario the heatwave hazard increases consistently across the entire county. Heatwave hazard remains greatest across built up areas in both scenarios.

The future increase in heatwave hazard impacts the greater concentration of roads in urban areas. An increase in heatwave hazard outside of built-up areas will impact the railway network, posing risks of railway buckling and travel disruption.

[137] Climate Risk Indicators (uk-cri.org)
[138] Consistent Set of Socioeconomic Dimensions Final Report.docx (ukclimaterisk.org), https://www.ukclimaterisk.org/wp-content/uploads/2020/07/Socioeconomic-Dimensions-database.xlsx

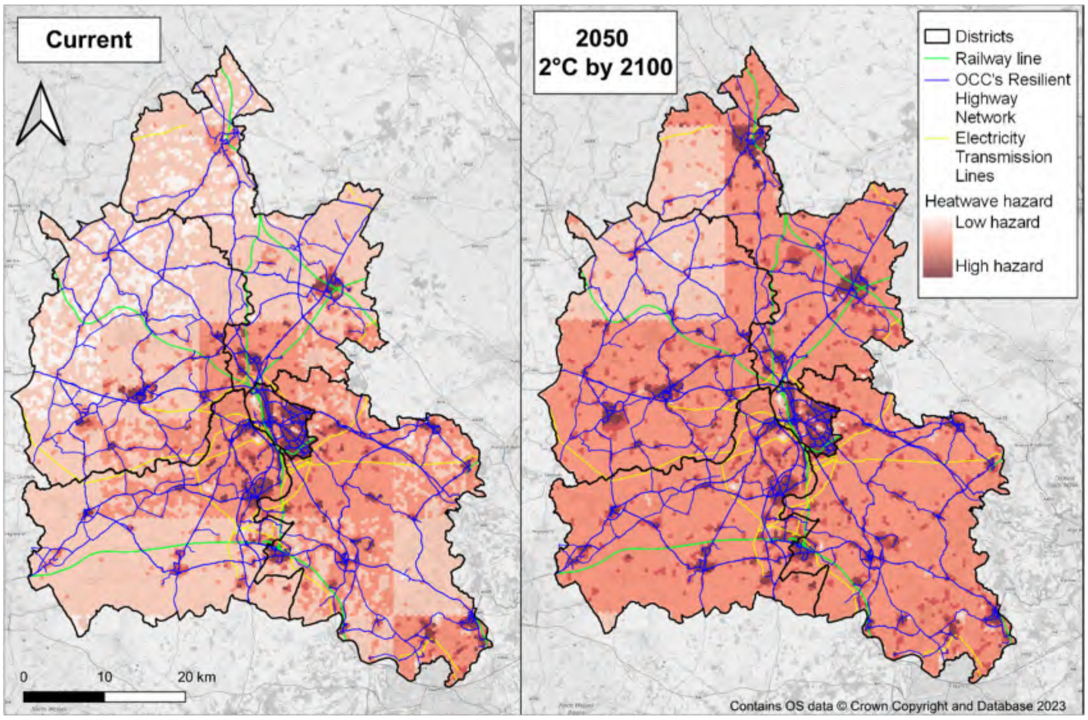


Figure 4-2 – 2050 +2°C heatwave hazard versus current heatwave hazard and critical infrastructure in Oxfordshire

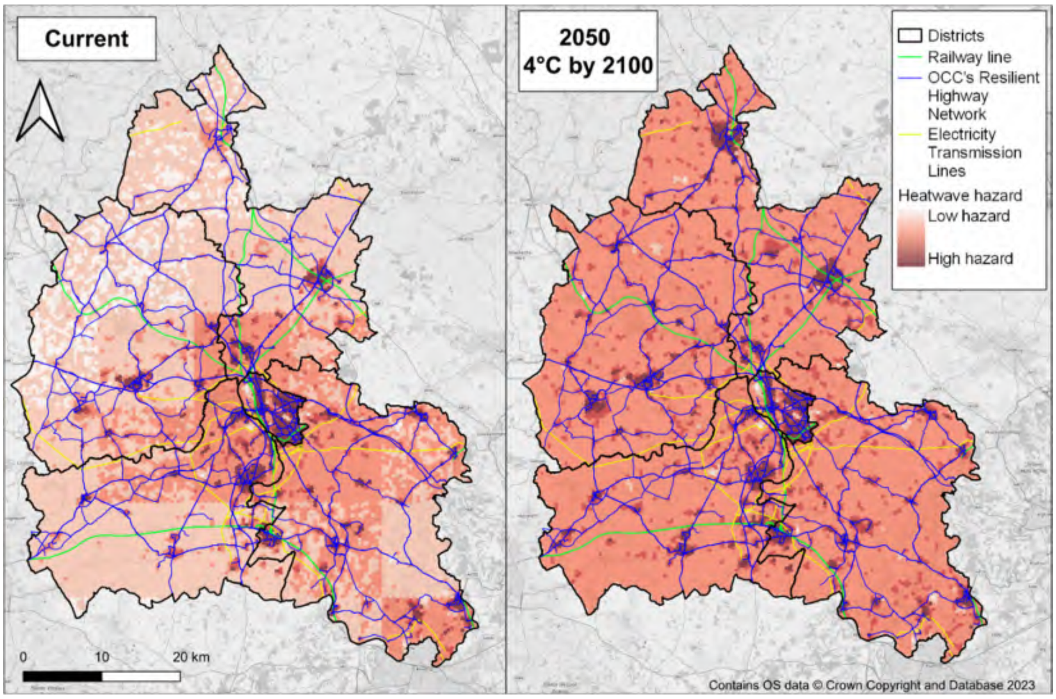


Figure 4-3 – 2050 4°C heatwave hazard versus current heatwave hazard and critical infrastructure in Oxfordshire

Table 4-2 shows the location of critical infrastructure within different levels of future heatwave hazard and the change from current to 2050 heatwave hazard. In future, all identified critical infrastructure is more greatly exposed to heatwave hazards, especially OCC's resilient highway network and the rail network. Notably, 101 electric charging points are expected to be located where there is a greater heatwave hazard.

Table 4-2 – Key critical infrastructure and current versus 2050 heatwave hazard scoring

Key critical infrastructure	Key infrastructure within future heatwave hazard (2050 on pathway to 4°C by 2100) score and change from current heatwave hazard				
	Lowest hazard (0-1)	*1-2*	*2-3*	*3-4*	*Highest hazard (4-5)*
ETLs (length in km)	-	- (-3)	3 (-62)	189 (+53)	19 (+11)
Roads (OCC's resilient highway network) (length in km)	- (-1)	- (-89)	37 (-1,549)	3,087 (+1,007)	1,485 (+631)
Rail network (length in km)	- (-1)	1 (-15)	2 (-205)	330 (+149)	142 (+71)
National cycle network (length in km)	-	- (-9)	1 (-108)	176 (+82)	83 (+35)
Mobile phone masts (count)	-	- (-1)	1 (-18)	45 (+12)	23 (+7)
Electric charging points (count)	-	- (-2)	2 (-13)	36 (-86)	256 (+101)

4.1.3. Low temperatures

Low temperatures can affect critical infrastructure such as roads, transport networks and utilities such as electrical and water supply infrastructure. Snow and ice can cause transport disruption and water supply issues due to frozen pipes. In both scenarios tested, the number of cold weather alerts per year is expected to decrease across all local authority areas in Oxfordshire[139]. In 2050, under a pathway of +4°C by 2100 warming scenario it is projected that the number of cold weather alerts per year will be fewer than a +2°C by 2100 warming scenario (Figure 4-4). This is a change of 0.6 and 0.9 fewer cold weather alert events per year from 2016 to 2050 under a pathway of +2°C by 2100 and +4°C by 2100 respectively. This may provide an opportunity due to a reduction in the impact of extreme cold on critical infrastructure.

[139] Climate Risk Indicators (uk-cri.org)

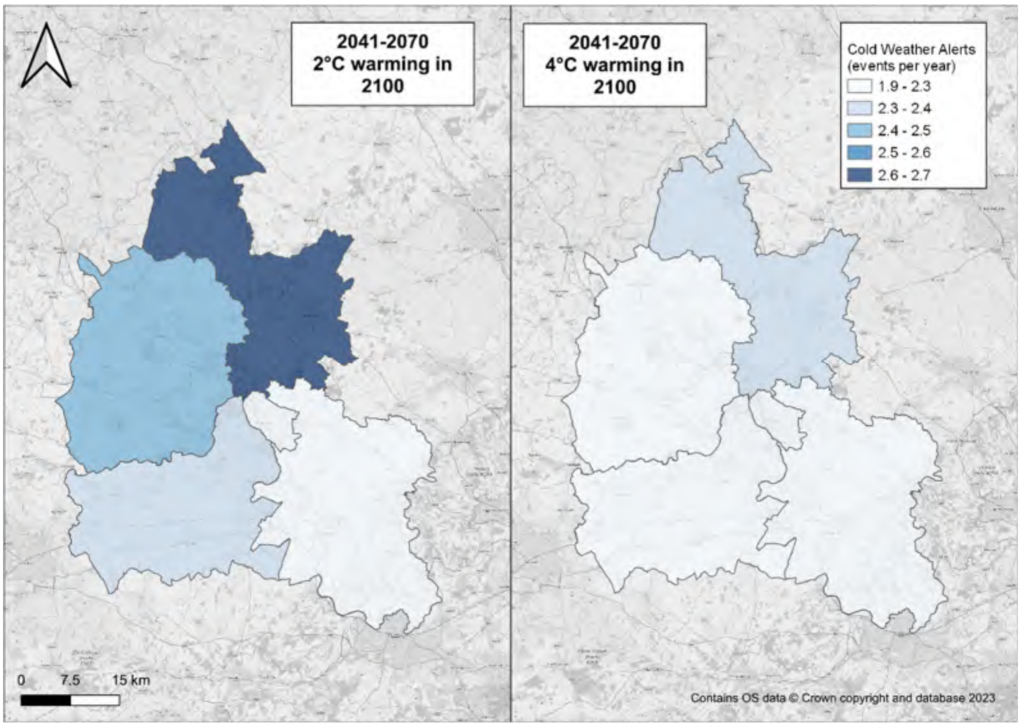


Figure 4-4 - Cold Weather Alerts in Oxfordshire in 2050 under a +2°C and +4°C by 2100 warming scenario[139]

4.1.4. High winds and storms

High winds and storms can cause damage to infrastructure cutting of roads and settlements with fallen trees and damaging electricity transmission lines causing power cuts. The observed monthly mean wind speed at 10 m in 1991-2020 in Oxford city, Benson in South Oxfordshire, Brize Norton in West Oxfordshire was 8.35 knots, 7.41 knots and 6.69 knots respectively compared to a national average of 8.33 knots[140].

Future trends in high winds and storms are highly uncertain. In the UK there is projected to be an increase in near surface wind speeds in the second half of the 21st century during the winter and an increase in the frequency of winter storms and more severe storms[142,143]. It should be noted that the increase in wind speeds projected is modest in comparison to monthly and seasonable variability. Trends in wind storms are difficult to detect due to this natural variability.

The impact on critical infrastructure from high winds and storms may include travel disruption due to falling debris and vegetations on roads and railway routes.

4.1.5. Drought

Droughts are known to impact Oxfordshire, notably in 2012, 2018 and 2022 (Table 2-1). Winter rainfall is projected to increase in Oxfordshire and summer rainfall projected to decrease by 2050. However, there is considerable uncertainty in these future changes[139,144]. An increase in soil moisture deficit is projected across Oxfordshire by 2050 under a +4°C by 2100 warming scenario (a +2°C by 2100 warming scenario is not available for soil moisture deficit), especially in Oxford and South Oxfordshire (Figure 4-6). As noted previously,

140 UK climate averages - Met Office
142 Met Office (2019) UKCP18 Factsheet Wind, Available at: ukcp18-fact-sheet-wind_march21.pdf (metoffice.gov.uk)
143 The influence of climate change on severe weather | Official blog of the Met Office news team
144 HEADLINE_FINDINGS (metoffice.gov.uk)

hydrological drought can impact on the reliability of water supplies in Oxfordshire and critical water supply assets such as the Farmoor Reservoir in Oxfordshire.

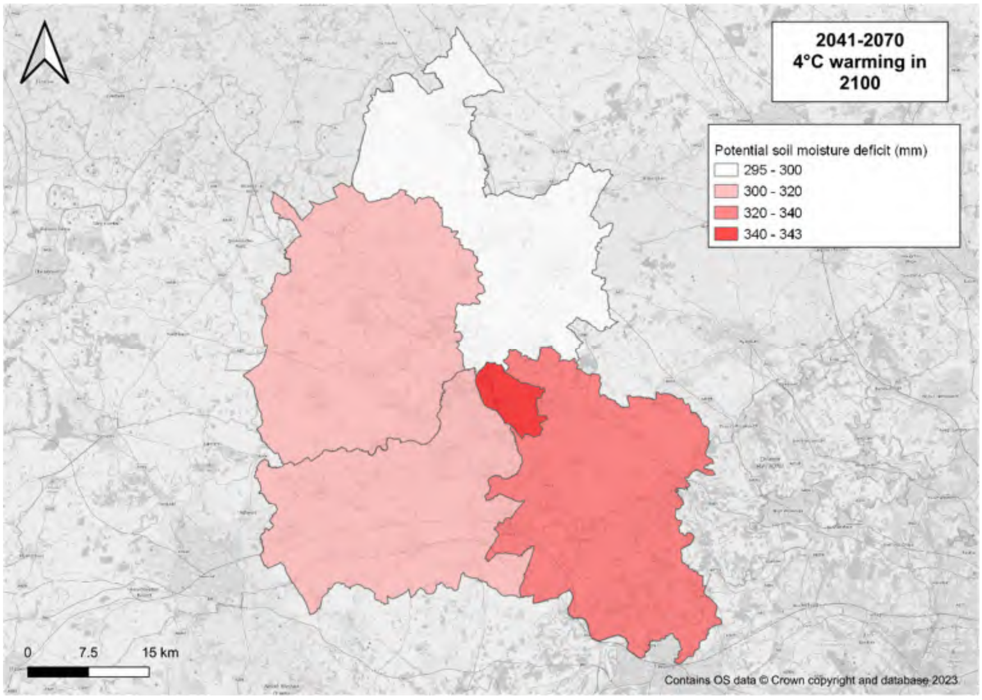


Figure 4-5 – Potential soil moisture deficit in 2050 under a 4°C by 2100 warming scenario

4.1.6. Cascading risks

Infrastructure consists of networks of systems, leading to one system causing problems in another system. The risk of network failure due to climate hazards such as flooding, heatwaves, low temperatures, high winds and storms and drought become more prominent under more extreme conditions. There is limited information on cascading risks to draw out an assessment of cascading risks in Oxfordshire at the time of writing.

4.1.7. Summary of climate risk to critical infrastructure

A summary of future climate risks to critical infrastructure in Oxfordshire is presented in Table 4-3. Key areas of CCRA3 risks are outlined to frame the previous assessment of climate-hazards to score each climate-hazard by CCRA3 risk area, for both the current and future scenarios under +2°C and +4°C warming by 2100. Current progress on OCC adaptation-related policies is also shown from the current risk section 3, to demonstrate key gaps in progress for each CCRA3 theme.

Based on the analysis presented previously and summarised in the table below, the greatest current risks identified across Oxfordshire is flooding with a high risk followed by heatwaves and drought which scored medium risk. Cascading risks are unknown due to the lack of available information to help understand the current risk of interacting climate-hazards. This should be a focus of future work to better understand cascading risks in Oxfordshire. Critical infrastructure such as transport and energy networks are particularly vulnerable to these climate-related hazards due to their potential to damage infrastructure and disrupt or cut off networks and key facilities.

Under future scenarios, flood risk remains high across all relevant CCRA3 risks regarding water supply, energy, telecoms, and transport. There is also an expected increase in heatwaves risk from high to very high risk and an increase in expected drought from medium to high risk.

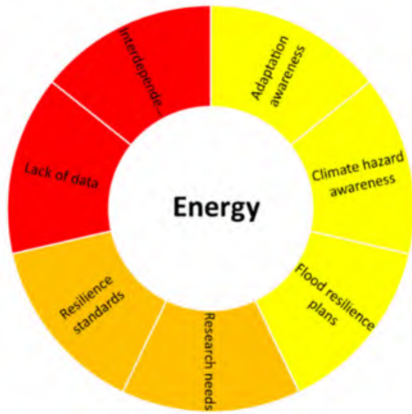
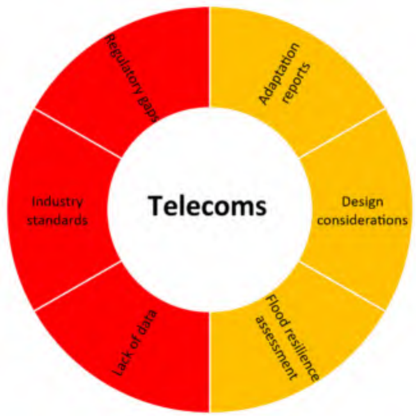
Current risk of high winds and storms scored medium risk as there has been events with impacts in Oxfordshire particularly regarding energy and transport infrastructure. However, there is currently insufficient data to support the assessment of future risk for high winds and storms as well as the interdependencies within this theme. Low temperatures scored low in terms of their current risk and future in Oxfordshire's critical infrastructure.

These findings align with expected changes in the future including an increase in temperatures, uncertainty in change in the future return period of flooding events and a decrease in summer rainfall which may result in drought.

Table 4-3 – Summary of future climate risks to critical infrastructure in Oxfordshire

Thematic Area	Relevant CCRA3 risks[145]	Climate-related hazard	Current risk assessment	Future risk assessment (2050 on a pathway to +2°C and +4°C by 2100') +2°C	+4°C	Current progress on OCC adaptation-related policies and plans
Critical infrastructure	**Water supply** Risks to infrastructure networks from cascading failures (I1) Risks to infrastructure services from flooding (I2) Risks of sewer flooding from heavy rainfall (I4) Risks to subterranean and surface infrastructure from subsidence (I8) Risks to public water supplies from reduced water availability (I9)	Flooding	H	H	H	
		Heatwave	M	H	VH	
		Low temperatures	L	L	L	
		High winds and storms	L	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	
	Energy Risks to infrastructure networks from cascading failures (I1) Risks to infrastructure services from flooding (I2)	Flooding	H	H	H	
		Heatwave	M	H	H	
		Low temperatures	L	L	L	

[145] As presented in the CCC Adaptation Progress Report: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

Thematic Area	Relevant CCRA3 risks[145]	Climate-related hazard	Current risk assessment	Future risk assessment (2050 on a pathway to +2°C and +4°C by 2100')		Current progress on OCC adaptation-related policies and plans
				+2°C	+4°C	
	Risks to hydroelectric generation from low or high river flows (I7) Risks to subterranean and surface infrastructure from subsidence (I8) Risks to energy, transport & ICT from high winds and lightning (I11)	High winds and storms	M	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	
	Telecommunications and IT Risks to infrastructure networks from cascading failures (I1) Risks to infrastructure services from flooding (I2) Risks to subterranean and surface infrastructure from subsidence (I8) Risks to energy, transport & ICT from high winds and lightning (I11)	Flooding	H	H	H	
		Heatwave	H	VH	VH	
		Low temperatures	L	L	L	
		High winds and storms	L	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	

Thematic Area	Relevant CCRA3 risks[145]	Climate-related hazard	Current risk assessment	Future risk assessment (2050 on a pathway to +2°C and +4°C by 2100')		Current progress on OCC adaptation-related policies and plans
				+2°C	+4°C	
	Transport Risks to infrastructure networks from cascading failures (I1) Risks to infrastructure services from flooding (I2) Risks to transport networks from embankment failure (I6) Risks to energy, transport & ICT from high winds and lightning (I11)	Flooding	H	H	H	
		Heatwave	H	VH	VH	
		Low temperatures	L	L	L	
		High winds and storms	M	U	U	
		Drought	L	L	L	
		Cascading	U	U	U	

Key *A full description of the classifications used can be found in Appendix A*

Risk assessment					
Low risk (L)	Medium risk (M)	High risk (H)	Very high risk (VH)	Risk unknown (U)	Not applicable (N/A)

Progress on policies and plans			
Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans

4.2. Health, communities, and the built environment

To understand the future impact of climate change on health, communities, and the built environment in Oxfordshire an assessment of future risk was completed for key climate-related hazards.

4.2.1. Future risk from key climate-hazards to health, communities, and the built environment

4.2.1.1. Flooding

Flooding impacts identified in the current risk assessment (in section 3) highlighted the impact of flooding particularly for settlements along the course of rivers in Oxfordshire, such as the River Thames in Abingdon and Oxford City, River Ock in Vale of White Horse district, River Evenlode in West Oxfordshire district and River Cherwell and River Ray in Cherwell district.

Overall, there is an increased risk of fluvial flooding and surface water flooding across Oxfordshire, which is determined by climate change, rates of population growth and the level of adaptation. According to the UK CCRA3 results for the region:

- The population exposed to fluvial flooding is projected to change slightly by the 2050s under +2°C pathway (-5% to +5%) and +4°C pathway (-6% to +5%) assuming current levels of adaptation.
- The population exposed to surface water flooding is projected to increase by the 2050s under +2°C pathway (+3% to +16%) and +4°C pathway (+3% to +16%) assuming current levels of adaptation.

In our model, the risk of flooding in future (2050 pathway for a +2°C and +4°C in 2100 warming scenario) versus current risk is broadly similar under both scenarios and is presented in Figure 4-6.

Future flood risk, which considers changes in the EAD from fluvial and surface flooding, frequency of fluvial and surface water flooding, floodplain extents and future populations of vulnerable groups, shows increased risk levels in proximity to cities and towns and river channels. Local hot spots of increased risk in 2050 include areas in the flood plain of the River Thames in the northeast of Vale of White Horse and River Ray in Cherwell.

The wards with the greatest risk of flooding in future are broadly consistent with current flood risk (Figure 4-7), although in 2050 Donnington and Abingdon Abbey Northcourt is within the top ten wards with the highest future flooding risk, replacing Holywell and Hinksey Park. Mapping of fluvial flooding hazard and risk is presented in Appendix E.

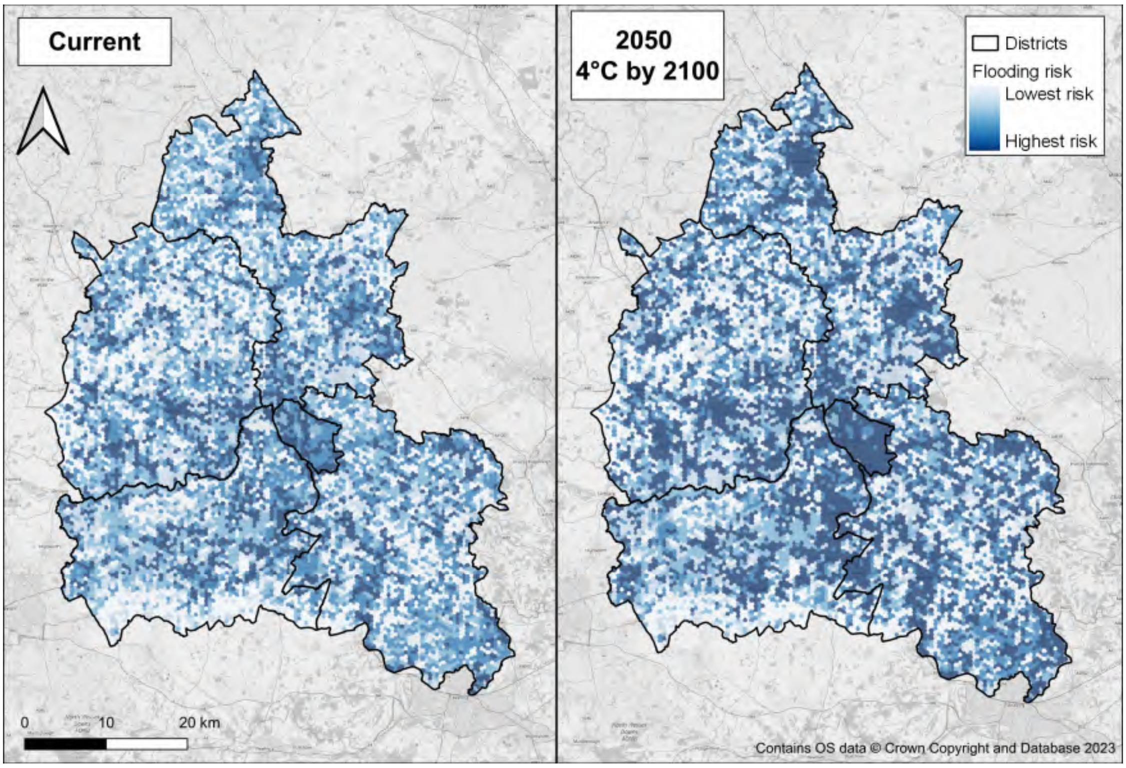


Figure 4-6 – 2050 4°C flooding risk versus current flooding risk

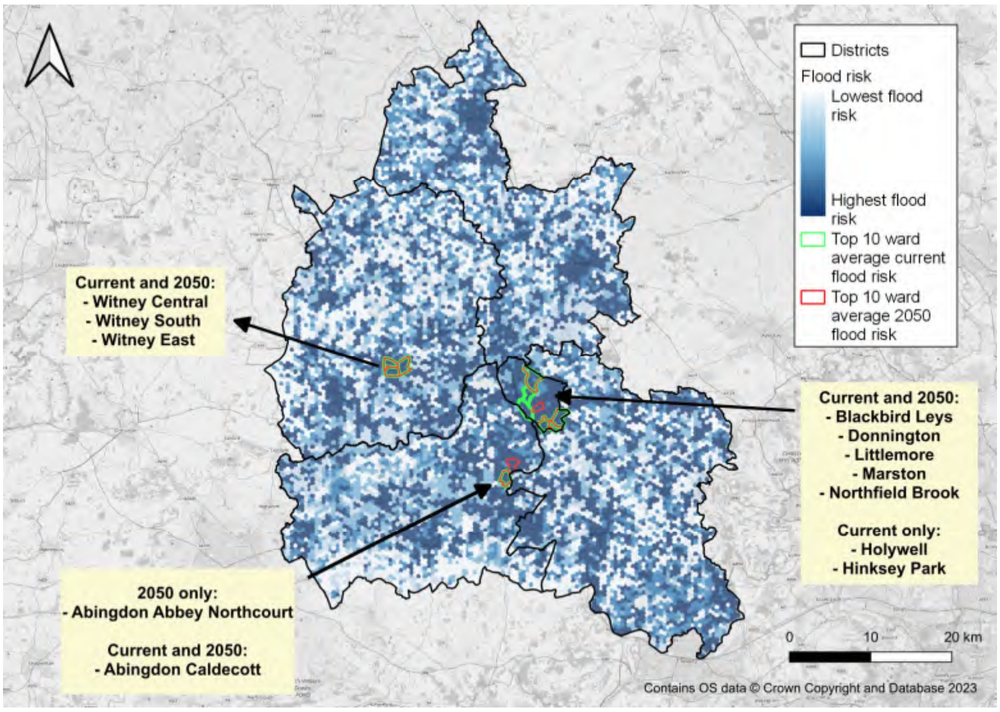


Figure 4-7 – Ten wards with the highest future fluvial and surface flood risk versus highest current flood risk in Oxfordshire

Key amenities and population groups within the future flood risk category versus the previous current flood risk score demonstrate an increase in flood risk in future for a number of vulnerable groups and essential amenities (Table 4-4). Notably, a greater number of children, elderly and disabled residents are expected to live in an area of higher flood risk in future. A greater number of care homes, educational establishments, GP and healthcare facilities and all building types are expected to be located in an area of higher flood risk in future than currently.

Table 4-4 – Key amenities and associated 2050 flooding risk scoring

Key amenities and population	Key amenities and population groups within future flooding risk score and change from current flooding risk				
	Lowest risk (0-3)	*3-6*	*6-9*	*9-12*	*Highest Risk (12-15)*
Aged under 15	-	956 (-4,128)	42,634 (-41,279)	72,133 (+40,638)	4,769 (+5,047)
Aged 75 and over	-	404 (-2,576)	25,470 (-18,661)	33,681 (+19,067)	2,170 (+4,015)
Total population	-	5,113 (-25,260)	253,918 (-236,399)	430,350 (+237,249)	24,710 (+26,336)
Disabled under Equality Act	-	547 (-3,486)	35,877 (-33,062)	62,634 (+31,710)	4,838 (+4,838)
Educational establishments (count)	-	- (-6)	54 (-177)	292 (+153)	30 (+30)
Care homes (count)	-	- (-3)	22 (-79)	133 (+70)	12 (+12)
Hospitals (count)	-	-	2 (-8)	15 (+8)	-
GP and healthcare facilities (count)	-	-	12 (-56)	80 (+51)	5 (+5)
Buildings (count)	- (-1)	401 (-4,784)	53,258 (-157,605)	255,314 (+141,189)	21,796 (+21,201)

4.2.1.2. Heatwave

Current risk of heatwaves demonstrated high heatwave risk in Oxford City, Witney, Abingdon and Banbury. The risk of heatwaves in future (2050 pathway for a +2°C and +4°C in 2100 warming scenario) versus current risk is presented in Figure 4-8 and Figure 4-9 and shows that:

- In 2050 for a +2°C in 2100 warming scenario, there is an increase in heatwave risk across the majority of the county in comparison to the current heatwave risk, notably, in the rural areas of West Oxfordshire and Vale of White Horse (Figure 4-8). Heatwave risk also intensifies in urban areas such as Abingdon, Banbury, Oxford and Bicester.
- In 2050 for a +4°C in 2100 warming scenario, heatwave risk portrays a similar change to +2°C in 2100 warming scenario, showing an overall increase in heatwave risk across the county and greater heatwave risk across urban areas. An increase in heatwave risk is notable in the +4°C in 2100 versus +2°C in 2100 scenario in the north-west of the county in Cherwell and West Oxfordshire, primarily due to an increase in cooling degree days in these areas between the +4°C and +2°C in 2100 scenarios.

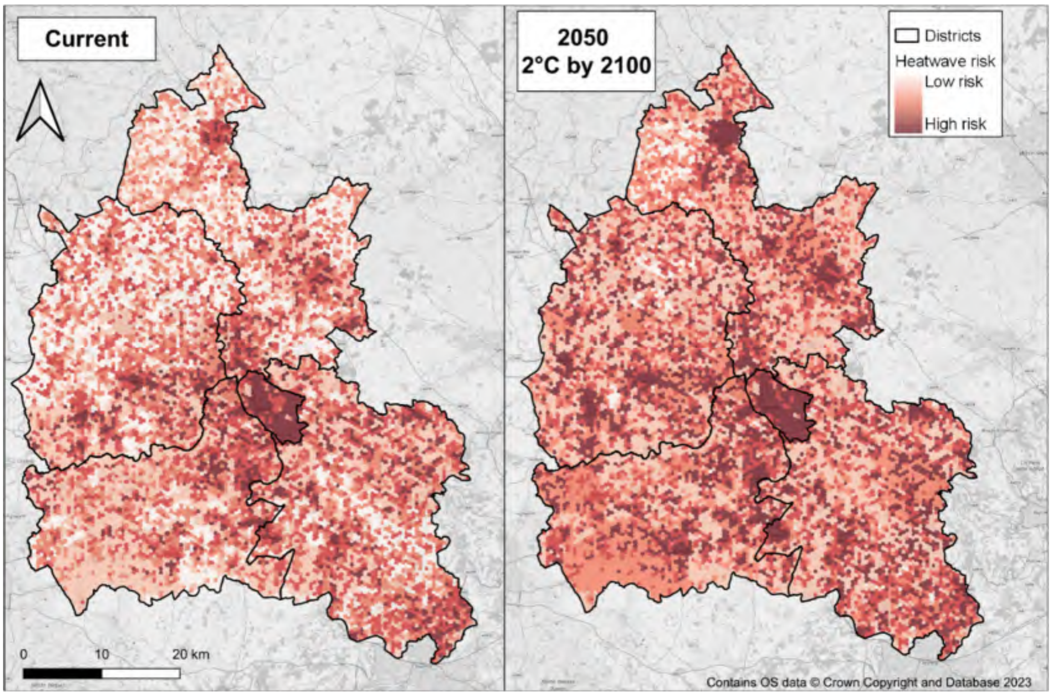


Figure 4-8 – 2050 +2°C heatwave risk versus current heatwave risk

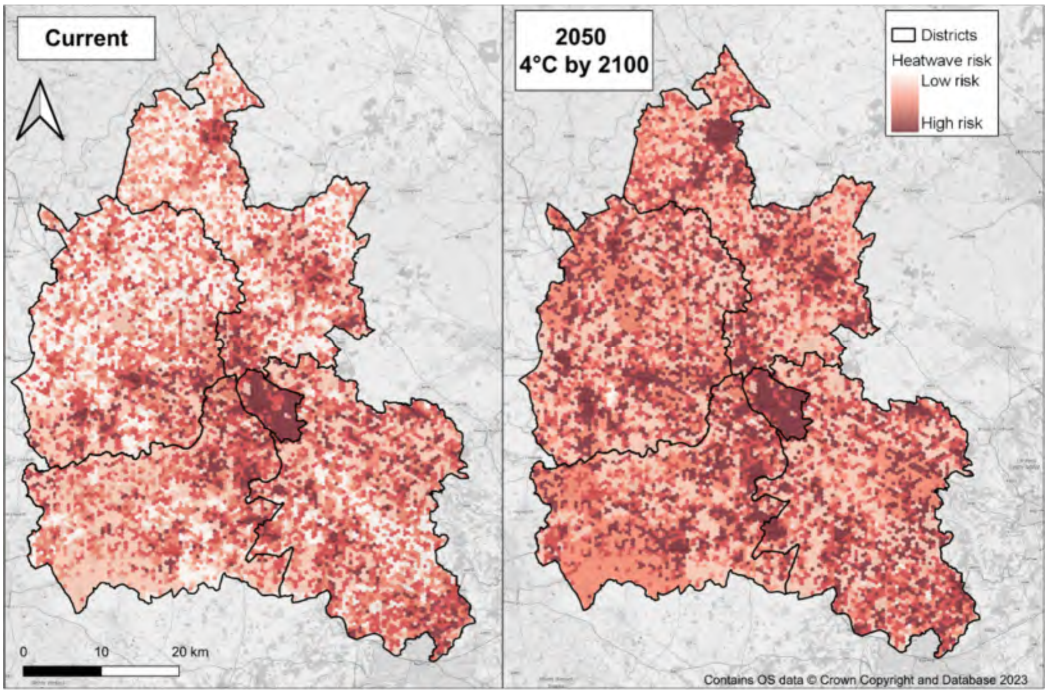


Figure 4-9 – 2050 +4°C heatwave risk versus current heatwave risk

The top ten wards with highest future and current risk are shown in Figure 4-10. The heatwave risk of 2050 with a +4°C warming in 2100 is presented to show a more extreme projection of heatwave for the county. Under this scenario there is a marked change in the top ten highest heatwave risk from current to 2050, which in 2050 includes wards in Witney and Banbury rather than solely wards in Oxford and Abingdon. Oxford remains the district with the greatest number of wards in the top ten future heatwave risk.

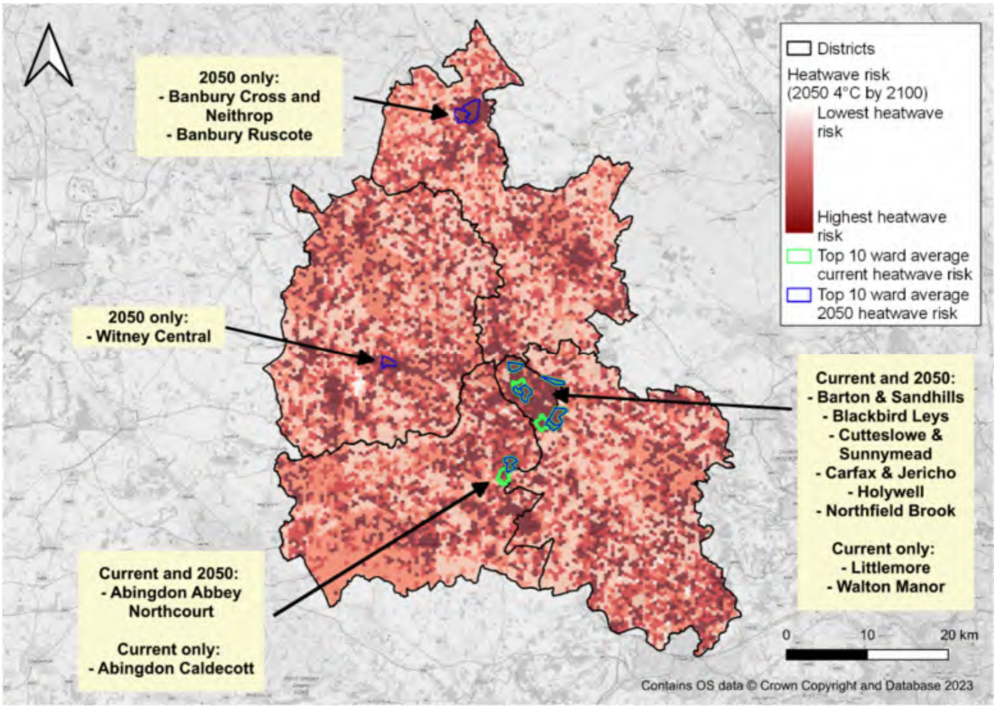


Figure 4-10 – Ten wards with the highest current heatwave risk versus highest future heatwave risk in Oxfordshire

Key amenities and population groups within the future heatwave risk category versus the previous current heatwave risk score demonstrate an increase in heatwave risk in future for a number of vulnerable groups and essential amenities (Table 4-5). Notably, children, elderly and disabled residents are more likely to live in an area of higher flood risk in future. A greater number of hospitals, care homes, educational establishments, GP and healthcare facilities and all buildings across Oxfordshire are expected to have a higher heatwave risk in future than currently.

Table 4-5 – Key amenities and associated 2050 heatwave risk scoring

Key amenities and population	Key amenities and population groups within future heatwave risk score and change from current heatwave risk				
	Lowest risk (0-3)	*3-6*	*6-9*	*9-12*	*Highest Risk (12-15)*
Aged under 15	-	- (-4,988)	69,405 (-13,847)	51,087 (+18,835)	-
Aged 75 and over	-	- (-2,859)	40,041 (-4,365)	21,684 (+7,224)	-
Total population	-	- (-31,342)	409,538 (-68,053)	304,553 (+98,395)	-
Disabled under Equality Act	-	- (-4,035)	56,978 (-10,390)	46,918 (+14,425)	-
Educational establishments (count)	-	- (-11)	187 (-48)	189 (+59)	-
Care homes (count)	-	- (-3)	76 (-37)	91 (+40)	-
Hospitals (count)	-	- (no change)	5 (-8)	12 (+8)	-
GP and healthcare facilities (count)	-	- (-1)	43 (-13)	54 (+14)	-
Buildings (count)	-	147	182,355	148,114	153

		(-6,940)	(-56,125)	(+63,002)	(+64)

4.2.1.3. Low temperatures

Low temperatures can cause direct impacts on health through exposure to cold resulting in greater risk of winter illnesses such as influenza, coronavirus and colds[146]. Indirect effects can also include the impact of cold weather on roads causing transport disruption to healthcare services such as ambulances. As outlined in section 4.1.3, cold weather alerts are expected to decrease under a +2°C and +4°C by 2100 warming scenario.

Additionally, heating degree days are a measure of the severity and duration of cold weather, using a threshold temperature of 15.5°C.[147] Heating degree days are projected to decrease from current levels in 2050 under both +2°C and +4°C warming by 2100 scenarios. Heating degree days decrease notably, between the +2°C and +4°C warming by 2100 scenarios in Oxford, South Oxfordshire and Vale of White Horse (Figure 4-11). This creates opportunities for reduced adverse risks associated with low temperatures such as cold related morbidity and mortality and reduced need to heat buildings.

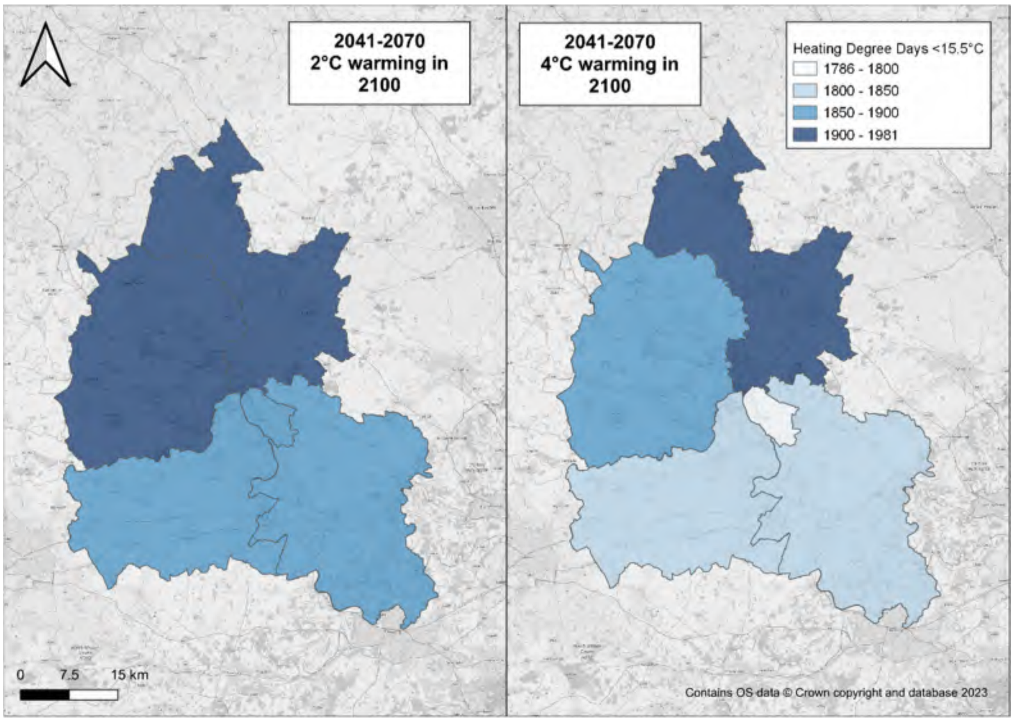


Figure 4-11 - Future heating degree days <15.5°C in Oxfordshire[148]

4.2.1.4. High winds and storms

High winds and storms can impact on communities, resulting in injuries and damage to buildings. As outlined in section 4.1.4, future trends in storms and high winds at local level are uncertain. At a national level, there is expected to be an increase in near surface wind speeds for the second half of the 21st century during winter, as well as an increase in the frequency of winter storms[149]. Data specific to Oxfordshire was not available at the time of writing.

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[146] How cold weather affects your health - Met Office
[147] Arnell, N.W., Kay, A.L., Freeman, A., Rudd, A.C., Lowe, J.A. (2021) Changing climate risk in the UK: A multi-sectoral analysis using policy-relevant indicators, *Climate Risk Management*, Volume 31, Available at: https://doi.org/10.1016/j.crm.2020.100265
[148] Climate Risk Indicators (uk-cri.org)
[149] Met Office (2019) *UKCP18 Factsheet Wind,* Available at: ukcp18-fact-sheet-wind_march21.pdf

4.2.1.5. Drought

Drought can cause subsidence, which may cause structural damage to buildings impacting those who reside, own or work in buildings. Winter rainfall is projected to increase in Oxfordshire and summer rainfall projected to decrease by 2050, however, there is considerable uncertainty in these future changes[139,150]. An increase in soil moisture deficit is projected across Oxfordshire by 2050, as outlined in section 4.1.5, suggesting an increased likelihood of drought conditions in the future.

4.2.1.6. Cascading risks

The risks from flooding and drought may have resultant effects on mental health[151]. Additionally, there are cascading risks to health from vector-borne pathogens associated with increased temperatures resulting in new habitable regions for ticks and mosquitoes.

4.2.2. Health impact assessment

A health impact assessment based on key climate hazards for Oxfordshire is presented below, which provides an overview of the impacts of climate change on physical and mental health and key interdependencies with air quality. A review of existing literature was conducted, building upon the assessment of current risk for Health, Communities and Built Environment as presented in section 3.2.1 and supported by quantitative evidence where available.

The UK Climate Change Risk Assessment (CCRA3) outlines a number of key risks and opportunities from climate change on health and health services at a national level (Figure 4-12). Emboldened risks are highlighted in the CCRA3 as needing further investigation to understand the risk and its implications on health in England. Figure 4-13

RISKS

- **Risks to health and wellbeing from high temperatures.**
- Risks to people, communities and buildings from flooding.
- **Risks to health and social care delivery from extreme weather.**
- **Risks of prison and education services from extreme weather.**
- Risks to health and wellbeing from changes to indoor and outdoor air quality.
- **Risks to health from vector borne diseases.**
- **Risk to UK public health from climate change overseas.**
- Risks to health from poor water quality or supply interruptions.

OPPORTUNITIES

- **Opportunities for health and wellbeing from higher temperatures**

Figure 4-12 – Key risks and opportunities for Health, Communities, and the Built Environment from the CCRA3[152]

Figure 4-13 below describes the main direct and indirect impacts and effects of hot weather and flooding on health as advised by the UK Health and Security Agency.

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150 HEADLINE_FINDINGS (metoffice.gov.uk)
151 https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf
152 CCRA3-Briefing-Health-Social-Care.pdf (ukclimaterisk.org)

Figure 4-13 – UK Health and Security Agency risks to health from hot weather and flooding[153]

4.2.2.1. Climate change and excess mortality

The CCRA3 Technical Report[93] highlights that 11 of the 61 climate risks identified across multiple sectors impact public health and broader health directly[154]. Adverse and extreme weather can have both negative and positive effects on health. In this section, we note the various potential effects of climate change on mortality.

Table 4-6 below describes the main climate-related hazards and how these may impact on health and mortality.

Table 4-6 – Summary of key climate-hazards and their impact on excess mortality

Hazard	Impact on excess mortality	Future risk
Cold spells	Mortality tends to be greater during the winter months (December to February) compared to rest of the year. Cold temperatures can have direct impacts on health, causing hypothermia and influenza, and indirect effects, such as frozen roads causing transport disruption to healthcare services.	Whilst climate change is projected to reduce the levels of cold-related mortality, the levels of cold-related mortality are still expected to remain high till the end of the century[154].
Extreme heat	Extreme heat can impact vulnerable groups which have a lower ability to adapt and the people at greatest risk from heat health impacts (morbidity and mortality), including: • Elderly people, chronically ill people and people taking certain medicines may have impairments in their thermoregulation, thus more likely to overheat. • Children under 5 years are unable to control their body temperatures as efficiently as adults and are more likely to overheat. • There is a link between increasing temperatures (resulting in dehydration) and increasing infections of Gram-negative bacteria, such as E. coli. (risk of such infectious diseases is greatest in elderly people).	There is a clear trend between the annual maximum temperature in Oxfordshire and number of excess deaths related to heat (see Table 4-7 below). This indicates that expected increase in temperatures in the future may result in a larger number of excess deaths.

153 Come rain or shine, adverse weather matters for our health - UK Health Security Agency (blog.gov.uk)
154 UK Health Security Agency (2023) *Adverse Weather and Health Plan Supporting evidence 2023 to 2024*, Document available under the Open Government Licence v3.0. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1155636/AWHP_Evidence.pdf, Accessed: [12/06/2023]

	• People with alcohol or drug dependence and homeless people may be less able to adapt to extreme temperatures. • People who work outside or use the outside for recreation	
Flooding	Although rare, direct physical health impacts can arise from flooding. Such impacts include drowning, injury due to collision with debris, electrocution or fire exposure, infection, and heart attacks[155]. Indirect impacts may include contamination, loss of clean water, and loss of transport that result in death[156].	An increase in flooding risk may lead to more physical health impacts from flooding if unaddressed.

Table 4-7 below presents recorded excess deaths in Oxfordshire during a heat-period[159]. Whilst Table 4-7 presents a relatively stable number of annual heat periods within Oxfordshire over the past six years (excluding the jump in 2022 where record breaking temperatures resulted in the first Level 4 HHA being issued), there is a clear trend between the annual maximum temperature in Oxfordshire and number of excess deaths related to heat.

Table 4-7 – Excess mortality during heat periods in Oxfordshire[157]

Year	Excess deaths in Oxfordshire due to heat[158]	Number of heat-periods[159]	Annual max temperature in Oxford[160]
2022	65	5	38.1°C
2021	44	2	31.3°C
2020	36	3	35.1°C
2019	34	3	36.5°C
2018	61	4	32.4°C
2017	35	2	32.5°C
2016	8	3	32.3°C

The table above also highlights how the annual maximum temperature in Oxfordshire has been increasing in recent years. According to the UK Health Security Agency, it is projected the number of UK-wide heat related deaths will triple by 2050 (relative to 2021)[154].

[155] Curtis, S. Fair, A., Wistow, J., Val. D.V., and Oven, K. (2017) Impact of extreme weather events and climate change for health and social care systems, *Environmental Health*, 16, Article number: 128, doi: https://doi.org/10.1186/s12940-017-0324-3
[156] Paavola, J. (2017) Health impacts of climate change and health and social inequalities in the UK., *Environmental Health*, 16, Article number: 113, doi: https://doi.org/10.1186/s12940-017-0328-z
[157] Excess mortality during heat-periods: 1 June to 31 August 2022 - Office for National Statistics (ons.gov.uk)
[158] Heat mortality statistics include the days before and after a heat episode, to account for lagged effects of temperature on mortality.
[159] UK Health Security Agency defines a heat-period as day(s) on which a Level 3 Heat Health Alert (HHA) is issues and/or day(s) when the mean Central England Temperature is greater than 20°C
[160] Data from Oxford Radcliffe Observatory https://www.geog.ox.ac.uk/research/climate/rms/reports.html. There were unverified reports of temperatures >40°C reported on the Met Office WOW system in Oxfordshire.

4.2.2.2. Climate change and impacts on morbidity

As well as deaths, adverse weather conditions can result in an increase in morbidity rates. Warmer weather and flooding events can impact healthcare services, result in an increase in disease transmittance, and be exacerbated by social inequalities[154].

- Healthcare services

The majority of healthcare facilities (hospitals, care homes, and hospitals) across Oxfordshire are located in areas of high future heatwave hazard, particularly in urban areas such as Oxford, Abingdon, Bicester, Banbury and Witney (Figure 4-14). Likewise, many facilities are located in areas of high future flood hazard, notably, west of Oxford City, Abingdon, Witney, Bicester and Banbury.

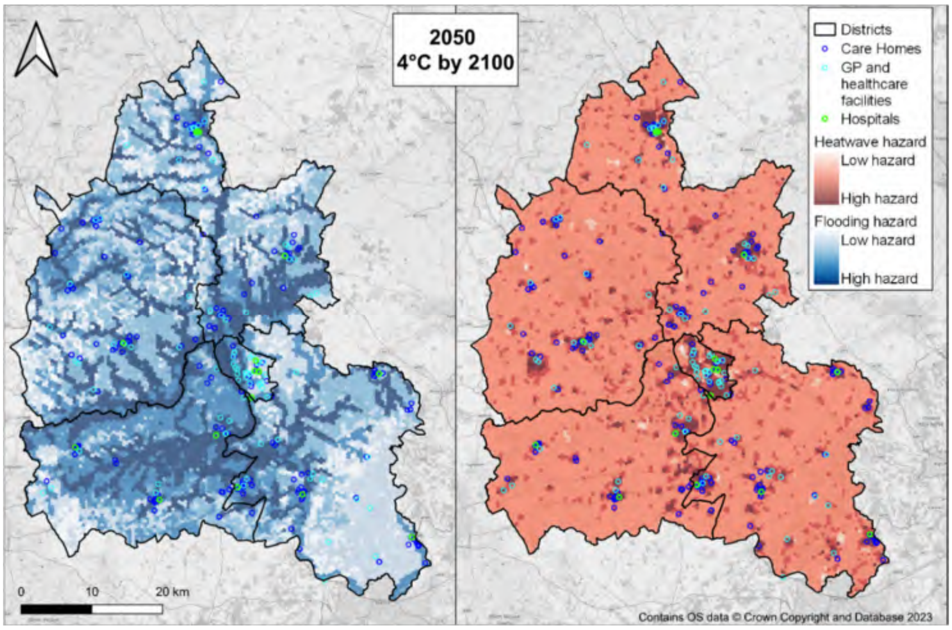

Figure 4-14 – Healthcare facilities and future flood and heatwave hazard

Surveys have found that hospital and GP surgery admissions, and ambulance call-out rates increase in relation to warmer weather. Similarly, extreme weather has been noted to increase ambulance call-out rates, 161162￼. Indirectly, warmer weather results in more people spending time outdoors and consequently, more injuries. Directly, warmer weather can result in heat related illnesses163, and it has been noted that the number of hospital admissions for respiratory diseases increase during heatwaves164,165. The increase in demand can put pressure on health services, pressure which is amplified by the direct risks health services also face from extreme weather. For example, flooding can breach GP surgeries and hospitals, making buildings inaccessible and unusable. Climate projections indicate that there will be a greater number of GP surgeries,

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[161] Paavola, J. (2017) Health impacts of climate change and health and social inequalities in the UK., *Environmental Health*, 16, Article number: 113, doi: https://doi.org/10.1186/s12940-017-0328-z

[162] Thornes JE, Fisher PA, Rayment-Bishop T, Smith C. (2014) Ambulance call-outs and response times in Birmingham and the impact of extreme weather and climate change. *Emerg Med J*.;31(3):220–8.

[163] Walkeden, J., Hunt, C. and Masding, V. (2022) Climate-related mortality and hospital admissions, England and Wales: 2001 to 2020

[164] UK Health Security Agency (2023) Heat mortality monitoring report: 2022, Available from: https://www.gov.uk/government/publications/heat-mortality-monitoring-reports/heat-mortality-monitoring-report-2022, Accessed on: [12/06/2023]

[165] Michelozzi P, et al. (2009) High Temperature and Hospitalizations for Cardiovascular and Respiratory Causes in 12 European Cities. *Am J Respir Crit Care Med*;179(5):383–9.

care homes and hospitals in flood risk zones[152]. Climate change can disrupt critical infrastructure used for health care, such as energy transmitters, and thus undermine healthcare[154].

Heatwaves may damage important hospital systems and assets, such as impairing the use of medical equipment and the storage of medicines. The thermal comfort of patients and staff is also put under stress due to hospital designs and requirements, such as safety protocols preventing windows from being opened, must be adhered to166. The UK Health Security Agency state that new hospitals are more likely to overheat than older hospitals, although changes to older buildings may reduce their adaptive capacity to mitigating the impacts of warmer temperatures.

- Vector-borne and other diseases

Warmer temperatures can have indirect consequences on health, such as by increasing the abundance of diseases, both vector-borne diseases (e.g. West Nile Virus from mosquitoes) and tick-borne diseases (e.g. Lyme disease)[167.] There is already evidence of West Nile Virus outbreaks in continental Europe during hot spring weather.

Currently in England, it has been observed that flooding can impact the density and distribution of native mosquitoes as more “ideal” habitats are created for them. A warmer climate may result in non-native mosquito populations settling in the UK, and bring a greater risk of diseases, such as dengue, chikungunya and Zika, that are rare in the UK[167].

Changes in climate not only impact the geographic expansion of infectious diseases, such as the spread of Lyme disease from ticks in Europe but can also increase the rate of pathogen maturation in vectors, thus increasing the chance of infection. High precipitation, for example, can heavily influence vectors that depend on water, such as mosquitoes. Similarly, droughts can result in a concentration of vectors around water bodies, increasing transmission of vector-borne diseases[168].

Climate change also increases the risk of contracting food-borne diseases. Due to the many stages of the food chain, there are many opportunities for bacterial contamination, and such opportunities are enhanced by warmer temperatures. In developed countries, the pathogen Campylobacter is the largest bacterial cause of diarrhoeal disease. One study has found that an increase in the distribution of Campylobacter infections correlates with increases in heavy rainfall and temperature. Similarly, Salmonella infections are higher in the summer than during winter[168].

Climate change influences the hydrological cycle at a global scale and consequently results in local hazards, such as droughts and flooding. For example, water runoff during a heavy rain event can transfer animal pathogens into waterways, and then water treatment and distribution centres, resulting in waterborne outbreaks. In addition, warming sea surface temperatures accelerate the production of certain pathogens in marine waters, thus increasing infection in recreational water users. With saline intrusion, this can spread inland to more populations[168].

- Health inequalities

Amplified adverse impacts may be noted on elderly population in the UK as they are highly vulnerable to extreme heat due to the high incidence of pre-existing medical conditions. Additionally, elderly people that live

[166] Curtis, S. Fair, A., Wistow, J., Val. D.V., and Oven, K. (2017) Impact of extreme weather events and climate change for health and social care systems, *Environmental Health*, 16, Article number: 128, doi: https://doi.org/10.1186/s12940-017-0324-3
[167] UK Health Security Agency (2021) *Understanding the health effects of climate change*, Available from: Understanding the health effects of climate change - UK Health Security Agency (blog.gov.uk), Accessed: [12/06/2023]
[168] Climate change and infectious disease in Europe: Impact, projection and adaptation - The Lancet Regional Health – Europe

alone or in rural areas are a more vulnerable population as they are less capable of responding to climate-related events (e.g. more exposed to Lyme's disease) and receiving aid.

Poor elderly people have a higher likelihood of contracting gastrointestinal illnesses if they live in areas of contaminated, or scarce, water supplies[169].

In the future, the elderly to other diseases introduced by insects and animals that have settled in the UK due to warmer weather. Furthermore, the elderly population in rural areas may have limited access to health care services to treat the aforementioned diseases and extreme weather-related ailments[161].

Climate change poses a threat to the potential of having future healthy, elderly populations. Elderly people are disproportionately affected by climate change due to enhanced physiological susceptibility and pre-existing health conditions. Elderly people are more at risk of adverse impacts from extreme temperatures since they have less adaptability, such as a lower sweating capacity, and they may use certain prescription medicines that increase the risk of heat-related illness. Extreme heat can cause dehydration and cardiovascular strain. In combination with poor air quality, extreme heat can worsen poor health, such as cardiovascular and respiratory diseases, in elderly people[170].

The adaptive capacity of people to recover from flood exposure may be lower for people with lower income and no insurance on damaged assets[161]. An increase in the frequency and scale of flooding could displace more people as homes are placed at risk, meaning the rate of homelessness may increase171. According to the UK Health Security Agency, the lower the socioeconomic position, the worse the health[154].

4.2.2.3. Other climate-related risks and impacts

- Mental health

Climate change poses risks to mental health and well-being. The Royal College of Psychiatrists completed a survey which found that 85% of the UK public think that climate and ecological emergencies will affect mental health in a decrease at least as much as unemployment and Covid 19[172]. The World Health Organisation (WHO) produced a policy brief[173] in 2022 that recommends approaches for governments to address the mental health impacts of climate change (Figure 4-15).

Integrate climate considerations with mental health programmes

Integrate mental health support with climate action

Build upon global commitments to addressing climate change

Develop community-based approaches to reduce vulnerabilities to climate risks

Close the funding gap that exists for mental health and psychosocial support (as mental health impacts related to climate change are unequally distributed with certain groups disproportionately affected)

[169] The 2030 Agenda for Sustainable Development and the UN Decade of Healthy Ageing 2021-2030 (who.int)
[170] The 2030 Agenda for Sustainable Development and the UN Decade of Healthy Ageing 2021-2030 (who.int)
[171] Environment Agency (2023) Available from: https://www.gov.uk/government/publications/state-of-the-environment/state-of-the-environment-health-people-and-the-environment#climate-change-and-health, Accessed: [12/06/2023]
[172] RCPsych declares a climate and ecological emergency
[173] World Health Organisation (2022) Available from: Mental health and Climate Change: Policy Brief (who.int), Accessed: [13/06/2023]

Figure 4-15 - Recommended approaches to address the impact of climate change on mental health[174]

'Eco-anxiety' is a relatively new term describing a sense of hopelessness and fear of environmental doom[175]. A study by Hickman *et al.* (2021)[176] surveyed 10,000 young people (aged 16-25) living in 10 different countries and found that half of the respondents felt sad, anxious, angry, powerless, helpless, or guilty. The countries faced different threats, from food insecurity to flooding, but the levels of eco-anxiety remained consistent across geographic regions.

Climate activists are also likely to face burnout from feelings of hopelessness toward the future and due to exhaustion from heavy involvement in activism activities (i.e., protest movements, support groups). Studies have also shown links between high temperatures and heatwaves with an increased rate of suicide, an increase in violent crime, and poorer sleep quality and reduced ability to work.[177]

Woodland et al. (2023)178 investigated studies on the health impacts of climate change on people living with a pre-existing mental health illness, evaluating their mental health before and after a climate-driven event (heat events, floods, wildfires, hurricanes, and droughts). The study found that 90% of the studies suggested an association between pre-existing mental health illness and a likelihood in adverse health impacts (i.e., increased mortality risk, new symptoms, exacerbation of current symptoms) following a climate-driven event. Their recommendation to mitigate the exacerbation of health inequalities is to include and consider people with pre-existing mental health illnesses within adaptation guidance and plans for mitigating the health impacts of climate change.

Case study: July 2021 Canada heat dome and mental health

The heat dome in Canada in 2021 was caused by a high-pressure system – the "heat dome" – with unprecedented high temperatures and increased concentrations of ground-level ozone and fine particulate matter[179]. Daily temperatures were 16° to 20°C above seasonal norms.

[180]

Impacts

- 740 deaths in the province of British Columbia - deadliest weather event in Canadian history (as of 2021).
- Schizophrenia was associated with a higher risk of death than any other chronic disease[181]

Case study: Climate Cafes – Low Carbon Oxford North and eco-anxiety

Low Carbon Oxford North[183] partners with local businesses (cafes, arts centres, etc.) to provide a supportive space where people can come together to talk about how the climate crisis is affecting them, without pressure to act. The Climate Cafes are facilitated by local volunteers to create a space for people to speak and share their feelings.

These gatherings offer a different approach to gatherings of people with climate change interests. What people are currently doing or should be doing is not discussed, as it acknowledges that feelings of guilt and frustration about not doing enough for the planet are pervasive and impact mental health negatively. Instead, these climate cafes focus on how climate change is making people think and feel.

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[174] World Health Organisation (2022) Available from: Mental health and Climate Change: Policy Brief (who.int), Accessed: [13/06/2023]
[175] BBC (2023) Available from: Climate change is harming my mental health - BBC News, Accessed: [13/06/2023]
[176] Hickman et al. (2021) Available from: Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey - The Lancet Planetary Health, Accessed: [13/06/2023]
[177] Climate change and mental health | The Bartlett - UCL – University College London
[178] Woodland et al. (2023) Available from: IJERPH | Free Full-Text | Investigating the Health Impacts of Climate Change among People with Pre-Existing Mental Health Problems: A Scoping Review (mdpi.com), Accessed [13/06/2023].
[179] Lee et al. (2023) Available from: Chronic Diseases Associated With Mortality in British Columbia, Canada During the 2021 Western North America Extreme Heat Event (wiley.com), Accessed: [13/06/2023]
[180] US-Canada heatwave: Visual guide to the causes - BBC News
[181] Risk of mortality among people with schizophrenia during the 2021 heat dome | British Columbia Medical Journal (bcmj.org)
[183] Climate cafes - Low Carbon Oxford North (lcon.org.uk)

- Significantly higher climate change anxiety following the event.[182]
    - 13% increase in average climate change anxiety levels among residents in British Columbia.
    - Residents reported they were much more worried about climate change following the heat event.
    - 29.8% of people felt their region was likely to be devastated by climate change (compared to 17.5% prior to the event).

Flooding has extensive impacts on mental health directly and indirectly. People who have experienced flooding are more likely to have symptoms of post-traumatic stress disorder, anxiety, and depression for 6 months to 3 years after the event. People living in the vicinity of flooded homes or in a community affected by flooding are likely to have elevated symptoms of mental health disorders, even if their household was not directly flooded. Other significant stressors to mental health include the loss of utilities such as gas, water and electricity services and the loss of access to health and social care services as a result of flooding.[184]

Recognising that most of the health burden in England associated with flooding is due to impacts on mental health and wellbeing, the UK Government have published guidance on flooding and managing public mental health[184]. This guide is directed at public health and local authorities, emergency services, health professionals and public agencies who interact with those at risk from the psychosocial impacts of flooding. Figure 4-16 below demonstrates the recommended response for flood events to ensure care for those most at risk of mental health problems following a flood event.

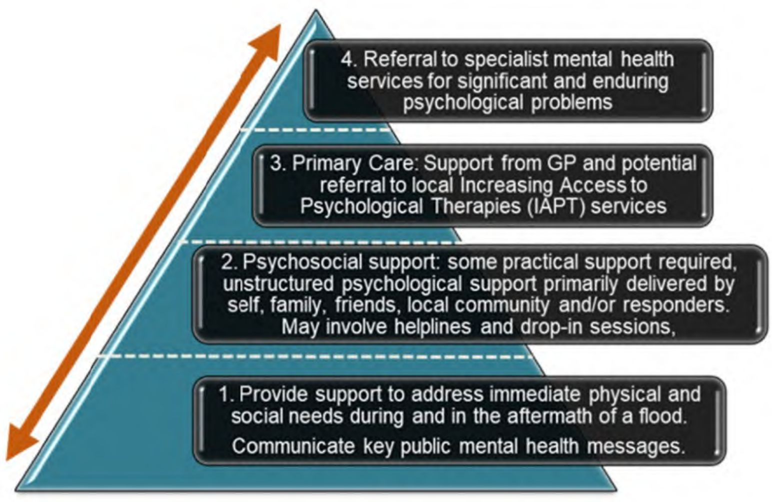


Figure 4-16 - Tiered pyramid for flood response[185].

[182] Simon Fraser University (2022) Available from: Heat dome and other climate events have growing impact on mental health—study - SFU News - Simon Fraser University Accessed: [13/06/2023]
[184] Flooding and health: assessment and management of public mental health - GOV.UK (www.gov.uk)
[185] Retrieved from UK Guidance for Flooding and health: assessment and management of public mental health (2022).

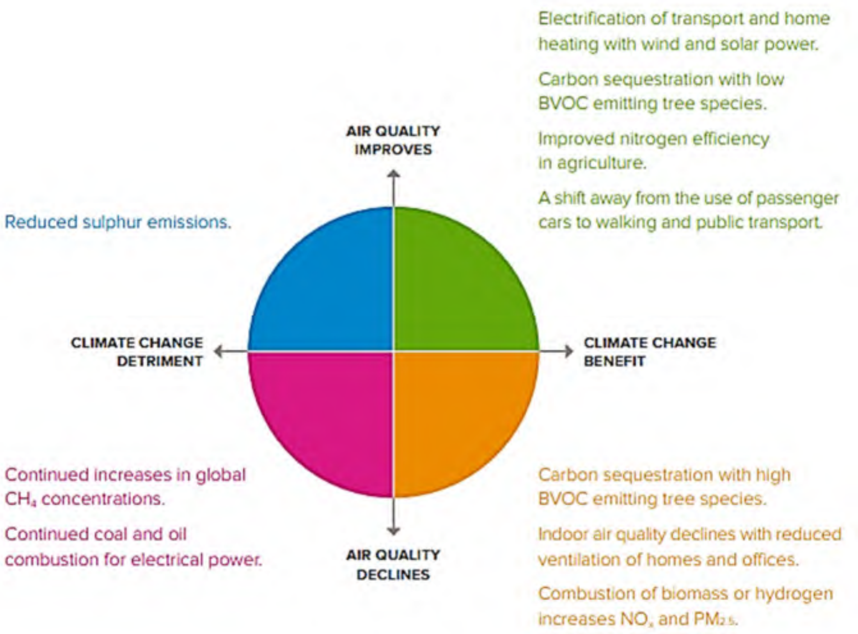
- Air quality

Climate change and air pollution are driven by anthropogenic emissions into the atmosphere. There are two broad categories of emissions that interact with the climate:

- Greenhouse gases warm the atmosphere by absorbing radiation which traps energy in the atmosphere and increases the temperature.
- Particulate matter composed of small solid and liquid particles which can absorb radiation similar to greenhouse gases, it can also reflect incoming solar radiation which cools the climate.

Air pollution and climate change are closely coupled; however, "(…) not all air pollutants affect the climate and not all climate change pollutants are air pollutants"[186]. Air pollution is one of the leading environmental risk factors for premature deaths worldwide. The main pollutants adversely impacting human health are particulate matter (PM10 and PM2.5), nitrogen dioxide, carbon monoxide, sulphur dioxide, and ground-level ozone. Climate change can influence air pollution due to changes in heatwave events becoming more frequent and/or severe and impacting local and regional meteorology patterns. Rising temperatures will lead to changes in chemistry associated with ozone formation, higher nitrogen oxide concentrations in more polluted regions will see increases in ozone but decreases in ozone where water vapour concentrations are high.

In the UK, air quality pollutant emissions have fallen over the past decade largely due to legislation and technology developments.[187] Pollutant emissions are spread over a number of sectors as previously dominant emitters have taken measures to control their impact. Transitions to net zero measures will deliver both climate change and air quality benefits. Figure 4-17 illustrates the effects of net zero and air quality control measures on climate change and air quality and where the co-benefits and disbenefits lie.188



[186] Akasha et al. (2021) Climate Change and Air Pollution. Available from: https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/16600/962_Climate_Change_and_Air_Pollution.pdf?sequence=3&isAllowed=y. Accessed [13/06/2023].
[187] Defra (2007) Air Quality and Climate Change: A UK Perspective (defra.gov.uk). Accessed [13/06/2023].
[188] The Royal Society (2021) Effects of Net-Zero Policies and Climate Change on Air Quality. Available from: https://royalsociety.org/-/media/policy/projects/air-quality/air-quality-and-climate-change-report.pdf?la=en-GB&hash=D0318D2EE1F11A087C8CBF03373DF770 Accessed [13/06/2023].

Figure 4-17 - Air quality and climate change responses to net-zero measures and air pollutant emissions control.[188]

Table 4-8 describes some of the main health impacts from indoor and outdoor air pollution.

Table 4-8 – Key health impacts due to poor outdoor and indoor air pollution

Outdoor ambient air pollution	Indoor air pollution	Particulate matter air pollution
• Accounts for 4.2 million deaths per annum due to acute and chronic respiratory diseases, heart disease, lung cancer, and stroke.[186] • Studies worldwide have found a direction connection between harmful air pollutants, particularly particulate matter pollution, to lung cancer and cancer of the urinary tract.[186] • Other serious risks from exposure to nitrogen dioxide, sulphur dioxide and ground-level ozone are asthma-related morbidity and mortality, bronchial symptoms, lung inflammation, and reduced lung function.[186]	• Responsible for noncommunicable diseases such as chronic obstructive pulmonary disease, stroke, ischemic heart disease, and lung cancer.[186] • The WHO reports that approximately 3.2 million people die prematurely every year from illnesses developed through household air pollution (i.e., using polluting stoves with solid fuels and kerosene).[189] • In low- and middle-income countries, the impact of indoor air pollution disproportionately affects women and children due to extensive time spend indoors with combustion sources.[189]	• Effect on cognition and mental health; wherein citizens of polluted cities and countries are, on average, likely to have worse cognitive ability than if the air quality was better.[190]

Air pollution will affect different population groups in different ways. For pregnant women, air pollution can cause babies to be born at a low birth weight. For children, they can develop asthma, slower development of lung function, development problems, and atherosclerosis. For the elderly, air pollution makes them more susceptible to an accelerated decline in lung function, dementia, heart attack, heart failure, and stroke.191

Air quality in Oxfordshire is relatively unpolluted and clean across most of the county but this picture is complex as 40% of the population live in rural towns and villages. However, there are several large urban centres including the city of Oxford.[191] As of 2021, the fraction of mortality attributable to particulate air pollution in Oxfordshire was 5.5% which is equal to England's average and slightly above the South East average (5.4%) (Figure 4-18).192

[189] WHO (2018). Household Air Pollution and Health [Online]. Available: Household air pollution (who.int) Accessed [13/06/2023].
[190] Shebab, M.A & Pope, F. D. (2019) Effects of short-term exposure to particulate matter air pollution on cognitive performance. Scientific Reports, 9, 8237.
[191] OCC (2023) Oxfordshire County Council Draft Air Quality Strategy 2023-2030. Available from: https://mycouncil.oxfordshire.gov.uk/documents/s65892/CAB_230523%20Air%20Quality%20Strategy%20Annex%201.pdf. Accessed [13/06/2023].
[192] JSNA (2023) Air Quality and Health. Available from: JSNA_Bitesize_AirQuality_Apr2023.pdf (oxfordshire.gov.uk). Accessed [13/06/2023].

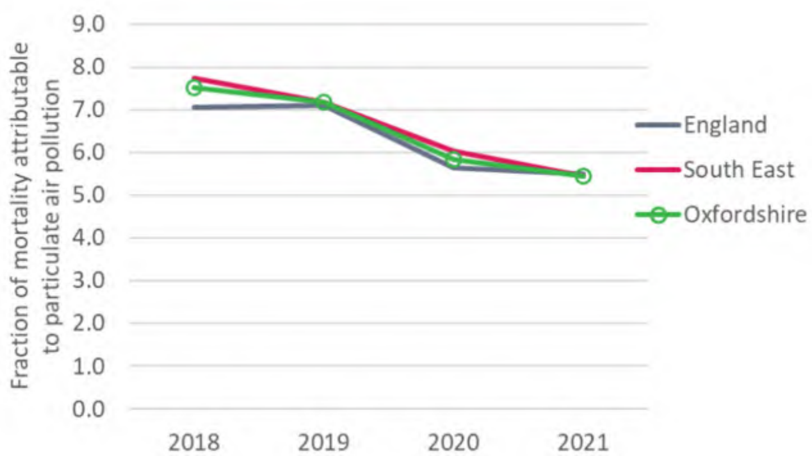


Figure 4-18 - Fraction of mortality attributable to particulate air pollution (2018 to 2021)[192]

Local contexts within the county are significant in determining sources of air pollution and adaptation strategies. For instance, air pollution in urban centres are caused by traffic and domestic combustion which contributes to particulate matter and nitrogen dioxide emissions. Whereas in rural parts of the county, the agriculture and industry sectors are the main sources of air pollution. The 2022 Annual Air Quality Status Report published by Oxford City Council found that levels of nitrogen dioxide remain high due to traffic (68% of emissions contributed by the transport sector).193 Additionally, levels of particulate matter within the city are aligned with the national trend for the pollutant.

The OCC Air Quality Strategy 2023-2030 outlines their strategies to support the ongoing delivery of air quality research and highlight the consideration of air quality in decision-making processes, working with district and city councils to prioritise actions that will benefit those most vulnerable to air pollution impacts and raising awareness among residents, and working to secure funding to delivery new air quality improvement projects. Other initiatives include the Oxford Zero Emission Zone to reduce traffic air pollution in the city of Oxford which will have co-benefits for air quality and climate change by reducing greenhouse gas emissions from vehicle combustion.

- Migration and health

Migration, both internal and international, can occur as a result of both climatic shock events, such as storms and droughts, and long-term climatic changes, such as flooding. Previous research has found that repeated crop loss and property damage, due to flooding, can result in pressure to migrate. Similarly, short-term changes in temperature and precipitation encourage migration as agricultural productivity and health are negatively affected[194].

Migration and climate change may disproportionality affect the most vulnerable in society, as it is likely that the healthiest, able-bodies population are more able to migrate. This is amplified by a population’s financial capacity and access to other resources that may be required to migrate[194].

As populations migrate to new regions, pressure may be placed on health services in the new regions. In addition, the experience of migration may introduce or enhance negative health impacts as migrants experience xenophobia, and poor housing and working conditions[194].

[193] Oxford City Council (2022). Available from: Air Quality Annual Status Report 2022 | Oxford City Council
[194] Rapid evidence assessment on the impacts of climate change on migration patterns - GOV.UK (www.gov.uk)

- Occupational risks

Living in an urban environment can increase susceptibility to urban heat island effects, and this is enhanced by climate change. This also applies to people who live in rural areas but work in urban areas[195].

Some people may experience unique occupational risks due to climate change. Whilst some may experience disruption to transport networks due to extreme heat that prevents them from commuting to work, other workers may face more direct impacts. Outdoor workers, such as workers in agriculture and forestry, are the most vulnerable to climate hazards, from wildfires to vector-borne diseases. In addition, emergency workers wear personal protective clothing and equipment that can add additional mental and physical strain to the workers. This strain can be amplified by extreme weather events. As the frequency of wildfires and climate-related emergency events is projected to increase, emergency responders may have to work longer, thus increasing fatigue196.

4.2.2.4 Health indicators and risk of heatwave in Oxfordshire

In order to understand further the health profile of Oxfordshire and wider health impacts due to climate change, a number of health indicators are examined based on wards with a high or very high current heat risk, as defined by the current heatwave risk scoring analysis.

A number of health indicators from the Oxfordshire Joint Strategic Needs Assessment (JSNA) website[197] were analysed at a ward level, converting MSOA level data into ward level data using GIS. There were a number of caveats to this spatial analysis, including:

- Heatwave risk scoring is based on Wards in 2022, whereas MSOAs derived from OCC Tableau are under 2011 classification of MSOA boundaries.
- When converting MSOA level scoring to ward level there was not a perfect spatial overlap for a number of wards, therefore, the wards were allocated to the MSOA with the greatest overlap.
- All scoring are ratios, therefore, multiple wards which align with the same MSOA will have the same score.

The following indicators were analysed:

- Cardiovascular disease: emergency hospital admissions for coronary heat disease (CHD), stroke and heart attack, deaths from Circulatory Disease age under 75 years, deaths from stroke, deaths from circulatory disease, deaths from coronary heart disease
- Respiratory disease: emergency hospital admissions for chronic obstructive pulmonary disease (COPD) and deaths from respiratory diseases
- Mental health: emergency hospital admissions for self-harm

Table 4-9 outlines the ward level scoring for each of the above health indicators using a standardised ratio for each indicator[198]. In the two wards with the highest current heatwave risk, Blackbird Leys and Northfield Brook, there is a clear high standardised ratio for the majority of health indicators relating to cardiovascular disease, respiratory disease and mental health. This suggests that areas with high current heatwave risk are also areas with higher health inequalities.

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[195] Heat in cities – the health impacts of a changing climate | Official blog of the Met Office news team
[196] Climate Change: Impact on Occupational Safety and Health (OSH) - OSHwiki | European Agency for Safety and Health at Work (europa.eu)
[197] Workbook: Oxfordshire Local Area Inequalities Dashboard (tableau.com)
[198] For more information on each of the ratios presented please go to: Workbook: Oxfordshire Local Area Inequalities Dashboard (tableau.com)

Table 4-9 - Health indicators (standardised ratio) at ward level for the wards with highest current heatwave risk.

The values for each health indicator presented below are highlighted in different shades of blue. The darker the shade of blue the higher the ratio is for that indicator across the wards presented; conversely, the lighter shades of blue represent the lower ratio values for that indicator. Also, please note that this is one single table presented in two separate pages due to limited space.

Category	Indicators (standardised ratio)	Blackbird Leys	Northfield Brook	Holywell	Carfax & Jericho	Cutteslowe & Sunnymead	Walton Manor	Abingdon Abbey Northcourt	Littlemore	Barton & Sandhills	Abingdon Caldecott	Donnington	Rose Hill & Iffley
Heatwave risk score	Current	10.9	10.5	10.5	10.2	10.2	10.0	9.9	9.8	9.8	9.8	9.8	9.8
	Future (2050 on pathway to 2°C by 2100)	10.9	10.7	10.4	10.2	10.1	10.0	10.1	9.9	10.2	9.8	9.8	9.8
	Future (2050 on pathway to 4°C by 2100)	10.9	10.7	10.4	10.2	10.1	10.0	10.1	9.9	10.2	9.8	9.8	9.8
Cardiovascular Disease	Emergency Hospital Admissions for CHD (2016/17-2020/21)	115	96	62	62	48	62	62	75	119	85	112	84
	Emergency Hospital Admissions for stroke (2016/17-2020/21)	101	99	102	102	62	102	81	105	82	98	83	94
	Emergency Hospital Admissions for heart attack (2016/17-2020/21)	120	109	74	74	53	74	65	76	150	90	123	82
	Deaths from Circulatory Disease age under 75 years (2016-2020)	110	153	80	80	63	80	91	77	115	70	102	101
	Deaths from stroke (2016-2020)	137	115	75	75	51	75	91	105	168	97	108	140
	Deaths from Circulatory Disease (2016-2020)	118	187	87	87	50	87	93	102	153	76	52	90
	Deaths from Coronary Heart Disease (2016-2020)	131	240	128	128	72	128	128	77	127	70	132	115
Respiratory disease	Emergency Hospital Admissions for COPD (2016/17-2020/21)	130	282	69	69	28	69	75	139	147	78	66	163

	Deaths from Respiratory Diseases (2016-2020)	90	105	67	67	44	67	78	63	147	87	109	108
Mental health	Emergency Hospital Admissions for self-harm (2016/17-2020/21)	131	319	81	81	103	81	120	175	201	142	110	130

Diseases	**Indicators (standardised ratio)**	**Cowley**	**St Mary's**	**Headington**	**Quarry & Risinghurst**	**Churchill**	**Witney Central**	**Summertown**	**Lye Valley**	**Temple Cowley**	**Marston**	**Witney South**	**Headington Hill & Northway**	**Abingdon Fitzharris**
Heatwave risk score	Current	9.7	9.7	9.6	9.6	9.5	9.5	9.4	9.4	9.3	9.2	9.2	9.1	9.0
	Future (2050 on pathway to 2°C by 2100)	9.7	9.7	9.7	9.8	9.5	10.2	9.5	9.4	9.4	9.2	9.8	9.1	9.2
	Future (2050 on pathway to 4°C by 2100)	9.7	9.7	9.7	9.8	9.5	10.2	9.5	9.4	9.4	9.2	9.8	9.1	9.2
Cardiovascular Disease	Emergency Hospital Admissions for CHD (2016/17-2020/21)	84	104	54	82	107	68	33	115	115	69	68	54	62
	Emergency Hospital Admissions for stroke (2016/17-2020/21)	94	78	64	102	73	74	71	101	101	65	74	64	81
	Emergency Hospital Admissions for heart attack (2016/17-2020/21)	82	111	51	75	111	68	31	120	120	80	68	51	65
	Deaths from Circulatory Disease age under 75 years (2016-2020)	101	127	89	75	104	72	76	110	110	71	72	89	91
	Deaths from stroke (2016-2020)	140	130	82	49	132	89	55	137	137	85	89	82	91
	Deaths from Circulatory Disease (2016-2020)	90	82	50	82	124	64	38	118	118	68	64	50	93
	Deaths from Coronary Heart Disease (2016-2020)	115	157	113	131	107	68	91	131	131	61	68	113	128
Respiratory disease	Emergency Hospital Admissions for COPD (2016/17-2020/21)	163	95	67	82	176	37	24	130	130	81	37	67	75

	Deaths from Respiratory Diseases (2016-2020)	108	129	59	55	99	64	63	90	90	68	64	59	78
Mental health	Emergency Hospital Admissions for self-harm (2016/17-2020/21)	130	88	48	139	139	153	44	131	131	114	153	48	120

Wards which are projected to have an increased future heatwave risk in comparison to current heatwave risk include Barton and Sandhills, Witney Central and Witney South. Barton and Sandhills which already have high health indicator ratios, with the projected increase in heatwave risk in future may exacerbate physical and mental health conditions such as cardiovascular diseases, respiratory diseases and mental health conditions. The Northfield Brook ward also have some of the highest health indicators-related ratios, but the risk of future heatwave is not expected to increase as much as in the case of Barton and Sandhills.

The wards with lowest health indicators-related ratios are Cutteslowe & Sunnymead and Summertown whose future risk of heatwave is not significant considering others wards at higher risk e.g. Barton and Sandhills.

Additional health indicators for Oxfordshire

A few additional health-related indicators are also provided below, including:

- Severe mental health
- Suicide rates
- Overall diabetes prevalence

Mental health and suicide rates

Higher temperatures are associated with greater risk of adverse mental health outcomes, including suicide, self-harm, and alcohol/drug misuse. During previous heatwaves in the UK, increases in suicide rates have been observed[199].

Severe mental health for the whole of Oxfordshire CCG in 2020/21 presented a value of 21 people per 100,000 which is lower compared to the value for England of 24.2 per 100,000 population[200].

Suicide standardised rates between 2001 and 2021 across Oxfordshire district councils have overall decreased over the last few years[201] as shown in Figure 4-19 with the main decrease noted for Oxford city council.

Figure 4-19 - Suicide rate for each Oxfordshire districts (2001-2021)

Diabetes

Figure 4-20 shows overall diabetes prevalence in Oxfordshire from 2015 up to 2020 and including projections to the years of 2025, 2030 and 2035[202].

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[199] Adverse Weather and Health Plan Supporting evidence
[200] Severe Mental Illness - Data - OHID (phe.org.uk)
[201] Public health profiles - OHID (phe.org.uk)
[202] Diabetes prevalence estimates for local populations - GOV.UK (www.gov.uk)

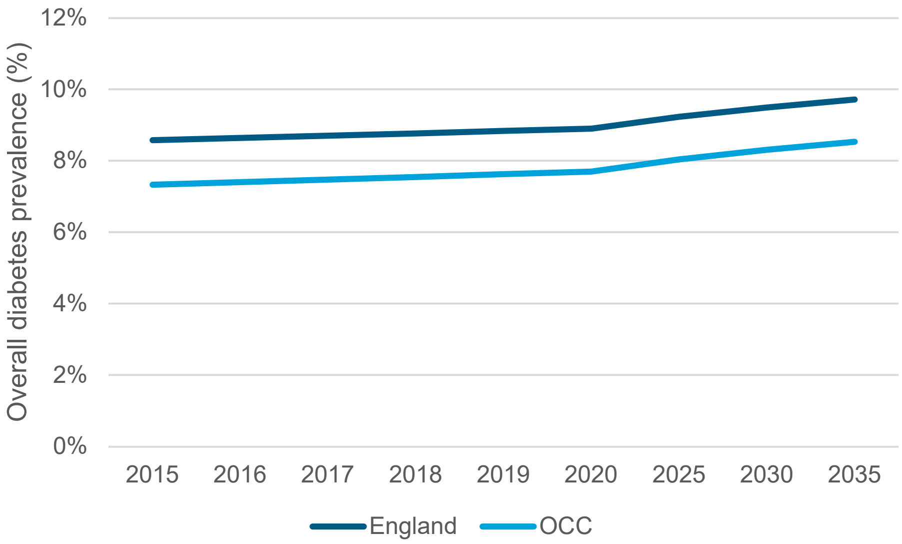


Figure 4-20 – Overall diabetes prevalence in Oxfordshire and England including projections (2015-2035)

Community preparedness and health

Community preparedness, in the form of social capital, is vital for developing resilience plans that can reduce the shocks from climate-related events. In addition, a community can contribute greater physical and financial resources to prepare for climate-related events and achieve greater responsive resilience. Such resilience can come in the form of psychological support, beneficial for mental health[203]. Resilience plans must not only focus on demographic factors, such as health and age, and physical defences, such as flood management assets, but also address social factors such as income disparity[204].

Community preparedness is vital to understand the needs of the members of the community so that resilience plans can be inclusive[203].

After a climate-related event, populations face both the direct impacts of the event, but also the indirect effects such as a reduced access to necessities, including water, food and shelter, and also a change in crime, education and employment. A reduced access to these resources can impact both mental and physical health, so having a more resilient community that is able to respond effectively is vital to maintaining a healthier community[204].

It is also important for community to prepare for long term climate events. For example, by encouraging communities to source and eat locally, this can improve a community's social and economic resilience to climate change, whilst encouraging healthy eating and well-being[204].

[203] Building community resilience in a context of climate change: The role of social capital | Ambio (springer.com)
[204] Community resilience to climate change: an evidence review | JRF

4.2.3. Summary of climate risk to Health, Communities, and the Built Environment

A summary of future climate risks to health, communities and the built environment in Oxfordshire is presented in Table 4-10. Key areas of CCRA3 risks are outlined to frame the previous assessment of climate-hazards to score each climate-hazard by CCRA3 risk area, for both the current and future under +2°C and +4°C warming by 2100 scenarios. Current progress on OCC adaption-related policies is also shown from the current risk section 3, to demonstrate key gaps in progress for each CCRA3 theme.

Based on the analysis presented previously and summarised in the table below, the greatest current risks identified in Oxfordshire are heatwaves and flooding which scored a high risk followed by drought which scored as medium risk. Health and communities are highly vulnerable to these events, which can pose a threat to the physical and mental health of vulnerable groups such as the elderly, children, and those with disabilities. For example, the impact of extreme heat leading to excess heat deaths and the inability of people to work or undertake day to day activities outside. It is noted that the areas that experience the highest health inequalities are also in the areas most at risk of extreme heat. Flooding can result in the spread of disease and cause substantial damage to homes and businesses. A reduction in the risk of low temperatures in the future does present an opportunity to lessen the impact of cold-related issues such as influenza in winter and the need to heat buildings in extreme cold. Cascading risks are unknown due to the lack of available information to support the current and future risk analysis of interacting climate-hazards.

Under future scenarios heatwaves are the highest risk increasing from high to very high followed by flooding which remains high across all relevant CCRA3 risks. Low temperature risk reduces to a low risk and drought increases to a high risk. This suggests that the expected future increase in heatwave and drought risk and prevailing high risk of flooding presents a key adverse impact on health, communities, and the built environment in future.

Table 4-10 – Summary of future climate risks to health, communities and built environment in Oxfordshire

Thematic Area	Relevant CCRA3 risks[205]	Climate-related hazard	Current risk assessment	Future risk Assessment (2050 on a pathway to +2°C and +4°C by 2100')		Current progress on OCC adaptation-related policy and plans
				+2°C	+4°C	
Health, communities, and the built environment	**Health** Risks to health and wellbeing from high temperatures (H1) Risks to people, communities, and buildings from flooding (H3) Risks to health and wellbeing from changes in air quality (H7) Risks to health from vector-borne diseases (H8) Risks to health and social care delivery (H12) Risks to health from poor water quality and water supply interruptions (PB13,14)	Flooding	H	H	H	
		Heatwave	H	VH	VH	
		Low temperatures	M	L	L	
		High winds and storms	L	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	
	Towns and cities	Flooding	H	H	H	

[205] As presented in the CCC Adaptation Progress Report: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

	Risks to health and wellbeing from high temperatures (H1) Risks to people, communities, and buildings from flooding (H3)	Heatwave	M	H	H	
		Low temperatures	L	L	L	
		High winds and storms	L	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	
	Community preparedness Risks and opportunities to health and wellbeing from high temperatures (H1, H2) Risks to people, communities and buildings from flooding (H3) Risks to cultural heritage (H11) Risks and opportunities from climate change to landscape character (N18)	Flooding	H	H	H	
		Heatwave	H	VH	VH	
		Low temperatures	L	L	L	
		High winds and storms	L	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	

Key | *A full description of the classifications used can be found in Appendix A*

Risk assessment	Low risk (L)	Medium risk (M)	High risk (H)	Very high risk (VH)	Risk unknown (U)	Not applicable (N/A)
Progress on policies and plans	Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans		

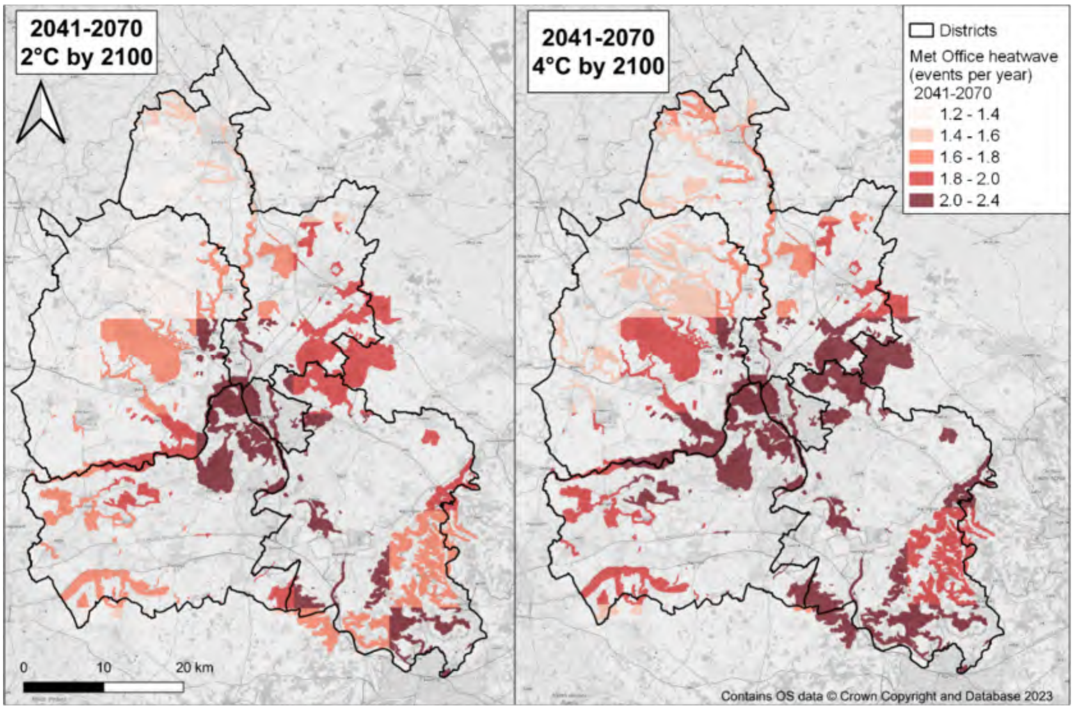
4.3. Natural environment and assets

To understand the future impact of climate-related hazards to the natural environment and assets, future hazards were identified for key targeted environmental assets, including Conservation Target Areas[206], Local Wildlife Sites[207] and grassland, woodland and arable land[208]. An assessment of future risk was completed for further key relevant climate-related hazards.

4.3.1. Heatwave

The natural environment is particularly vulnerable to heatwaves which can create conditions for wildfires and droughts, which can damage important and rare habitats and species[209].

Future Met Office defined heatwave events per year within proposed and current Local Wildlife sites and Conservation Target Areas are presented in Figure 4-21. Across the majority of the county there is an increase in heatwave events per year by 2041-2070 under the pathway to +4°C by 2100 than the pathway to +2°C by 2100 within conservational important areas. Likewise, future Met Office defined heatwave events per year within woodland, arable and grassland land use increase between a pathway to +2°C by 2100 and pathway to +4°C by 2100. This is particularly true in the south-west of Oxfordshire.



[206] Ecological networks | Thames Valley Environmental Records Centre (tverc.org) and Local Wildlife Sites | Thames Valley Environmental Records Centre (tverc.org)
[207] Ecological networks | Thames Valley Environmental Records Centre (tverc.org) and Local Wildlife Sites | Thames Valley Environmental Records Centre (tverc.org)
[208] Marston, C., Rowland, C. S., O'Neil, A. W., & Morton, R. D. (2022). Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A
[209] Ecological networks | Thames Valley Environmental Records Centre (tverc.org) and Local Wildlife Sites | Thames Valley Environmental Records Centre (tverc.org)

Figure 4-21 - Met office heatwave events under future scenarios for areas assigned as proposed or current Local Wildlife Sites or Conservation Target Areas[210][211]

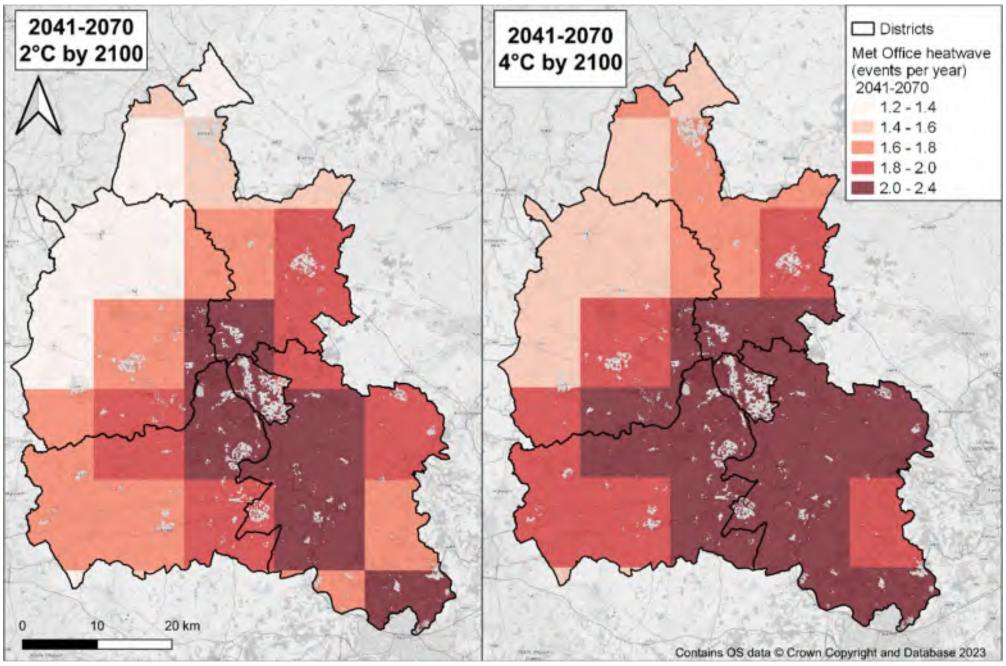


Figure 4-22 – Met office heatwave events under future scenarios for areas assigned as woodland, arable and grassland land use[212]

High temperatures are likely to impact on food production. Dairy cattle heat stress days per year for the 2050s is presented in Figure 4-23. Days per year where cattle are considered heat stressed is expected to increase from current levels in all local authorities across Oxfordshire. This increase in heat stress for livestock is particularly prominent under a +4°C by 2100 warming scenario, especially for the southern local authorities Oxford, Vale of White Horse and South Oxfordshire.

[210] Ecological networks | Thames Valley Environmental Records Centre (tverc.org) and Local Wildlife Sites | Thames Valley Environmental Records Centre (tverc.org)
[211] Climate Risk Indicators (uk-cri.org)
[212] Product Form - UKCP (metoffice.gov.uk) and Marston, C., Rowland, C. S., O'Neil, A. W., & Morton, R. D. (2022). Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A

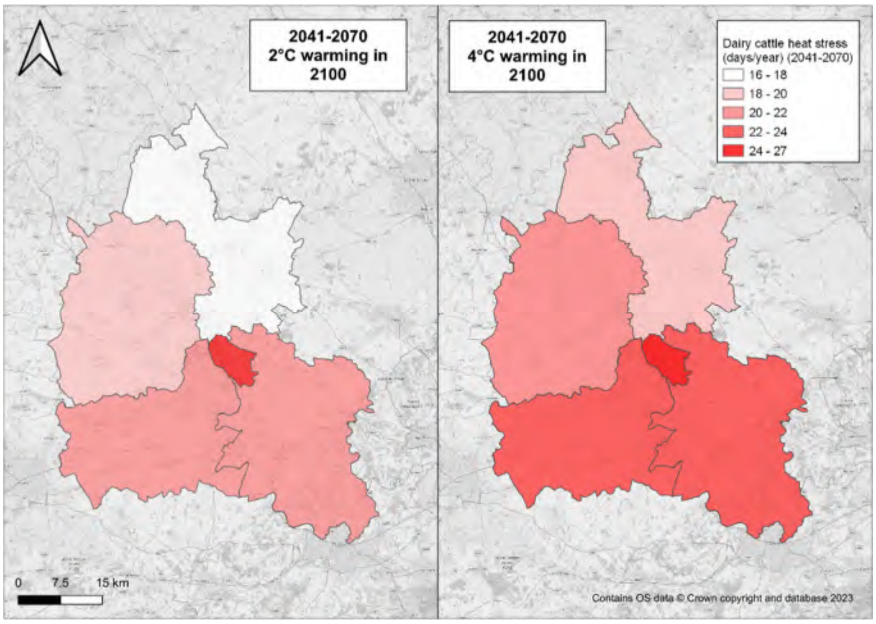
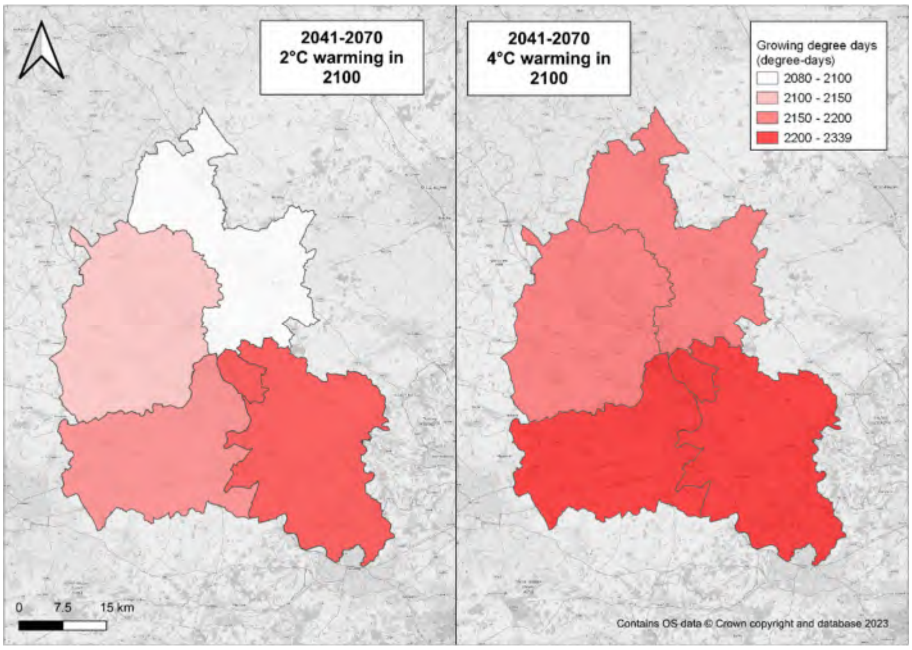


Figure 4-23 - Dairy cattle heat stress in future[213]

Growing degree days for Oxfordshire have also been assessed for the 2050s. Growing degree days provide an understanding of the duration of crop growth duration, which is indicative of greater yield as greater temperatures result in the growing season starting earlier leading to a longer growing season[214]. Growing degree days increase from current levels across both future scenarios, especially a +4°C by 2100 warming scenario for southern local authorities (Figure 4-24). This increase may increase potential productivity for crops such as wheat, barley and for grassland[215]. However, drought conditions in future alongside higher temperatures may prevent increased yield of other crop types such as wheat and potatoes.[216]



[213] Climate Risk Indicators (uk-cri.org)
[214] The effect of climate change on agro-climatic indicators in the UK | SpringerLink
[215] The effect of climate change on agro-climatic indicators in the UK | SpringerLink
[216] The effect of climate change on agro-climatic indicators in the UK | SpringerLink

Figure 4-24 - Growing degree days in future[217]

4.3.2. Flooding

Flooding can have an impact on the natural environment, particularly regarding flooding of arable land and disruption to agriculture activities. Flooding can also increase soil runoff and erosion and force the migration of species. Area at high risk of flooding have been outlined in the current risk assessment in section 3.1.3.1and 3.2.3.1, and in the future risk assessment in section 4.1.1 and 4.2.1.1. Flooding is expected to increase in 2050, primarily in area in proximity to rivers and towns and cities.

4.3.3. Wildfire

Extreme temperatures can result in increased wildfire risks in the natural environment[218]. Wildfires can also result in loss of natural carbon stores such as trees and peatland. Wildfires are projected to increase in number and severity in the future. Figure 4-25 presents the number of days per year where the Met Office defined Fire Danger Index is expected to be at least 'Very High'[219] by 2050 under +2°C and +4°C warming in 2100 scenarios. An increase is expected for all of Oxfordshire compared to the baseline and an even greater increase in 'Very High Fire Danger' (as classified by the Met Office) is expected in 2050 under a +4°C warming in 2100 scenario for all local authorities except Cherwell.

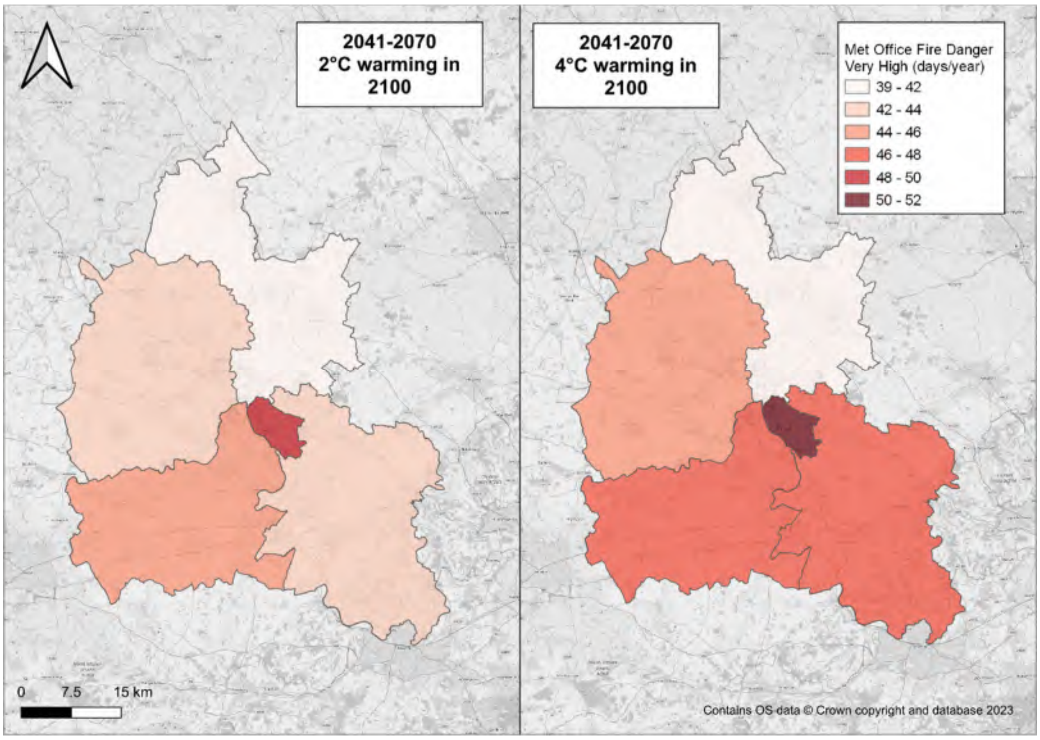


Figure 4-25 - Met Office Fire Danger events in future[220]

4.3.4. Drought

Drought can create an adverse environment for wildlife, agriculture, and forestry by impacting on crops and other vegetation growth[221]. Lower water levels can also negatively impact the health of ecosystems and their

[217] Climate Risk Indicators (uk-cri.org)
[218] CCRA-Evidence-Report-England-Summary-Final.pdf (ukclimaterisk.org)
[219] Fsi - Met Office
[220] Climate Risk Indicators (uk-cri.org)
[221] Lobley, M. and Wheeler, R. (2021) Managing extreme weather and climate change in UK agriculture: Impacts, attitudes and action among farmers and stakeholders, *Climate Risk Management*, Volume 32, https://doi.org/10.1016/j.crm.2021.100313

ability to function[222]. Drought is expected to become more likely in the future, with a decrease in summer rainfall expected[223]. Soil moisture deficits are projected to increase across Oxfordshire in 2050 as outlined in section 4.1.5, indicative of intensified drought conditions in future.

4.3.5. Cascading risks

The risks from drought and flooding on agriculture may result in food-borne diseases[224]. Cascading risks on the natural environment and assets may also include risks to species and habitats from new species colonisation if baseline temperature and rainfall change. In addition, land for agriculture or forests may be no longer suitable resulting in die back of vegetation and crops due to forecasted higher temperatures and increased flooding in future.

[222] https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf
[223] HEADLINE_FINDINGS (metoffice.gov.uk)
[224] https://www.gov.uk/government/news/government-publishes-uks-third-climate-change-risk-assessment

4.3.6. Summary of climate risk to Natural Environment and Assets

A summary of future climate risks to the natural environment and assets in Oxfordshire is presented in Table 4-11. A summary of future climate risks to the natural environment and assets in Oxfordshire is presented in Table 4-11. Key areas of CCRA3 risks are outlined and assessed using the preceding analysis based on current and future scenarios of relevant Climate Risk Indicators on the Natural Environment and Assets. This frames the previous assessment of climate-hazards to score each climate-hazard by CCRA3 risk area, for both the current and future under +2°C and +4°C warming by 2100 scenarios. Current progress on OCC adaption-related policies is also shown from the current risk section 3, to demonstrate key gaps in progress for each CCRA3 theme.

Based on the analysis presented previously and summarised in the table below, the highest current risks to natural environment and assets are flooding, heatwave, wildfire, and drought, which all score a medium risk. The natural environment and assets are particularly vulnerable to these climate-related hazards due to the impact of flooding on arable land impacting on the ability to pursue farming activities, higher temperatures leading to biodiversity loss, wildfire destroying habitats and drought adversely impacting crop yield and the ability of ecosystems to function.

Under future scenarios flood risk remains medium across all CCRA3 risks, heatwave and wildfire risk increases to high/very high and drought risk increases to high risk. Evidently, the impact of extreme heat and drought, and as a result wildfire, will have the greatest impact in the future on natural environment and assets in Oxfordshire.

Table 4-11 – Summary of future climate risks to natural environment and assets in Oxfordshire

Thematic Area	Relevant CCRA3 risks[225]	Climate-related hazard	Current risk assessment	Future risk Assessment (2050s on a pathway to +2°C and +4°C by 2100')		Current progress on OCC adaptation-related policy and plans
				+2°C	+4°C	
Natural environment and assets	**Nature** Risks to terrestrial habitats and species (N1, N2, N3) Risks to soils (N4) Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions (N5) Risks to freshwater habitats and species (N11, N12) Risks and opportunities to landscape character (N18)	Flooding	M	M	M	
		Heatwave	M	H	VH	
		Low temperatures	L	L	L	
		Wildfire	M	H	VH	
		High winds and storms	L	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	
	Working land and forestry Risks to soils (N4)	Flooding	M	M	M	
		Heatwave	M	H	VH	

[225] As presented in the CCC Adaptation Progress Report: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

	Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions (N5) Risks to agriculture and forestry (N6, N7, N8, N9) Risks to aquifers agricultural land (N10)	Low temperatures	L	L	L	
		Wildfire	M	H	VH	
		High winds and storms	L	U	U	
		Drought	M	H	H	
		Cascading	U	U	U	

Key *A full description of the classifications used can be found in Appendix A*

Risk assessment	Low risk (L)	Medium risk (M)	High risk (H)	Very high risk (VH)	Risk unknown (U)	Not applicable (N/A)

Progress on policies and plans	Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans

4.4. Business and industry

To understand the future impact of climate change on Business and Industry in Oxfordshire identified in section 3.4, an assessment of future risk was completed for key climate-related hazards.

4.4.1. Flooding

Flooding can cause substantial damage to buildings and industry, damaging sites and causing a loss in productive time. Flooding has been assessed through risk mapping in section 4.2.1.1, highlighting particularly high future flood risk in proximity to rivers in Oxfordshire, in particular in Abingdon, Witney and Oxford where the River Thames and River Windrush run through.

Industries in proximity to potential fluvial flooding include research and innovation such as Science Vale in proximity to Abingdon and Oxford City life sciences sectors. Agriculture will also be impacted in rural locations, affecting crop growth cycles.

4.4.2. Heatwave

The impact of heatwave across Oxfordshire in future is presented in section 4.2.1.2. Future heatwave risk is expected to increase across all of Oxfordshire especially urban areas. This will impact worker productivity, especially on those who work outdoors[226].

Winter rainfall is projected to increase in Oxfordshire and summer rainfall projected to decrease by 2050[139,227]. An increase in soil moisture deficit is projected across Oxfordshire by 2050, as outlined in section 4.1.5, suggesting an increased likelihood of drought condition in future.

Drought and water scarcity is likely to impact on businesses as water is needed for a multitude of industries including farming and manufacturing nationally[228].

4.4.3. Transition risks

Transition risks consider how the transition to Net Zero alters the risks from climate change[229]. The transition to Net Zero may change the characteristics of things that are affected by climate change, for example, the energy network transitioning to renewable sources and greater reliance on electricity for electric vehicles.

In Oxfordshire, transition risks which may impact on the county include the risks to businesses and industries as policies change in accessing capital and changing demands for goods and services. For example, an increase in the use of electricity, will result in a greater level of risk from climate-related hazards impacting electrical networks, such as high winds and storms and heatwaves.

4.4.4. Cascading risks

Climate hazards can result in cascading risks that impact assets, operations and utilities within businesses and industries. This is particularly true of high winds and storms and low temperatures, which impact transport networks, supply chain disruption, ICT infrastructure and telecommunications which in turn impact multiple sectors which are reliant on these networks. Winter storms are likely to increase in frequency in future, whereas temperatures are expected to broadly increase across the county in future which present an opportunity to reduce cascading risks associated with low temperatures[230].

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226 https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf
227 HEADLINE_FINDINGS (metoffice.gov.uk)
228 https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf
229 Independent-Assessment-of-UK-Climate-Risk-Advice-to-Govt-for-CCRA3-CCC.pdf (theccc.org.uk)
230 Met Office (2019) *UKCP18 Factsheet Wind,* Available at: ukcp18-fact-sheet-wind_march21.pdf

4.4.5. Summary of climate risk to Business and Industry

A summary of future climate risks to business and industry in Oxfordshire is presented in Table 4-12. Key CCRA3 risks are outlined below and assessed according to the preceding assessment to score current and future risk, under +2°C and +4°C warming by 2100 scenarios, posed by climate-related hazards. Current progress on OCC adaption-related policies is also shown from the current risk section 3, to demonstrate key gaps in progress for each CCRA3 theme.

The greatest current risk identified, as a result of all previous analysis and literature review is for flooding, heatwave and drought, which score a medium to high current risk. Low temperatures and high winds and storms remain not applicable due to the lack of defined CCRA3 risk in relation to these climate-related hazards. Cascading risks remain uncertain due to the lack of available information to decipher the current risk of interacting climate-hazards. Business and industry are particularly vulnerable to flooding, heatwave and droughts due to the flooding of sites, impact on workers ability to be productive due to high temperatures and the impact of water scarcity on specific areas such as the manufacturing sector.

Under future scenarios flood risk is expected to remain high, drought risk is expected to increase to high across all relevant CCRA3 risks and heatwave risk increases to a high to very high risk level. Therefore, key considerations will need to be made for business and industry in targeting resilience efforts towards these key climate-related hazards to prevent the adverse effect on workers and economic cost on businesses and industry.

Table 4-12 – Summary of future climate risks to business and industry in Oxfordshire

Thematic Area	Relevant CCRA3 risks to OCC[231]	Climate-related hazard	Current risk assessment	Future risk Assessment (2050 on a pathway to +2°C and +4°C by 2100') +2°C	Future risk Assessment (2050 on a pathway to +2°C and +4°C by 2100') +4°C	Current progress on OCC adaptation-related policy and plans
Business and industry	**Business** Risks to business from flooding (B1) Risks to businesses from water scarcity (B3) Risks to business from reduced employee productivity (B5) Risks to business from disruption to supply chains and distribution networks (B6)	Flooding	H	H	H	
		Heatwave	M	H	VH	
		Low temperatures	N/A	N/A	N/A	
		High winds and storms	N/A	N/A	N/A	
		Drought	M	H	H	
		Cascading	U	U	U	

Key *A full description of the classifications used can be found in Appendix A*

Risk assessment					
Low risk (L)	Medium risk (M)	High risk (H)	Very high risk (VH)	Risk unknown (U)	Not applicable (N/A)

Progress on policies and plans			
Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans

231 As presented in the CCC Adaptation Progress Report: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

4.5. Preparing for unpredictable extremes

While most climate change risk assessments adopt a scenario approach based on futures typically with +2°C to +4°C warming, it is good practice in risk assessment[232] and climate change adaptation to consider the implications of 'unpredictable extremes[233].' These low-likelihood high-impact scenarios are plausible but extreme outcomes that are associated with the 'high-end' of RCP8.5 scenarios. These include the types of chronic changes or extreme events that would cause significant harm, damage, and disruption in the UK. These scenarios may be linked to tipping points in the global climate system such as changes in ocean circulation, which could be triggered by much lower rates of global warming. A recent review considered 9 climate tipping points and found that 6 of these become far more likely once warming exceeds 1.5˚C[234].

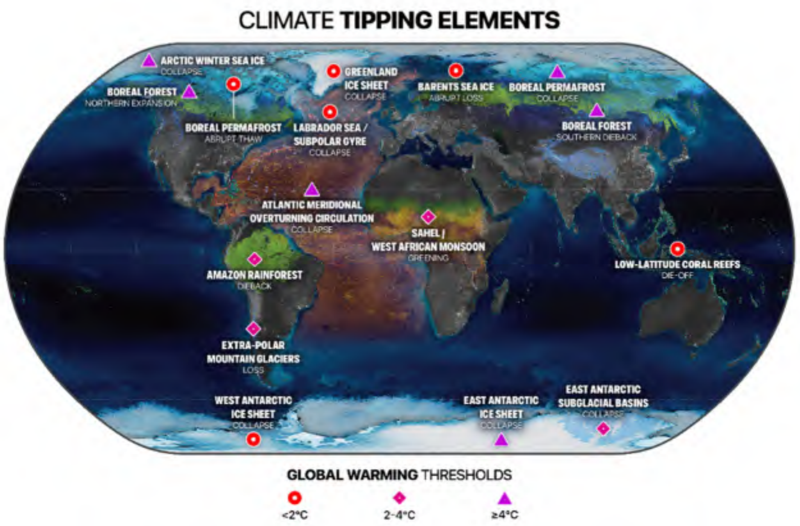

Figure 4-26 - Global climate tipping elements[235]

There are several climate tipping points that would directly have an impact on extreme temperatures and rainfall in the UK. These include enhanced long-term warming due to higher emissions, stronger carbon cycle feedbacks and greater climate sensitivity than assumed in current models. Another is the impact of more rapid reduction in changes in aerosols emissions in Asia that could accelerate warming by around 0.5°C higher by the 2050s.

Other high impact scenarios, related to volcanic eruptions or ocean circulation change could reduce the rate of warming by several degrees in the UK. For this assessment we consider the upper 90th percentile of the UKCP18 RCP8.5 probabilistic scenarios or highest impact from the Regional Climate Models or Local Climate Models. The high UK temperatures observed in July 2022 were a high-end scenario that was evident at the margins of UKCP18 projections for 2022 under RCP8.5; future temperature extremes may be much higher or longer in duration. Further details on high impact storylines will be published by the UK Climate Resilience Programme later this year[236].

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[232] Preparing for extreme risks: Lords committee report - House of Lords Library (parliament.uk)
[233] 'Prepare for unpredictable extremes' is one of the Climate Changes Committee's Ten Principles of Good Adaptation presented in the CCRA3.
[234] Exceeding 1.5°C global warming could trigger multiple climate tipping points (science.org)
[235] Exceeding 1.5°C global warming could trigger multiple climate tipping points (science.org)
[236] High impact scenarios for the UK (webinar) - (ukclimateresilience.org)

The number of heatwaves per year under extreme scenarios compared to the +2°C and +4°C by 2100 warming scenarios used in the previous future risk assessment can be viewed in Table 4-13 below. Evidently, the extreme scenario of UKCP18 RCP8.5 probabilistic scenario results in 6.1 heatwave events per year by 2086, compared to 2.2 and 4.3 events per year for a median of the +2°C and +4°C warming by 2100 scenarios.

Table 4-13 – Met Office heat wave events per year in Oxfordshire under extreme scenario (RCP8.5, 90th percentile) versus +2°C and +4°C by 2100 scenarios[237]

Year	**+2°C by 2100** (heatwave events per year)		**+4°C by 2100** (heatwave events per year)		**RCP8.5** (heatwave events per year)	
	Median / 50th percentile	90th percentile	Median / 50th percentile	90th percentile	Median / 50th percentile	90th percentile **High-end scenario**
2016	1.1	1.4	1.0	1.3	1.1	1.4
2026	1.4	1.8	1.2	1.7	1.3	1.9
2036	1.7	2.2	1.5	2.1	1.8	2.6
2046	1.8	2.5	1.8	2.7	2.3	3.4
2056	1.9	2.9	2.1	3.7	2.9	4.6
2066	2.0	3.2	2.7	4.4	3.6	5.3
2076	2.2	3.4	3.5	4.6	4.2	5.8
2086	2.2	3.7	4.3	5.1	4.8	6.1

4.5.1. The unseen risk of extreme temperatures in Oxfordshire

The heatwave in July 2022 was regarded as unprecedented as maximum temperatures exceeded 40°C in a large area of the south and east of England, with the highest temperature of 40.3°C recorded at Coningsby in Lincolnshire. Temperatures in Oxfordshire were close to this maximum and records were exceeded in Oxford and across the county. Oxford Radcliffe Observatory[238] (ORO) recorded a maximum temperature of 38.1°C on 19th July, 1.6°C higher than the previous record set in 2019. Nearby at Headington Quarry 39.7°C was recorded and a number of sites across Oxfordshire reported in excess of 40°C[239] but the data are yet to be verified by the Met Office.

An analysis of the ORO data and climate model attribution studies shows that the chance of very high temperatures in Oxfordshire is much higher than previously assumed.

- Maximum temperatures are increasing at a greater rate than average temperatures in Oxford; our analysis shows an increase of 2.3°C in maximum temperatures between 19th century and last decade compared to around 1.2°C in average temperatures[240] (Figure 4-26).

[237] Climate Risk Indicators (uk-cri.org)
[238] ORO, which is operated by University of Oxford has recorded temperatures since 1815 and provides open data to assess local climate change https://www.geog.ox.ac.uk/research/climate/rms/reports.html
[239] Based on a review of live observations 19th July 3pm Met Office WOW - Home Page
[240] Atkins analysis of ORO time series based on differences between 2003-2022 and 1891-1900 periods (20 year blocks), using trends analysis to focus on the climate change signal rather than natural variability.

- In any given year, there is now a 1% chance of exceeding 38.7°C in Oxford and around 0.5% chance of exceeding 40°C (based on observations), which is higher than reported in the UKCP18 probabilistic extremes but similar to the results of more recent climate model attribution studies[241] (Figure 4-27).
- Maximum temperatures will be greatest in urban areas with limited green space. In fully urbanised areas night-time maximum temperatures are likely to be 4°C higher than the surrounding countryside[242].
- Increased levels of morbidity and mortality can be anticipated when maximum temperatures exceed 24°C [243]. In Oxfordshire some 283 people have died due to excess heat between 2016-2022, with 65 deaths attributed in 2022 across 5 hot periods[244]. Risks are strongly linked to vulnerability and exposure factors (see heatwave mapping).
- Increased high temperatures could lead to trebling of health and productivity impacts[245] and are compounded by poor air quality, high pollen levels and buildings that are not equipped to deal with high temperatures.

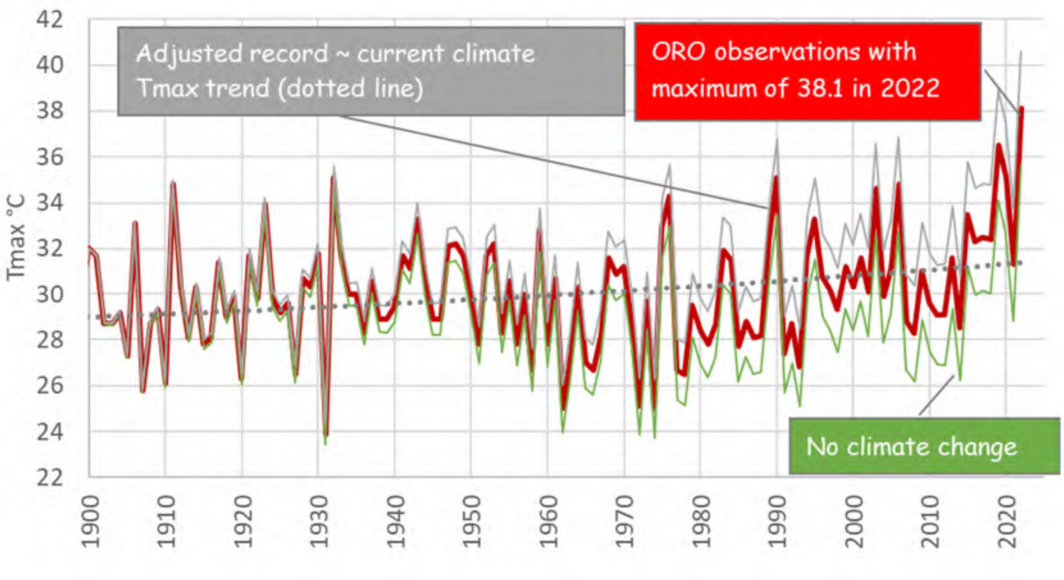


Figure 4-27 – Maximum temperature observations showing the historic 20th century climate (red) and alternative time series with no climate change (green) and de-trended to represent the 2020s climate with climate change (grey)

[241] UK and Global extreme events – Heatwaves - Met Office & Chances of 40°C days in the UK increasing - Met Office & Climate study backs up Met Office research | Official blog of the Met Office news team
[242] Atkins analysis for National Trust ref:
[243] Masselot et al., 2023 Excess mortality attributed to heat and cold: a health impact assessment study in 854 cities in Europe, The Lancet Planetary Health, Volume 7, Issue 4, 2023, Pages e271-e281, ISSN 2542-5196, https://doi.org/10.1016/S2542-5196(23)00023-2.
[244] ONS Excess mortality during heat-periods: 1 June to 31 August 2022. Co-produced with Health Protection Agency
[245] Risks to health, wellbeing and productivity from overheating in buildings - Climate Change Committee (theccc.org.uk)

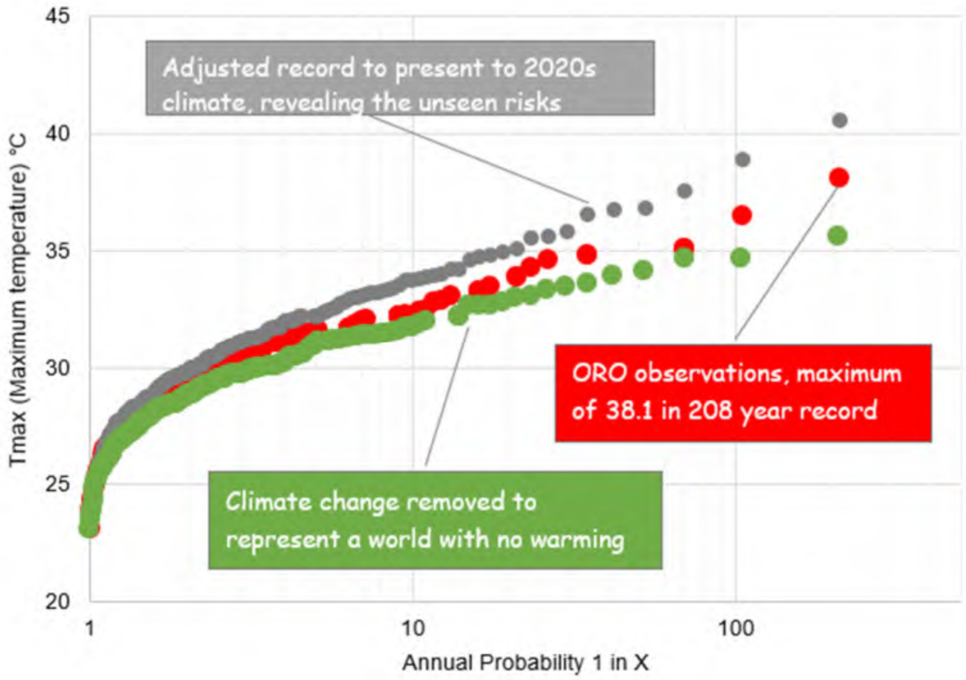


Figure 4-28 – Extreme value analysis of three alternative datasets of maximum temperature

5. Conclusions

This report provides an overview of the current and future risk from climate-related hazards in Oxfordshire. Various methods have been used to conduct this assessment including climate hazard and risk mapping of flooding and heatwave events, mapping of Climate Risk Indictors, qualitative research, stakeholder engagement with the CSGM and quantitative analysis of climate modelling data.

A summary risk score table is presented below which outlines the overall assessment of current and future risk for each of the four key thematic areas of greatest importance to Oxfordshire: critical infrastructure; health, communities, and the built environment; natural environment and assets; and business and industry. The table below summarises individual assessments of relevant CCRA3 risks presented in sections 4.1.7, 4.2.3, 4.3.6 and 4.4.5 for each thematic areas. Current and future risk have been classified from low to very high in order to present an understanding of the level of risk and provide a visual overview of where actions should be targeted to improve climate adaptation and resilience.

Currently, the greatest risk from climate-related hazards in Oxfordshire is flooding, heatwaves and droughts which overall, have been scored from medium to high risk based on available evidence and data. This is primarily due to the location of many settlements in Oxfordshire within proximity of rivers (such as Oxford, Abingdon, and Witney), the increase in temperatures in the last century, and previous drought events in the county.

In future, flooding risk remains at a medium to high risk level and, even though winter rainfall is expected to increase in Oxfordshire, there is uncertainty in changes in return periods in future flooding. Heatwaves are expected to become more frequent in the future and overall temperatures are projected to increase, posing a high to very high risk level across Oxfordshire particularly under a 4°C warming by 2100 future scenario. This in turn, will impact on future drought events although its specific impacts will vary between the four thematic areas (particularly within sub-thematic areas).

Low temperatures are expected to become a lower risk in the future, due to projected increase in temperature across Oxfordshire. This provides an opportunity for reduced adverse impacts associated with low temperatures, such as health impacts and damage or disruption to transport and energy networks. Future changes to the risk of high winds and storms and cascading risks remain uncertain due to lack of available data to make an assessment.

Table 5-1 - Summary of current and future risk assessment by key thematic area

Thematic Area	Climate-related hazard	Current risk	Future risk assessment	
			+2°C	+4°C
Critical infrastructure	Flooding	H	H	H
	Heatwave	M to H	H to VH	VH
	Low temperatures	L	L	L
	High winds and storms	L to M	U	U
	Drought	L to M	L to H	L to H
	Cascading	U	U	U

Thematic Area	Climate-related hazard	Current risk	Future risk assessment	
			+2°C	+4°C
Health, communities and built environment	Flooding	H	H	H
	Heatwave	M to H	H to VH	H to VH
	Low temperatures	L to M	L	L
	High winds and storms	L	U	U
	Drought	M	H	H
	Cascading	U	U	U
Natural Environment and Assets	Flooding	M	M	M
	Heatwave	M	H	VH
	Low temperatures	L	L	L
	Wildfire	M	H	VH
	High winds and storms	L	U	U
	Drought	M	H	H
	Cascading	U	U	U
Business and Industry	Flooding	H	H	H
	Heatwave	M	H	VH
	Low temperatures	N/A	N/A	N/A
	High winds and storms	N/A	N/A	N/A
	Drought	M	H	H
	Cascading	U	U	U

Key

Low risk (L)	Medium risk (M)	High risk (H)	Very high risk (VH)	Risk unknown (U)	Not applicable (N/A)

Note: Risks showing more than one classification (e.g., L to M) represent the range of scores given within that theme. In such instances, the colour showed represent that of the lowest scoring risk.

Following this assessment of current and future risk posed by climate-related hazards, targeted adaptation activities will need to be enhanced and/or planned and put in place at a fast pace in order to adequately support building Oxfordshire's resilience to climate change and prepare its communities, critical infrastructure, businesses, and the natural environment for ongoing and future changes in climate. There are still gaps in evidence, and part of the adaptation response may include further work in several areas identified in Table 5-2 with a full analysis in Appendix F.

Table 5-2 – Strength of evidence and gaps for further research by theme

Risk theme	Strength of evidence	What is included in the detailed vulnerability assessment report?	Gaps for further research
Critical Infrastructure	✪✪✪✪✪	• Critical infrastructure was mapped including transport systems, power systems and major water resources features. • Flood risk assessment for surface water and river flooding mapped all assets exposed to flooding. • Extreme heat and its impacts were assessed using an innovative vulnerability mapping approach. • Local and national policies were reviewed, highlighting gaps in plans and progress in the County	• Making stronger links between local water demand, the environment and new water infrastructure • Reductions on local water demand and moving towards water neutrality for new development • Impacts of climate change on water quality in the context of limited sewage works capacity and housing growth • Risks of electricity and telecoms. infrastructure failures on communities and sectors
Health, Communities and Built Environment	✪✪✪✪✪	• Population and key indicators were mapped including indices of multiple deprivation, as well as hospitals, GP practices, care homes, schools, all building footprints, and listed buildings. • Flood and heat vulnerability mapping identified the most at-risk communities. • A more detailed assessment was completed on the health impacts of climate change, including making linkages to cardiovascular, respiratory diseases and mental health. • Local and national policies were reviewed, highlighting	• Further work on extreme heat and rainfall (ongoing) • Understanding extreme heat impacts on productivity • Evidence to support adaptation actions in a county wide heat resilience plan • Building characteristics that contribute to climate vulnerability • Benefits of property flood resilience

Risk theme	Strength of evidence	What is included in the detailed vulnerability assessment report?	Gaps for further research
		gaps in plans and progress in the County	
Natural Environment and Assets	✪✪✪✪✪	• Landscape character, land use, environmental designations etc.. were mapped. • Exposure to high temperatures was explored using selected indicators. • Local and national policies were reviewed, highlighting gaps in plans and progress in the County	• Opportunities for landscape recovery and natural flood management • Linking climate and Biodiversity Net Gain • Risks to Oxfordshire's agricultural land • Delivering nature-based solutions in urban and rural environments
Business and Industry	✪✪✪✪✪	• A higher-level narrative was provided for business and industry. • Local and national policies were reviewed, highlighting gaps in plans and progress in the County	• Gathering evidence from Climate Finance Disclosures from Oxfordshire businesses • Supply chain risks
Other aspects	✪✪✪✪✪	• An overall risk scorecard summarised the relevant CCRA3 risks and links these to hazards, baseline risk and future risks under a 2 degree and 4 degree pathway. It also summarised current OCC adaptation related policies and plans.	• Impacts of climate change on inequality in Oxfordshire • More work on interdependencies between sectors, e.g. energy and water

Appendices

Appendix A. Methodology

A.1. Database of sources

A database of available data has been created to provide a detailed understanding of the different datasets available for the project. A screenshot of the Excel database is outlined below, showing the key column headers such as the key thematic areas of relevance to OCC that the data aligns to:

- **Physical Infrastructure**: including energy, transport, telecommunications, and water infrastructure.
- **Natural Environment and Assets**: including terrestrial and freshwater environments, agriculture and forestry, landscape, and ecosystem services.
- **Health, Communities and Built Environment**: focusing on specific climate hazards (for example heat or flooding) that affect multiple sectors as well as specific policy areas (for example health systems).
- **Business and Industry**: Domestic risks to business and industry.

Purpose					Database of available data for Oxfordshire County Council (OCC) WP1			
Link to OCC screening data document					Oxfordshire County Council - screening data.docx			
ID	**Key theme**	**Data**	**Source of data**	**Type of data**	**Spatial scale**	**Temporal scale**	**Available/open source?**	**URL**
7	Health, Communities and Built Environment	UK Index of Multiple Deprivation (IMD)	Ministry of Housing, Communities and Local Government	Georeferenced	LSOA	2019	Yes	Lower Super Output Area (LSOA) IMD 2019 (OSGB1936) | Lower Super Output Area (LSOA) IMD 2019 (OSGB1936) | Ministry of Housing, Communities and Local Government (arcgis.com)
9	Health, Communities and Built Environment	Health and GP facilities	NHS	Georeferenced	Postcode	2021	Yes	GP and GP practice related data - NHS Digital
13	Health, Communities and Built Environment	Disability data	NOMIS	Database	LSOA	2021 Census	Yes	Nomis - Official Census and Labour Market Statistics - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)
15	Natural Environment and Asset	OS Open Greenspace	OS OpenData	Georeferenced	Local parks, green spaces polygon	2022	Yes	OS Open Greenspace | OS Data downloads | OS Data Hub
16	Physical Infrastructure	OS Open Roads	OS OpenData	Georeferenced	Roads - line data	2022	Yes	OS Open Roads | Vector Map Data for GIS | Free OS Data downloads
17	Natural Environment and Asset	OS Watercourse	OS OpenData	Georeferenced	Rivers - line data	2022	Yes	OS Open Rivers | OS Data downloads | OS Data Hub
18	Natural Environment and Asset	Flood Map for Planning (Rivers and Sea) - Flood Zone 2	EA	Georeferenced	Flood zone mapping - polygon	2023	Yes	Flood Map for Planning (Rivers and Sea) - Flood Zone 2 - data.gov.uk
19	Natural Environment and Asset	Flood Map for Planning (Rivers and Sea) - Flood Zone 3	EA	Georeferenced	Flood zone mapping - polygon	2023	Yes	Flood Map for Planning (Rivers and Sea) - Flood Zone 3 - data.gov.uk

The data collected is a mixture of georeferenced data (shapefiles, raster GIS files, coordinates), academic journals, reports, and Excel datasets. Common sources include the Census 2021, Defra, Environment Agency, NHS, Ordnance Survey, Insight Oxfordshire, OCC, OCC districts, Met Office and the UK Climate Resilience Programme.

Data gaps remain, notably for the understanding of the impact of climate change events such as droughts, flooding, and heatwave on physical and mental health. There is little available data to assess the impact of certain climatic hazards such as high winds in a quantitative manner. Therefore, the assessment of current and future climate risk will focus on the impact of flooding and heatwaves in Oxfordshire.

Data varies in granularity. Population characteristics for Oxfordshire is available at Lower Super Output Area (LSOA) level, primarily from the 2021 Census.

A.2. Current risk assessment mapping

Current risk to climate-related hazards have been assessed for heatwaves and flooding based on the interaction between hazard, exposure, and vulnerability to define overall risk.

Hazard + Exposure + Vulnerability = Risk

Current risk is then mapped to a hex grid, comprised of 500m resolution hex shaped grids across Oxfordshire County. The following datasets are used to define heatwave and flooding risk across Oxfordshire. It should be noted that hex grids are produced based on a hazard score for critical infrastructure. A risk score is produced only for health, communities and built environment. Natural environment and assets make use of data from the Climate Risk Indicators and HadUK observed data.

Fluvial flooding mapping presented in Appendix E, makes use of only the risk of flooding from rivers and EAD from fluvial flooding due to climate change only (weighted by the number of buildings in each hex).

Climate-related hazard	Theme	Current Risk			
		Hazard	**Exposure**	**Vulnerability**	**Mapping created**
Heatwave	Critical infrastructure	Hex grid score derived as an average of: • Cooling Degree Days (Climate Risk Indicators Climate Risk Indicators (uk-cri.org) 12km resolution, RCP6.0, 2001-2030 for a midpoint of 2015) • Urban heat island (urban/suburban land cover %) (Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A) • Greenspace % OS Open Greenspace OS Open Greenspace | Data Products | Ordnance Survey	Locations of: OCC resilient highway network (data supplied by OCC), electricity transmission networks (OS Open Zoomstack | Data Products | Ordnance Survey) and rail network (Open Rail Data · GitHub)	Policy/procedures for managing heatwaves (melting road surface, power cuts, water disruptions)	Exposure layers layered over hazard hex scoring to identify areas/infrastructure more prone to heatwaves.
	Health, communities and built environment	Hex grid score derived as an average of: • Cooling Degree Days (Climate Risk Indicators Climate Risk Indicators (uk-cri.org) 12km resolution, RCP6.0,	Hex grid score derived as an average of: • Building heights • Building count (Building Heights in Great Britain from	Hex grid score derived as an average of: • % of population under 15 (Census 2021)	Map of current heatwave risk hex grid: *Current risk = Hazard + Exposure + Vulnerability*

Climate-related hazard	Theme	Current Risk			
		Hazard	Exposure	Vulnerability	Mapping created
		2001-2030 for a midpoint of 2015) • Urban heat island (urban/suburban land cover %) (Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre. https://doi.org/10.5285/A22BAA7C-5809-4A02-87E0-3CF87D4E223A) Greenspace % OS Open Greenspace OS Open Greenspace | Data Products | Ordnance Survey	Emu Analytics (emu-analytics.net))	• % of population older then 75 (Census 2021) • % with disability under the Equality Act 2011 (Census 2021) • % rented households (Census 2021) Index of Multiple Deprivation (Ministry of Housing, Communities and Local Government 2019)	
	Natural environment and assets	• Number of days 1990-2021 when temperatures >27°C HadUK-Grid maximum air temperature at 1.5m Product From - UKCP (metoffice.gov.uk)	Hazard layer is cropped to the extent of Local Wildlife Sites (both existing and proposed) and Conservation Target Areas (TVERC Data | Thames Valley Environmental Records Centre) and woodland, arable and grassland land use (Land Cover Map 2021 (10m classified pixels, GB) [Data set]. NERC EDS Environmental Information Data Centre.)	Policy/procedures for managing heatwaves	Hazard layer cropped to 1) Local Wildlife Sites (both existing and proposed) and Conservation Target Areas, and 2) Arable, grassland and woodland land use
Flooding	Critical infrastructure	Hex grid score derived as an average of: • Risk of flooding from rivers and sea (Risk of Flooding from Rivers and Sea - data.gov.uk) • Risk of surface water flooding (ArcGIS Web Application (data.gov.uk)) • EAD for fluvial and surface water flooding due to	Locations of: OCC resilient highway network (data supplied by OCC), electricity transmission networks (OS Open Zoomstack | Data Products | Ordnance Survey) and rail network (Open Rail Data · GitHub)	Policy/procedures for improving flooding incidents	Exposure layers layered over hazard hex scoring to identify areas/infrastructure more prone to flooding.

Climate-related hazard	Theme	Current Risk			
		Hazard	Exposure	Vulnerability	Mapping created
		climate change (ukclimaterisk.org/wp-content/uploads/2020/07/Future-Flooding-Main-Report-Sayers-1.pdf) weighted by the number of buildings in each hex (Building Heights in Great Britain from Emu Analytics (emu-analytics.net)).			
	Health, communities and built environment	Hex grid score derived as an average of: • Risk of flooding from rivers and sea (Risk of Flooding from Rivers and Sea - data.gov.uk) • Risk of surface water flooding (ArcGIS Web Application (data.gov.uk)) • EAD for fluvial and surface water flooding due to climate change (ukclimaterisk.org/wp-content/uploads/2020/07/Future-Flooding-Main-Report-Sayers-1.pdf) weighted by the number of buildings in each hex (Building Heights in Great Britain from Emu Analytics (emu-analytics.net)).	Hex grid score derived as an average of: • Building heights • Building count (Building Heights in Great Britain from Emu Analytics (emu-analytics.net))	Hex grid score derived as an average of: • % of population under 15 (Census 2021) • % of population older then 75 (Census 2021) • % with disability under the Equality Act 2011 (Census 2021) • % rented households (Census 2021) • Index of Multiple Deprivation (Ministry of Housing, Communities and Local Government 2019)	Map of current flooding risk hex grid: *Current risk = Hazard + Exposure + Vulnerability*

For health, communities and built environment only each element is ranked to create an overall hazard, exposure and vulnerability score which sums up to a heatwave and flooding current risk score across a 500m hex grid in Oxfordshire. Scoring is defined as higher or lower hazard, exposure or vulnerability by the below categories.

	Hazard	Exposure	Vulnerability
Higher	**HAZARD** **Heatwave:** Higher number of cooling degree days Greater % of urban and surburban land cover (urban heat island) Lower % of green space **Flooding:** Higher risk of flooding from rivers and sea Higher risk of surface flooding Higher EAD for fluvial and surface water flooding and higher number of buildings	**EXPOSURE** **Heatwave:** Greater number of buildings Buildings at higher heights **Flooding:** Greater number of buildings Buildings at lower heights	**VULNERABILITY** **Heatwave/flooding:** Higher proportion of children, elderly, rented households, people with disabiltiies Higher population density Most deprived areas (index of multiple deprivation)
Lower	**HAZARD** **Heatwave** Lower number of cooling degree days Lower % of urban and surburban land cover (urban heat island) Higher % of green space **Flooding:** Lower risk of flooding from rivers and sea Lower risk of surface flooding Lower EAD for fluvial and surface water flooding and lower number of buildings	**EXPOSURE** **Heatwave:** Lower number of buildings Buildings at lower heights **Flooding:** Lower number of buildings Buildings at higher heights	**VULNERABILITY** **Heatwave/flooding:** Lower proportion of children, elderly, rented households, people with disabiltiies Lower population density Least deprived areas (index of multiple deprivation)

A.3. Future risk assessment mapping

To understand the change in future risk compared to the current risks, 2 scenarios were explored assuming the impact of a +2°C and +4°C warming by 2100 in the year 2050. These scenarios were used (instead of Representative Concentration Pathways 4.5 and 8.5[246]) to better align with current national assessments and studies, such as the CCRA3, which have applied these scenarios. CCRA3 states that the "the UK must adapt to a minimum average global temperature rise of between +1.5 and +2°C for the period 2050 – 2100 and consider the risks up to a +4ºC warming scenario"[247].

Flooding and heatwave hazard, vulnerability and exposure categories were rescored where future projections data was available.

Fluvial flooding mapping presented in Appendix E, makes use of only the risk of river flooding and EAD uplifts for fluvial flooding due to climate change only (weighted by the number of buildings in each hex).
The following data sources were used to produce 2050 scoring of risk for heatwaves and flooding.

[246] It should be noted that there is a fair alignment between RCP4.5. and the +2°C scenario as well as the RCP8.5 and the +4°C scenario.

[247] https://www.theccc.org.uk/wp-content/uploads/2021/07/Independent-Assessment-of-UK-Climate-Risk-Advice-to-Govt-for-CCRA3-CCC.pdf

Category	Heatwave or flooding	Current category	Future uplift applied
Hazard	Heatwave	Cooling Degree Days	UK Climate Risk Indicators Cooling Degree Days >22°C for 2050 for +2°C by 2100 and +4°C by 2100 warming scenarios.[248]
		Urban heat island (urban and suburban land cover)	CCRA3 socioeconomic database for changes in land use in England by 2050 'central scenario' based on land use category 'settlement'.[249]
		Green space	CCRA3 socioeconomic database for changes in land use in England by 2050 'central scenario' based on land use category 'grassland'.[249249]
	Flooding	Risk of flooding from rivers and sea	CCRA3 projections of future flood risk 'Expected Annual Damage' to provide uplift in return periods for fluvial flooding for 2 scenarios assuming the impact of a +2°C and +4°C warming by 2100 in the year 2050.[250] Within the CCRA climate change frequency factors are applied to estimate impacts on EAD, therefore EAD increases because assets are flooded more often. We have used the same factors to change flood frequency only.
		Surface water flood risk	CCRA3 projections of future flood risk 'Expected Annual Damage' to provide uplift in return periods for surface water flooding for 2 scenarios assuming the impact of a +2°C and +4°C warming by 2100 in the year 2050[250]
		EAD for fluvial and surface water flooding weighted by number of buildings	CCRA3 projections of future flood risk 'Expected Annual Damage' to provide uplifts in EAD assuming the impact of a +2°C and +4°C warming by 2100 in the year 2050[250]
Exposure	Heatwave / flooding	Building heights	No change as no future scenario data available
		Building concentration	No change as no future scenario data available
Vulnerability	Heatwave / flooding	% Under 15	CCRA3 socioeconomic database for population by 2050 'central scenario' for overall population and by age group at a local authority level. [249,249]
		% Over 75	
		Population density	
		% Disability	No change as no future scenario data available
		Rented households	No change as no future scenario data available
		Income deprivation	No change as no future scenario data available

Once 2050 future uplifts were calculated and where possible for 2 scenarios assuming the impact of a +2°C and +4°C warming by 2100 in the year 2050, a hazard, exposure and vulnerability scoring for heatwave and flooding were calculated. The following future risk was mapped in section 5 for each thematic area.

	Theme	Future

[248] Climate Risk Indicators (uk-cri.org)
[249] https://www.ukclimaterisk.org/wp-content/uploads/2020/07/Socioeconomic-Dimensions-database.xlsx
[250] https://www.ukclimaterisk.org/wp-content/uploads/2020/09/CCRA3-Results-Summary-External-02Sept2020.xlsx

Climate-related hazard		Hazard	Exposure	Vulnerability	Mapping to create
Heatwave	Critical infrastructure	Hex grid score (for two scenarios the impact of a +2°C and +4°C warming by 2100 in the year 2050) as an average of: • Cooling Degree Days • Urban heat island (urban/suburban land cover %) • Greenspace %	Locations of: OCC resilient highway network, electricity transmission networks and rail networks	Policy/procedures for managing heatwaves (melting road surface, power cuts, water disruptions)	Exposure layers layered over hazard hex scoring to identify areas/infrastructure more prone to heatwaves
	Health, communities and built environment	Hex grid score (2050 2 scenarios assuming the impact of a +2°C and +4°C warming by 2100 in the year 2050) derived as an average of: • Cooling Degree Days • Urban heat island (urban/suburban land cover %) Greenspace %	Hex grid score (remains as current exposure score) derived as an average of: • Building heights Building count	Hex grid score (2050 scenario) derived as an average of: • % of population under 15 • % of population older then 75 • % with disability under the Equality Act 2011 • % rented households Index of Multiple Deprivation	Map of future for the year 2050 (2 scenarios assuming the impact of a +2°C and +4°C warming by 2100 in the year 2050) heatwave risk hex grid: *Current risk = Hazard + Exposure + Vulnerability*
	Natural environment and assets	Climate Risk Indicators Met Office Heatwave events per year score (for two scenarios the impact of a +2°C and +4°C warming by 2100 in the year 2050)	Hazard layer is cropped to the extent of Local Wildlife Sites (both existing and proposed) and Conservation Target Areas and woodland, arable and grassland land use	Policy/procedures for managing heatwaves	Hazard layer cropped to 1) the extent of Local Wildlife Sites (both existing and proposed) and Conservation Target Areas and 2) arable, grassland and woodland land use

Flooding	Critical infrastructure	Hex grid score derived (2050 +2°C by 2100 and +4°C by 2100 scenarios) as an average of: • Risk of flooding from rivers and sea • Risk of surface water flooding • EAD for fluvial and surface water flooding weighted by number of buildings	Locations of: OCC resilient highway network, electricity transmission networks and rail networks	Policy/procedures for improving flooding incidents	Exposure layers layered over hazard hex scoring to identify areas/infrastructure more prone to flooding
	Health, communities and built environment	Hex grid score derived (2050 +2°C by 2100 and +4°C by 2100 scenarios) as an average of: • Risk of flooding from rivers and sea • Risk of surface water flooding • EAD for fluvial and surface water flooding weighted by number of buildings	Hex grid score (remains as current exposure score) derived as an average of: • Building heights • Building count	Hex grid score (2050 scenario) derived as an average of: • % of population under 15 • % of population older then 75 • % with disability under the Equality Act 2011 • % rented households • Index of Multiple Deprivation	Map of future flooding risk hex grid: *Current risk = Hazard + Exposure + Vulnerability*

A.4. Classifications used in this study

Progress on climate adaptation-related policies and plans in OCC were assessed based on evidence available and using the classification adopted by the CCC on their assessment report[251] on the progress of adaptation policies and plans at national level:

Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans

[251] https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

Policy milestones: • are almost entirely achieved or in place • are comprehensive and appropriately ambitious • include monitoring and evaluation	Policy milestones: • are achieved or in place for key milestones but some gaps remain • cover most important elements, could be more ambitious • include some monitoring and evaluation	Policy milestones: • are partially achieved or in place with some key milestones missing • cover some important elements, could be more ambitious • include some monitoring and evaluation	Policy milestones: • are mostly not achieved, only minor policies in place • lack important elements, do not cover key areas or lack ambition • have minimal monitoring and evaluation

The assessment of current and future risk was classified by adapting the classification used in the CCRA3 assessment report[252] as follow:

Low risk (L)	**Medium risk (M)**	**High risk (H)**	**Very high risk (VH)**	**Unknown risk (U)**	**Not applicable (N/A)**
Low likelihood with minimal disruption and damage by the hazard.	Medium likelihood of localised areas of disruption by the hazard. Hazard may cause annoyance or affect routines.	High likelihood of localised and/or widespread disruption and damage by the hazard. Hazard causes damage to infrastructure, buildings, communities, and/or wider environmental assets.	Very high likelihood, widespread disruption and damage by the hazard. Hazard causes severe damage to infrastructure, buildings, communities, and/or wider environmental assets.	There is currently a lack of data and/or there are challenges in estimating future hazard.	The hazard does not have an impact on the theme.

A.5. Study limitations

Several limitations were identified when completing the study, which primarily related to data availability including:

- Data was not available to develop the mapping of current hazards as well as their impacts on key themes. This included available data on current hazards and their impacts (e.g. storms, droughts, etc), the location of specific events on the ground, and data on the characteristics/feature of specific themes e.g. business and industry.
- Data was not available to inform a calculation of both a 2050 +2°C by 2100 and +4°C by 2100 scenarios for all hazards, exposure, and vulnerability variables. In situations where data on future hazard, exposure, or vulnerability were not available, the same data/scores attributed to those variables in the current risk assessment were used.

[252] UK Climate Change Risk Assesment 2022 (publishing.service.gov.uk)

- For vulnerability variables only a 2050 calculation was available and was not broken down to +2°C by 2100 and +4°C by 2100 scenarios. A central scenario was used for 2050 based on the CCRA3 socioeconomic database for changes in population at a local authority level for overall population and by age group[253].

[253] https://www.ukclimaterisk.org/wp-content/uploads/2020/07/Socioeconomic-Dimensions-database.xlsx

Appendix B. Current climate risk at national level

B.1. Critical infrastructure

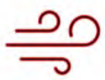
Risks and impacts	Critical infrastructure
Flooding	Fluvial flooding can pose a risk to critical infrastructure, such as railways and roads, as heavy rainfall can result in embankment and other earthworks failure. According to the CCRA3, 1691 km of railway and 450 rail stations are exposed to 1-in-30 year surface water flooding events across the UK as of 2022[63,254]. Severe weather and flooding events can have large impacts on bridges causing mass disruption, as observed after a major bridge collapsed in Tadcaster after the 2015 winter floods[63,254]. Bridge collapses can result in delays to emergency services, rupturing of pipelines and losses of fibre optics communications, directly and indirectly impacting the local economic output. Very high river flows have the potential to damage hydroelectric generation equipment.
High temperatures	High temperatures can increase thermal loading on structures, such as bridges and pavements, posing a risk to rail, road and energy infrastructure. Railway lines can buckle, and asphalt can melt which impacts transport networks including airports. Extreme heat also poses a risk to ICT infrastructure, as components may develop faults from overheating. High temperatures can also increase the demand for cooling, putting additional pressure on the electricity supply[254].
High winds and storms	High wind speeds can lead to failure of tall components of critical infrastructure such as energy transmission lines, telecoms and ICT infrastructure. As dependence on digital infrastructure grows, the impacts of outages increases. Part of the UKs energy is developed from wind turbines. To prevent mechanical damage, wind turbines are designed to stop when a wind speed threshold has been exceeded (generally around 56 mph). This means that energy generation can be reduced to near zero during periods of strong winds. This has the impact to affect to affect other systems that rely mainly on wind generated electricity[254] (see below for details on cascading failures).
Drought	Water scarcity can affect business operations and drought can result in a reduction of electricity generation from hydroelectric power (although it is worth noting that most of England's large hydro installations are located in the north). Drought can also affect other sections of the electricity supply industry since water is also required for cooling and hydrogen production. According to the CCRA3, the electricity supply industry accounted for "49% of estimated actual abstraction and 65% licenced abstraction in 2016 and 2017"[254] although most of this is non-consumptive use.

[254] https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf

	Nearly 50% of the freshwater abstracted from rivers and aquifers in England is used for the public water supply[65]. Severe drought poses a risk to household and non-household water supply, which means business operations are at risk from extreme drought and water scarcity if investment does not keep pace with climate change[254]. Shrinkage and swelling of high plasticity clays as a result of alternating drought and flood events can result in subsidence, thus impacting transport infrastructure and buried infrastructure. The south and east of England are particularly prone to subsidence due to the presence of high plasticity clays; 35% of high voltage subterranean electricity cables in England are located in areas with high susceptibility to shrink-swell subsidence[254].
Low temperatures	Snow and ice from cold temperatures can cause line faults, affecting energy transmission across the country. However, note that critical infrastructure can also benefit from a reduced risk of extreme cold events.
Cascading failures	Since infrastructure consists of a network of systems, vulnerabilities in one system can cause problems in another system. The CCRA3 reports that the risk of network failures is currently high, affecting up to millions of people per year with urban areas most at risk[254].

B.2. Health, communities, and the built environment

Risks and impacts	Health, communities, and the built environment
Flooding	Towns and cities are normally composed of impermeable materials. Whilst there may be drainage systems in place, heavy rainfall has the potential to overtop the system. The CCRA3 states that 476,000 and 976,000 people are at risk of fluvial and surface water flooding, respectively (as of 2022)[254]. Flooding and intense rain may result in increased damp, negatively affecting the building envelope and causing mould. This may result in poor living and working conditions for building occupants. In addition, gardens may flood impacting recreational land use. Flooding (and extreme heat) can result in school closures, impacting the learning opportunities of younger communities. Risks of sewer flooding due to heavy rainfall could result in poor water quality, posing a risk to health. In addition, flooding can interrupt transport links which can pose a risk to health and social care delivery[254].
High temperatures	Towns and cities are normally composed of materials that absorb and retain heat, meaning that they are typically warmer than rural areas. It is estimated that 20% of English household properties overheat, with flats and more energy efficient properties more likely to overheat[254]. High temperatures introduce health risks such as heat stress can result in heat-related mortality and morbidity. In 2022 the UK experienced a record-breaking heatwave with certain areas breaching 40°C temperatures for the first time. This corresponded with a record-breaking

	heat-related mortality in the UK. It is estimated that the South East of England will experience more heat related deaths than any other region in the UK[254]. Long periods of extreme heat can place pressure on health and social care systems as they become overwhelmed and higher temperatures may result in wildfires, which can negatively impact air quality[254]. In addition, warmer weather can increase the rate of transmission of vector-borne diseases, including dengue from mosquitos and tick-borne diseases such as Lyme disease. Similarly, higher temperatures, and greater variations in rainfall can increase the occurrence of other vectors that will affect crop and livestock production, thus impact food safety and security. Stock shortages, and thus higher prices, mean parts of the population may not consume the nutrients they require, thus impacting their health[254]. Higher temperatures during the winter months may reduce the number of cold-related deaths, thus reducing the strain on the NHS. In addition, warmer weather may increase the amount of physical activity undertaken such that physical and mental wellbeing improves. Furthermore, warmer weather could improve the production of nutritious crops, such as soya, which can further improve health[254].
High winds and storms 	High winds and storms may result in structural damage to buildings, which could impact occupants financially, and impact their health and wellbeing[254].
Drought 	Subsidence and shrink-swell caused by drought may result in structural damage to buildings, which could impact occupants financially, as well as impact their health and wellbeing. The south of England is particularly prone to subsidence[254]. Low river flows may result in poor water quality, posing a risk to health[254].
Low temperatures 	Low temperatures may directly result in illnesses. In addition, snow and frozen roads can impact access to health services[254].
Cascading failures	The risks from drought and flooding may have resultant effects on mental health[254]. Warmer weather may reduce the amount of heating required, resulting in a reduction in winter fuel poverty. However, consequently, warmer weather may increase the amount of cooling demand, resulting in summer fuel poverty which may cause adverse effects on mental health[254].

The risks stated above have an impact on cultural heritage, which include:

- moveable heritage (museums and archives),
- archaeological resources,
- buildings and structures,
- cultural landscapes and associated communities, and
- intangible heritage (folklore, language, practices).

- Archaeological sites may be at risk from additional climate hazards. For example, warmer temperatures may result in additional pests that can metabolise building timbers, and drought may result in invisible deterioration of buried archaeological deposits.

B.3. Natural environment and assets

Risks and impacts	Natural environment and assets
Flooding	Flooding can make fields inaccessible and thus, interrupt agricultural practices[254]. The wet autumn of 2019 caused operational delays, resulting in a decrease in winter wheat planting of 13%[255]. Heavy rainfall and flooding can affect arable farming practices by resulting in increased soil runoff and erosion, diseased grains and increased slugs. Similarly, flooding can impact pastoral farming by reducing grass, causing silaging issue, and contaminating grass. Note that certain land management practices may exacerbate the flood risk in areas.
High temperatures	High temperatures can also result in a greater abundance of wildfires, which poses a risk to farming, forestry, and other critical natural assets meaning biodiversity loss may be observed. Most wildfires that occurred in 2009-10 and 2011-12 occurred on agricultural land and in broadleaved woodland. In addition, an increase in seasonal aridity and wetness poses a risk to soils, affecting agriculture[65]. High temperatures may also increase the abundance of pest and pathogen outbreaks, and result in the establishment of invasive and non-native species, thus disrupting native ecosystems[254]. On the other hand, higher temperatures could enhance biodiversity and improve the growth of pre-existing species in England. This can translate into an increase in agricultural and forestry productivity[254].
High winds and storms	High winds and storms can cause crop damage and blow down trees. In addition, delays to agricultural operations, such as spraying, may occur[256]
Drought	Drought poses a risk to the public water supply, which means agricultural operations are at risk from water scarcity. 2020 UK wheat yields were 40% lower than wheat yields in the wet 2019 winter[254]. Drought has detrimental impacts on agricultural practices[257] as it impacts crop and grass growth and can result in poor quality crops. A reduction in grass growth can result in lower cow fertility, reduction in milk yield, additional costs to farmers to buy-in feed, and premature culling[258]. The hot, dry summer of 2018 resulted in an additional 30,000 cow

[255] AHDB, (2019) UK cropping intentions shift to spring following delayed autumn planting [Online]. Available: https://ahdb.org.uk/news/uk-cropping-intentions-shift-to-spring-following-delayed-autumn-planting.
[256] https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf
[257] Salmoral, G., Ababio, B., Holman, I.P. (2020) Drought Impacts, Coping Responses and Adaptation in the UK Outdoor Livestock Sector: Insights to Increase Drought Resilience. *Land*., 9(6):202. https://doi.org/10.3390/land906020
[258] https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf

	slaughtering's, 6% lower wheat yields and 10% lower spring barley yields compared to the 5 year average at the time[259,260]. In addition, lower water levels may negatively impact the health of ecosystems and their ability to function[65].
Low temperatures	Cold temperatures can impact pastoral agriculture by reducing animal growth and impact the dairy production as pipes freeze[261]
Cascading failures	The risks from drought and flooding on agriculture may result in food-borne diseases[63].

B.4. Business and industry

Risks and impacts	Business and industry
Flooding	Flooding can damage businesses directly and indirectly, for example, by damaging sites and resulting in lost production time. It is expected that 5,535 non-residential properties in the Thames valley are currently at risk of fluvial flooding[254].
High temperatures	High temperatures, and other extreme weather, can impact the availability and affordability of insurance as extreme weather becomes more common and more insurance claims are made[254]. High temperatures can impact worker productivity, as their health is negatively impacted and their ability to commute to work may decrease. Workers involved in outdoor manual labour are most likely to be affected[254].
Drought	Water scarcity can impact businesses, since water is required for cooling, heating, chemical dissolution, and many other requirements. Approximately 1 billion litres of water are used per day by "industry, power generation and farming", with the manufacturing sector requiring the most water (45-55% of direct abstractions)[254].

259 https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf
260 NFU (2018) Learning lessons from the 2018 agricultural drought
261 https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-England-Summary-Final.pdf

Cascading failures	Climate hazards can result in cascading risks that impact assets, operations and utilities within businesses and industries. High winds and storms can impact business and industry through cascading effects. High winds can impact transport networks and consequently cause supply chain disruptions across multiple sectors. Similarly, high winds may impact telecommunications, energy and ICT infrastructure that industries may be reliant on[254]. Cold temperatures can impact business and industry through cascading effects. Cold temperatures can impact transport networks, thus causing supply chain disruptions across multiple sectors. In addition, extreme weather, such as low temperatures, may impact business and industry by reducing the availability and affordability of insurance[254].

Appendix C. Climate adaptation-related initiatives in Oxfordshire

C.1. Adaptation-related initiatives and projects in Oxfordshire

C.1.1. Oxfordshire Green Infrastructure Framework

OCC commissioned a report to establish a case for investment in green infrastructure in Oxfordshire that aims to tackle sustainability challenges with natural solutions and to generate social, economic and environmental benefits. The framework[262] is aimed at all organisations, businesses, and stakeholders in Oxfordshire with an interest in long-term sustainable development of the county.

One of the many benefits of green infrastructure is its significant contribution to climate change mitigation and adaptation. Green infrastructure will enable transport infrastructure and urban areas to become more resilient to flooding and extreme weather events. It can also help to moderate temperatures and reduce the urban heat island effect. By creating more attractive and safer green infrastructure travel corridors, people can be motivated to reduce their emissions from transport and will enhance physical health and quality of life.

The Oxfordshire Green Infrastructure Framework is driven by local and national policies. Some notable policy links include the 25 Year Environment Plan, the UK Climate Change Act (2008), and the National Planning Policy Framework (2019). The list of local policy links include:

- Oxfordshire Local Transport Plan (2016)
- Oxfordshire Infrastructure Strategy (2017)
- Oxfordshire Local Industrial Strategy (2019)
- Oxfordshire's Joint Health & Wellbeing Strategy 2018-2023 (2019)
- Oxfordshire Local Flood Risk Management Strategy (2014)
- Oxfordshire Plan 2050 (2019)

The framework sets out key evidence and statistics for the status of Oxfordshire's infrastructure (e.g., housing, transport, health) and how green infrastructure can contribute to enabling greater resilience and adaptation to climate change. It sets out recommendations for the implementation of green infrastructure moving forwards.

C.1.2. Pathways to Zero-Carbon Oxfordshire

The University of Oxford's Environmental Change Institute (ECI) created a report[263] highlighting pathways for the county to achieve a zero-carbon economy and future by 2050. Several stakeholders were involved in the development of the report and pathways, these include OCC, Low Carbon Hub, Cherwell District Council, Oxford City Council, West Oxfordshire District Council, South Oxfordshire and Vale of White Horse District Councils, Oxford Sciences Innovation, the Greater South East Energy Hub, Oxford Brookes University and Scottish and Southern Electricity Networks. The report provides key decision-makers and businesses in the county practical solutions for creating a zero-carbon future.

Key themes included in the report are innovation, transport, buildings and heating, renewable energy, and land use. It was identified that in all net-zero pathways, the following mitigation and adaptation actions are involved:

- The expansion of solar generating capacity in the county

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[262] Green infrastructure and access to nature | Oxfordshire County Council
[263] Pathways to a zero carbon Oxfordshire

- Widespread retrofitting programme for existing homes and non-domestic buildings
- Phasing out gas boilers and fossil-fuelled modes of transport
- Innovation in food production to maintain or increase output whilst agricultural land makes way for development
- The protection and restoration of ecosystems and natural capital for enhanced sequestration capacities and increased biodiversity

C.1.3. Local Energy Oxfordshire project

Project Local Energy Oxfordshire (LEO) aims to advance innovative approaches to help accelerate our transition to a zero-carbon energy system through decentralised local energy solutions. [264] Oxfordshire is one of the three demonstrator projects in the UK and focuses on taking a whole systems approach through ongoing cross-sectoral collaboration between key stakeholders including OCC, Equiwatt, Low Carbon Hub, Scottish and Southern Electricity Networks, University of Oxford, Oxford Brookes University, Nuvve, Oxford City Council and Piclo. The project focuses on three key components:

- Testing new market and flexibility models by exploring new products and services that can support commercial opportunities on how energy is produced, stored and use across households, business and communities,
- Advancing the capacity of networks to manage smart, renewable and storage technologies by learning what needs to change in existing networks to prepare them for changing to smart local energy systems,
- Facilitating local participation of individuals, households and organisations in the energy transition.

C.1.4. Tree Policy for Oxfordshire

Recognising that trees are critical to climate change adaptation and are important public assets, OCC have set out policies for the protection of trees and woodland in the county. It requires all agents, partners and contractors of the council to comply with the Tree Policy.[265] The policies set out aim to:

- Outline commitment for climate adaptation by proactive tree care and tree planting in built-up areas and the countryside
- Promote and encourage care for existing trees to maximise their climate and biodiversity value, amenity value and public benefits by ensuring optimal life expectancy
- Deliver increased canopy cover across Oxfordshire

This policy aims to deliver on broader objectives such as climate adaptation, flood alleviation, carbon sequestration, health and wellbeing, and landscape resilience. The policy focuses on four broad areas: (a) tree planting and establishment, (b) tree care, (c) removal, communications and protection, and (d) county council planning and regulatory functions.

C.1.5. Oxford Flood Alleviation scheme

Oxford has a long history of flooding with significant floods in recent decades causing more damage to homes, businesses, and transport infrastructure (roads and railway). Climate change is expected to increase the frequency and severity of floods. The Oxford flood alleviation scheme[266] is designed to manage flood risk in the

[264] LEO-Final-Report-Web_lr.pdf (project-leo.co.uk)

[265] Tree Policy for Oxfordshire

[266] Oxford Flood Scheme - GOV.UK (www.gov.uk)

city over the next 100 years by creating a new stream with wetland wildlife corridor running through the existing floodplain to the west of Oxford.

The scheme partners are the Environment Agency, OCC, Oxford City Council, Vale of White Horse District Council, Thames Water, Thames Regional Flood and Coastal Committee, Oxford Flood Alliance, Oxfordshire Local Enterprise Partnership, University of Oxford, and National Highways. Funding has come from the central government and local contributions, with £40 million raised by partners so far.

This scheme will reduce flood risk to homes and businesses thereby reducing financial damage and lessening the stress and mental impact of flooding. It will also reduce flood related disruptions to essential utilities like water, electricity, telecommunications, and internet. Additionally, the creation of new wetland habitat will attract more wildlife and biodiversity and enhance the enjoyment of the area for recreational use. The proposed scheme contains nature-based features and will have a low carbon footprint. The planting of more trees and hedgerows will have benefits for carbon sequestration capacities and air quality improvement.

C.1.6. West Oxfordshire Net Zero Carbon Toolkit

The Net Zero Carbon Toolkit[267] is aimed at small and medium-sized house builders, architects, self-builders, and consultants and covers the process from pre-planning through to construction for delivering net-zero carbon and low energy homes. The advice for implementing energy efficiency measures and decarbonising homes will help reduce the carbon footprint of new and existing buildings. This toolkit was developed by the West Oxfordshire, Cotswold, and the Forest of Dean District Councils. The toolkit is also available for local authorities to use and adapt. Beyond energy, the toolkit considers design decisions that affect a home's impact on the environment and carbon emissions. Other considerations include supporting and enhancing biodiversity and Green Infrastructure to benefit communities and reducing flood risk through Sustainable Urban Drainage Systems (SuDS).

C.1.7. Zero Carbon Oxford Partnership

The Zero Carbon Oxford Partnership[75] is a collaboration between leaders from Oxford's major businesses, universities, councils, hospitals and other large organisations with a goal to reduce carbon emissions, develop funding bids, share learnings and seek national government support.

The Zero Carbon Oxford roadmap, published in July 2021, outlines an aim to reduce Oxford's carbon emissions by 88% by 2040 relative to 2018 emissions. The roadmap divides the city's emissions into five sectors considered to have the greatest climate impact – domestic, commercial, industry, institutional, and transport. A total 88% reduction in carbon emissions by 2040 relative to 2018 means a reduction of each sector's related emissions by:

- Domestic: 87%
- Commercial: 86%
- Industry: 86%
- Institutional: 91%
- Transport: 88%

To stay on track, the roadmap contains milestones, five-yearly carbon targets until 2040. The milestones assist the Zero Carbon Oxford Action Plan which identifies the key actions required before 2030, including delivering a biodiversity strategy, retrofitting of council homes, supporting transformative energy projects, and lobbying the government to raise energy efficiency standards in the private rented sector. Longer term actions will be identified as the immediate actions are achieved.

[267] How to achieve net zero carbon homes - West Oxfordshire District Council (westoxon.gov.uk)

Landsec, a commercial property company and one of the Zero Carbon Oxford partners, announced the creation of a £135 million net zero transition investment plan in November 2021[76]. The fund will see 24,000 tonnes of carbon emissions removed from Landsec's operation.

C.2. Strategic and local plans in Oxfordshire

C.2.1. Oxfordshire Strategic Plan

The Oxfordshire Strategic Plan 2022-2025[268] sets out the County Council's vision to making Oxfordshire greener, fairer, and healthier. The first strategic priority set out is to address the climate emergency by setting ambitious net-zero targets and prioritising climate action and community resilience in planning. Areas of focus in this priority include:

- Working with partners to implement the 'Pathways to Zero Carbon' route map for decarbonising Oxfordshire,
- Net zero buildings, operations and supply chains by 2030 and supporting energy efficient residential homes,
- Supporting biodiversity and nature recovery while adapting to the impacts of climate change (extreme weather and supply chain disruption),
- Supporting community and business activities to reduce carbon emissions and shifting towards a resilient and local zero carbon economy,
- Promoting the shift towards active travel methods and accelerating the transition to electric vehicles,
- Sustaining the benefits of Project Local Energy Oxfordshire for a greener, fairer and resilient renewable energy network,
- Reducing the energy, visual and environmental impacts of street lighting with their LED street lighting replacement programme.

Other priorities related to climate change adaptation across the county include the investment in a more inclusive, integrated and sustainable transport network and preserving and improving access to nature and green spaces.

C.2.2. Cherwell District Council

The Cherwell Local Plan 2011-2031[269] sets out how the district will grow and change up to 2031; a key goal driving the plan is achieving sustainable economic growth by creating jobs, boosting housing supply in targeted sustainable locations, mitigate and adapt to climate change, and achieve biodiversity net gains. The council undertook a Local Climate Impacts Profile (LCLIP) that reviewed extreme weather events experienced over 2003 to 2008 which found the most significant event to be flooding. Additionally, it recognised that heatwaves were infrequent in that 5-year period but if they were to increase in frequency, there would be significant impacts on health, biodiversity, and infrastructure. The following strategies have been laid out to mitigate and adapt to the impacts of climate change in the district: the Cherwell Sustainable Community Strategy 'Our District Our Future', Council's Low Carbon Environmental Strategy, and Eco Bicester: seeking to deliver sustainable building standards across the town.

[268] Strategic Plan 2022-2025 (oxfordshire.gov.uk)
[269] Adopted Cherwell Local Plan 2011-2031 (Part 1) | Adopted Cherwell Local Plan 2011-2031 (Part 1) | Cherwell District Council

C.2.3. Oxford City District Council

The Oxford Local Plan 2036[270] looks ahead to build on Oxford's economic strengths and to ensure prosperity and opportunities for all. The plan contains policies to mitigate and adapt to climate change in line with the Climate Change Act 2008. Some of the objectives include enhancing green spaces with public access so they deliver multiple benefits to health and wellbeing, gains in biodiversity, and adaptation to climate change. Additionally, the plan also considers sustainable design and construction by limiting emissions throughout the building process. Green and Blue Infrastructure Networks are also highlighted in the plan because of contributions to health, biodiversity, water management, air quality, and supporting jobs and tourism.

Recognising that flooding is a widespread and frequent hazard to the city, the Oxford City Strategic Flood Risk Assessment Level 1 (November 2018) concluded that a considerable proportion of the city is at risk to fluvial flooding, but other properties also face risk from surface water, sewer, and groundwater flooding. The plan highlights the Oxford Flood Alleviation Scheme (as detailed above) as a partnership project that will benefit the city in terms of reduced flood risk to homes, businesses, and transport infrastructure.

C.2.4. South Oxfordshire District Council

The overall strategy in South Oxfordshire Local Plan 2011-2035[271] consists of supporting and developing infrastructure across the villages, meeting unmet housing needs of Oxford City, and more specifically related to the natural environment – protecting and enhancing the countryside and areas within the two AONBs and Oxford Green Belt and contributing to tackling climate change.

One example is the Didcot Garden Town involving collaboration between South Oxfordshire, Vale of White Horse, and Oxfordshire County councils. The Garden Town aims to reduce reliance on motorised vehicles and will promote active and public transport through attractive and accessible movement networks. New development in the town will enhance the natural environment through Green and Blue Infrastructure networks to support climate resilience and increase ecological networks and biodiversity.

Other aspects in the plan cover trees and hedgerows that can absorb atmospheric pollution and increase climate resilience and thus new development proposals are advised to provide a net increase in tree canopy cover where possible. There is emphasis on protecting Conservation Target Areas that form the ecological network of Oxfordshire and provide resilience to future climate change. Mitigating and adapting to climate change is also addressed through low-carbon objectives. The council aims to support community-led initiatives to support the inclusion of decentralised energy networks and the use of decentralised energy sources in development. The council is committing to becoming carbon neutral by 2030.

C.2.5. Vale of White Horse District Council

The Vale of White Horse Local Plan 2031[272] identifies responding to climate change as a key objective. The district high quality and rural nature such as the Oxford Green Belt, North Wessex Downs Area of Outstanding Natural Beauty and 52 designated Conservation Areas. The Vale intends to meet Government targets for reducing greenhouse gas emissions through low carbon and renewable energy generation, efficient use of energy and natural resources, and equipping new developments to adapt to warmer, wetter winters and hotter, drier summers. There are also plans to maintain and improve the natural environment which include biodiversity, landscape, Green Infrastructure, and waterways.

The Plan also includes core policies related to:

- The Oxford Green Belt which seeks to protect the land and manage the growth of the city of Oxford,

[270] Adopted Oxford Local Plan 2036 | Oxford City Council
[271] Adopted Local Plan 2035 - South Oxfordshire District Council (southoxon.gov.uk)
[272] Local Plan 2031 - Vale of White Horse District Council (whitehorsedc.gov.uk)

- Strategic Water Storage Reservoirs to safeguard land for the provision of a reservoir to assist with water supply management in the South-East of England, should this be needed in the future.

C.2.6. West Oxfordshire District Council

The West Oxfordshire Local Plan 2031[273] has been shaped by extensive community engagement to ensure focus on the issues of greatest significance to West Oxfordshire. The environmental objectives of the plan include:

- Promoting inclusive, healthy, safe and crime free communities,
- Conserving and enhancing the character and significance of the district's environment,
- Contributing to reducing the causes and adverse impacts of climate change, especially flood risk,
- Enabling improvements in water and air quality,
- Minimising the use of non-renewable natural resources and promoting widespread use of renewable energy solutions.

One of the policies in the plan recognises that networks of natural habitats provide valuable resource and protection and thus creating links between fragmented habitats to create greater coherence and resilience will increase adaptation to climate change and other pressures. Another policy highlights the public realm and green infrastructure in which the district aims to provide opportunities for walking and cycling within built-up urban areas and maximise opportunities for urban greening through landscaping schemes and tree-planting and integrating green infrastructure into proposals that would normally use man-made 'grey infrastructure' (i.e., man-made ditches, detention ponds). Additionally, the shift towards renewable and low-carbon energy has been led by community initiatives such as South Hill Solar Community Energy and Eynsham's People Power Station Project. This will help deliver long-term benefits to local communities such as reduced energy bills and usage and will encourage greater use of renewable energy. The council also set out that flood risk will be managed using a sequential, risk-based approach (in accordance with the National Planning Policy Framework) of avoiding flood risk to people and property.

C.3. Other adaptation-related plans, initiatives, and reports

C.3.1. 25 Year Environment Plan

The 25 Year Environment Plan[274] is a national policy that sets out goals for improving the environment within a generation and details how the government will work with communities and businesses to achieve this. Below are the list of goals and targets outlined in the policy:

- Clean air: i.e., meeting targets on air pollutant reduction and halving the effects of air pollution on health by 2030,
- Clean and plentiful water: i.e., meeting objectives for water bodies that are specially protected, whether for biodiversity or drinking water,
- Thriving plants and wildlife: i.e., achieving a growing and resilient network of land, water and sea that is richer in plants and wildlife,
- Reducing the risks of harm from environmental hazards: i.e., boosting the long-term resilience of homes, businesses and infrastructure from natural hazards like flooding, drought and coastal erosion,

[273] Local Plan 2031 - West Oxfordshire District Council (westoxon.gov.uk)
[274] At a glance: summary of targets in our 25 year environment plan - GOV.UK (www.gov.uk)

- Using resources from nature more sustainably and efficiently: i.e., improving the management of resources such as food, fish, and timber,
- Enhancing beauty, heritage and engagement with the natural environment: i.e., safeguarding and enhancing the beauty of natural scenery, and ensuring high quality, accessible, natural spaces close to where people live and work to benefit health and wellbeing,
- Mitigating and adapting to climate change: i.e., continuing to cut greenhouse gas emissions, implementing a sustainable and effective second National Adaptation Programme,
- Minimising waste: i.e., working towards zero avoidable waste by 2050, eliminating avoidable plastic waste by end of 2042,
- Managing exposure to chemicals: i.e., safely managing the use of chemicals and ensuring the levels of harmful chemicals entering the environment (including through agriculture) are significantly reduced,
- Enhancing biosecurity: i.e., protecting wildlife and livestock and boosting the resilience of plants and tress by tackling invasive non-native species and meeting the goals in the Tree Health Resilience Plan of 2018.

C.3.2. UK Net Zero Strategy

The UK's Net Zero Strategy[275] sets out how the country will deliver on its commitment to reach net zero emissions by 2050. This Strategy will secure over 400,000 jobs in green industries and unlock approximately £90 billion in private investment by 2030. It sets out a comprehensive economy-wide plan for how British businesses will be supported in their transition to clean energy and green technology. With the investment, businesses are supported in gaining a competitive edge in low carbon technologies and developing thriving green industries.

C.3.3. Thames Water Climate Change Adaptation Report

To address climate change risks and impacts on critical water infrastructure, the Thames Water Climate Change Adaptation Report for 2015-2020[276] addresses the company's approach to improving operational resilience and reducing the impact of hazards on customers. Some hazards that water infrastructure is affected by include multi-year drought, high record-breaking temperatures, cold spells, extreme wet weather, storms, and flooding. These hazards all challenge the ability to serve customers. To mitigate risks, Thames Water's approach encompasses the development of climate change risk assessments, the Water Resources Management Plans (WRMP) framework, and the Drainage and Wastewater Management Plan (DWMP) framework. Under the WRMP24, adaptation measures Thames Water aims to implement include:

- Improving pipes,
- Installing smart water meters,
- Reducing customers water use by providing free water-saving devices and tailored advice,
- Boosting water supplies through a new aquifer storage and recovery scheme,
- Protecting the environment by reducing their licenses abstraction,
- Boosting drought resilience by delivering on WRMP19 for resilience to a 1-in-200-year drought.

Thames Water also have a journey to net zero carbon road map[277] with four high-level themes central to the company's progress towards net zero by 2030. These are:

1. Reducing carbon emissions by designing and operating assets to emit as few carbon emissions as possible,

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[275] UK's path to net zero set out in landmark strategy - GOV.UK (www.gov.uk)
[276] Climate-change-adaptability-report.pdf (thameswater.co.uk)
[277] Our-journey-to-net-zero.pdf (thameswater.co.uk)

2. Decarbonise operations by using lower carbon technologies that provide the same capabilities,
3. Creating a net negative future by growing renewable energy products and procuring renewably energy when they cannot decarbonise their supplies,
4. And considering schemes such as carbon offsets, carbon capture and storage, and carbon sequestration opportunities.

Other measures Thames Water have included in their net zero road map include:

- Reducing fossil fuel use by increasing the use of biogas on sites which can then be converted into biomethane for exports to the gas grid as fuel for vehicles and alternative to natural gas,
- Harnessing solar power by increase the amount of solar power generated by over 50% with panel installations,
- Introducing electric vehicles to their fleet, including where to install charging points on sites and in the community,
- Improving energy efficiency by continually upgrading water and sewage treatment processes,
- Unlocking resources by helping farmers substitute manmade fertilisers with biosolids, which saves resources and avoids carbon emissions.

C.3.4. SGN 3rd Round Climate Change Adaptation Report

SGN delivers gas to Oxfordshire, covering around 90% of households across the South East region of England.

SGN's 3rd Round Climate Change Adaptation Report[278] uses Met Office UK Climate Projections to the end of this century as the network infrastructure generally has an operational life expectancy of 30 to 80 years.

The threat of frequent and severe surface water flooding, extreme precipitation events, sea-level rise, and wildfire represent an emerging risk for the gas and electricity provider. Twenty-two potential climate change hazards were identified that may impact SGN operations.

As such, the company has reviewed its risk management and actions. Interdependencies are highlighted as disruptions to electricity infrastructure can also have knock-on impacts on gas operations (i.e., through storms). SGN intends to remain an active participant in the Energy Networks Association (ENA) group on climate change resilience and that will look to collaboration and share knowledge and good practice on adaptation actions.

C.3.5. National Grid 3rd Round Climate Change Adaptation Report

National Grid is the UK's energy system, the company has committed to reducing its carbon emissions to net zero by 2050 and are facilitating decarbonisation to deliver a clean energy future. In their 3rd Round Climate Change Adaptation Report[279], they found that risks from raised temperatures and erosion increased since the second-round report. Flooding, ground movement, wind damage, vegetation growth, and lightning follow in the list of climate risks. The actions they intend to take include:

- Reviewing its standards and specifications for construction of new assets to ensure resilient operation from the impacts of climate change throughout the life cycle,
- Undertaking a flood risk assessment using latest data, updating the 2008 assessment,
- Undertaking a river scour risk modelling exercise for gas transmission pipelines at river crossings using Met Office climate change scenarios to inform its future depth of cover inspections and mitigation plans.

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278 3rd Round Climate Change Adaptation Report (sgn.co.uk)
279 Third Round Climate Change Adaptation Report (National Grid)

C.3.6. Network Rail Weather Resilience and Climate Change Adaptation Plan

Network Rail uses UK Climate Projections data to plan for climate change impacts. Extreme weather and increased frequent, severe flooding affect key transport infrastructure. The Weather Resilience and Climate Change Adaptation (WRCCA) Plan[280] identified the following gaps in current asset management which include:

- The Asset Policy lacking acknowledgement and alignment to climate projections,
- Knowledge gaps on asset condition and sensitivities to various weather types and climate variables,
- Current extreme weather plans associated with weather resilience are not fit for purpose,
- And interdependencies between different assets and external factors are not adequately addressed.

As a result of these gaps and recognising the increasing risk of climate change, Network Rail have compiled a list of headline actions and measures such as:

- Monitoring and management review every five years to reflect updates to climate change projections,
- Developing whole life cycle model incorporating weather and climate change into asset sustainability models to measure degradation,
- Reviewing and updating scour standards and actions to align with projected changes in sea level rise and river flows alongside catchment-based assessments,
- And reviewing and updating existing drainage and water management strategy which includes consideration of catchment-based impacts for precipitation and water flows (flood levels).

C.3.7. UKHSA Adverse Weather and Health Plan

The UKHSA Adverse Weather and Health Plan[281] aims to prepare people from the health impacts of severe heat across England. The plan outlines areas where the public, independent, and voluntary sectors, health and social care organisations, and local communities can deliver the best possible outcomes during adverse weather. Some action areas for delivery include service delivery, capacity building, risk management, and early warning systems.

C.3.8. Tree Health Resilience Strategy

The Tree Health Resilience Strategy[282] aims to protect trees from the threat of pests and diseases across England. England's treescape comprise of various types of trees such as hedgerows, infield trees, street trees, trees in orchards/woodlands/parks/gardens, forestry plantations, and woodlands. This national strategy sets out how trees are valued and a list of actions that are government-led and sector-led.

C.3.9. Thames Valley Flood Scheme

The Thames Valley Flood Scheme[283] outlines the ways in which flood risk across the Thames Valley catchment (the land around the non-tidal section of the River Thames) can be managed on a large scale. The scheme aims to reduce flood risk and build climate resilience for communities, businesses and infrastructure in the Thames Valley. They identified seven strategic options for flood risk management which include:

- Flood storage options: (a) offline and (b) online flood storage,
- Natural flood management options: (c) run-off attenuation features, (d) change in soil and crop management, (e) woodland planting, (f) washlands, and (g) wetland creation.

[280] Network Rail Asset Management
[281] Adverse Weather and Health Plan: heat advice - GOV.UK (www.gov.uk)
[282] Tree health resilience strategy (publishing.service.gov.uk)
[283] What is the Thames Valley Flood Scheme? | Engage Environment Agency (engagementhq.com)

The Thames Valley Flood Scheme works by complementing other existing and planned schemes which include the Oxford Flood Alleviation scheme (see more details on this in Section 5). The Scheme is part of a three-layered approach to reducing flood risk. Layer 1 is at the home and business level where households can make changes to their property to increase resilience to flooding through measures such as flood gates or flood resilient materials and the use of the Flood Re insurance scheme. Layer 2 is at the community level which include permanent measures such as flood walls, embankments or bypass channels and other temporary measures during flood events such as flood barriers and pumps. Layer 3 is at the catchment scale where the Flood Scheme complements the household and community level approaches by planning catchment-wide measures to deliver the most benefits in a cost-beneficial manner.

C.3.10. Local Transport and Connectivity Plan

The plan[284] sets out the policies and strategies for developing Oxfordshire's transport system to 2031 with four over-arching transport goals:

- Support jobs and housing growth and economic vitality
- Reduce transport emissions and meet obligations set out by the Government
- Protect and, where possible, enhance Oxfordshire's environment and improve quality of life
- Improve public health, air quality, safety and individual wellbeing

This policy is essential as it will take into account climate change mitigation as the public rights of way network will experience the impacts of the climate emergency through increased extreme weather events (e.g., rainfall/flooding, strong winds, fire/overheating). The plan was motivated by the recognition that transport is responsible for the largest proportion of greenhouse gas emissions in the county. Thus, there is an urgent need to decarbonise all forms of transport within the county by encouraging other modes of transport (walking, cycling, public and shared transport) and supporting the uptake of zero-emission vehicles.

C.3.11. Zero Emission Zone in Oxford

Implemented by the Oxford City Council in collaboration with the OCC, the zero-emission zone (ZEZ)[285] in the city centre is the first of its kind as a regulatory driver to encourage the transition to zero emissions transport. The aim is to tackle air pollution, congestion, and improve residents' quality of life. Zero emission vehicles in the zone will avoid charges, whereas other vehicles will pay fees when entering the ZEZ. Additionally, the pedestrianisation of the city centre will increase vitality and improve air quality.

C.3.12. Sustainable Warmth Grants

Oxfordshire County Council was awarded funding from the national government's Sustainable Warmth Fund. These grants[286] would be put towards energy efficiency upgrades to be fitted to residential homes in Oxfordshire. Residents from homes heated by gas apply to the funding scheme and are awarded:

- Up to £10,000 for homes connected to the mains gas grid
- Up to £25,000 for homes not connected to the mains gas grid

The most recent scheme ran until March 2023 and aimed to improve poorly insulated homes for low-income residents in properties with an Energy Performance Certificate rating of D or below. The funding could be put towards energy-efficiency improvements that include, but are not limited, to solid wall insulation, underfloor insulation, solar PV panels, and high heat retention storage heaters.

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[284] Oxfordshire County Council - Active Travel Strategy
[285] Oxford zero emission zone (ZEZ) | Oxfordshire County Council
[286] Sustainable Warmth Grants | Oxfordshire County Council

C.3.13. Oxfordshire's Electric Vehicle Infrastructure Strategy

Motivated by the UK Government's Road to Zero Strategy[287] restricting the sale of fossil-fuelled cars from 2030, it is predicted that at least 1 in 5 cars in Oxfordshire will be fully electric by 2030. The Oxfordshire Electric Vehicle Infrastructure Strategy[288] sets out how Oxfordshire's councils can realise the vision for electric vehicle charging whereby:

- Residents, businesses, and visitors in the county will be confident they can recharge EVs conveniently
- The county's charging provision will develop to meet user needs now and, in the future, and in doing so will support Oxfordshire's transition to decarbonising transport and improving air quality

This strategy is being delivered in partnership with Oxford's academic institutions and technology firms, the Energy Superhub Oxford project, Local Energy Oxfordshire, Oxfordshire's V2GO project, Go Ultra Low Oxford project, and Park and Charge project. The pipeline of projects is delivering more than 400 charging points.

C.3.14. Biodiversity and Planning Guidance

The Biodiversity and Planning guidance[289] were produced by OCC, the Berkshire, Buckingham and Oxfordshire Wildlife Trust (BBOWT) and the Thames Valley Environmental Records Centre (TVERC). The guidance document provides maps illustrating biodiversity in Oxfordshire and combines planning policy with information on wildlife sites, habitats and species to identify where biodiversity should be protected. The guidance is also directed at planning officers, those writing neighbourhood plans, and those submitting a planning application. Key points include protected species and planning policy and the possibility of requiring a licence from Natural England, Conservation Target Areas (Oxfordshire has 37 and covers 20% of the county by area and contains 95% of the Site of Special Scientific Interest land area in Oxfordshire), and wildlife licences. Specifically for the Conservation Target Areas, each CTA provides a focus for the delivery of biodiversity work, agri-environment schemes, and biodiversity enhancements through the planning system. They offer opportunities for establishing and enhancing new habitats and networks of wildlife. Additionally, Areas of Outstanding Natural Beauty (AONBs) are nationally important for landscape and are protected through national and local planning policies, and legislation. The Chilterns AONB, Cotswolds AONB, and North Wessex Downs AOB extend into Oxfordshire.

[287] Reducing emissions from road transport: Road to Zero Strategy - GOV.UK (www.gov.uk)
[288] Oxfordshire Electric Vehicle Infrastructure Strategy
[289] Biodiversity and planning | Oxfordshire County Council

Appendix D. Summary of national and local adaptation-related policies and plans

The following sections highlight existing national policies and local policies and initiatives that aim to address the impact of climate change on each of the four themes of interest to Oxfordshire: critical infrastructure; health, communities, and the built environment; natural environment and assets; and business and industry.

The summary of national polices and plans described below have been retrieved from the UK Climate Change Committee (CCC) latest report on Adaptation Progress in England[290] as well as other sources of information when appropriate e.g. the latest UK Health Security Agency Adverse Weather Plan published in May 2023.

The summary of OCC-related policies and plans have been compiled based on existing projects and initiatives in Oxfordshire as described in this Appendix in the previous sections.

The colour coding used below is consistent with the CCC Adaptation Progress report as follow (and as explained in Appendix A):

Credible policies and plans	Partial policies and plans	Limited policies and plans	Insufficient policies and plans
Policy milestones: • are almost entirely achieved or in place • are comprehensive and appropriately ambitious • include monitoring and evaluation	Policy milestones: • are achieved or in place for key milestones but some gaps remain • cover most important elements, could be more ambitious • include some monitoring and evaluation	Policy milestones: • are partially achieved or in place with some key milestones missing • cover some important elements, could be more ambitious • include some monitoring and evaluation	Policy milestones: • are mostly not achieved, only minor policies in place • lack important elements, do not cover key areas or lack ambition • have minimal monitoring and evaluation

The progress assessment provided at the local level in the tables below is a qualitative assessment of both existing national policies that influence policy at OCC level as well as existing policies at local level.

[290] Report available at: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf

D.1. Critical infrastructure

National progress on critical infrastructure[291]		Summary of national policies and plans	Summary of OCC policies and plans	Progress assessment of policies at OCC level
Water supply	Reduce demand	Credible plans are in place to reduce demand, including new statutory targets for per capita consumption and a requirement to demonstrate resilience to a 1 in 500 year 'extreme' drought in the next round of water resource plans. • New Ofwat allocation of £100 million for demand reduction in next price review, mandatory water efficiency labelling confirmed and Government's roadmap for more water efficient buildings published. • Insufficient progress in reducing demand relative to targets	• Thames Water intend to reduce customer demand through water saving devices and tailored advice. • West Oxfordshire included the optional water efficiency building regulation in their local plan as Policy OS3 – Prudent Use of Natural Resources[292] and Policy OS4 – High quality design which requires new developments to demonstrate resilience to future climate change risks and use of water conservation measures.	Demand reduction plans Demand reduction funding
	Improved system performance	• New statutory Environment Act targets for leakage and water company plans are required to demonstrate resilience to flooding and coastal change. • Limited progress in reducing leakage relative to targets. No large-scale interruptions to water supply due to weather have been reported, but more data is needed to better monitor this.	• Thames Water intend to reduce leakage by 50% by 2050 according to the dWRMP24[293]. • As outlined in their net zero road map, Thames Water plan to increase the security of their system through measures including decarbonising their operations.	Leakage targets
	Increased supply	• No new reservoirs have been built in the UK in the last 30 years but new schemes are emerging. • Emerging draft regional water resource plans show positive progress in more joined up planning between water companies and large water users. However, they propose few new interconnections of water resources	• Thames Water have outlined multiple options of increasing supply within Oxfordshire in their WMRP24. This includes a proposed reservoir south-west of Abingdon. This major scheme is not supported by VoWH or OCC, who favour alternative options. • If Thames Water's demand reduction options are sufficient, then no additional sources of water will be	Increase in supply

[291] The themes used here are the same as those adopted in the CCC report on Adaptation Progress for the same of consistency between the national assessment and the local assessment of policies and plans in Oxfordshire.
[292] Local-plan.pdf (westoxon.gov.uk)
[293] Our draft plan - Thames Water Resources Management Plan (thames-wrmp.co.uk)

		between regions and the demand-supply gap in 2050 is bigger than previously estimated.	required till 2039. If the demand reduction options are unsuccessful, then treatment and network assets must be constructed from 2040. This includes a transfer from Henley's water resource zone.	
	Interdependencies identified and managed	• Adaptation Reporting Power reports demonstrate limited progress on interdependencies by some water companies but gaps in reporting remain, including on supply chain risks.	• It is anticipated that Thames Water are well aware of and are managing interdependent risks, but may need to disclose more information, e.g. in ARP4 reports. One issue is that the level of service for water supply is far higher than the level of service for electricity supply, so investment is needed in back up power solutions.	Interdependencies disclosure limited
Energy	Reduced vulnerability of energy assets to extreme weather	• Climate change is a consideration in statutory planning applications for new infrastructure and reports submitted under the Adaptation Reporting Power demonstrate progress in some areas. • Some specific policies and standards exist to increase asset resilience, such as for flood protection of substations. • There is a need for minimum resilience standards and a clearer climate resilience remit for regulators. • Some progress in flood resilience, but more information is needed for other hazards, including heat and drought.	• The Oxford Flood Alleviation Scheme aims to reduce flood risk in Oxford. • SGN identified 22 potential climate hazards that may impact their operations. • National Grid have published their 3rd Round Climate Change Adaptation Report, which highlights the actions they will take to mitigate the climate hazards they face.	Flood resilience plans Climate hazard awareness Adaptation awareness
	System level security of supply	• Government has committed to a decarbonised, secure energy supply by 2035 and acknowledged the need for resilience, but there is no defined standard for system level resilience and delivery challenges remain. • More research is needed to understand possible climate impacts on the energy system, and this must be integrated into system design and investment processes.	• SGN is an active participant in the ENA group on climate change resilience where good practice adaptation actions are discussed. • Project LEO, supported by the Oxfordshire Strategic Plan, aims to achieve a decentralised energy system. • The Pathways to Zero-Carbon Oxfordshire plan outlines ways to expand the solar generating capacity of Oxfordshire. • Cherwell District Council intend to reduce reliance on grid electricity by generating their own power and reducing demand[294].	Resilience standards Research needs
	Interdependencies identified and managed	• Coverage of interdependency risks has improved in some adaptation plans but this remains an area of significant challenge.	• SGN have identified interdependencies that may affect their operations (e.g. disruptions to electricity infrastructure).	Interdependencies risks

[294] https://www.cherwell.gov.uk/info/7/environment/752/climate-emergency

		• It is not possible to assess progress in delivery across the whole energy system due to a lack of data for generators.	• The Net Zero Carbon Toolkit has been created to encourage low energy and net-zero carbon homes.	Lack of data
Telecoms	Vulnerability of assets reduced	• There remains no visible plan or process by the industry or Government with actions to manage long-term climate risks to the sector. Flood resilience of critical telecommunications infrastructure was assessed in the 2016 National Flood Resilience Review. • Guidance for critical national telecommunications infrastructure includes design considerations and operational processes for resilience to physical threats, including extreme weather, floods and lightning, though specific climate scenarios are not mentioned. • Adaptation Reporting Power reports provide some insight on progress, but there is a lack of detailed risk assessment and adaptation plans for operators. • Some progress in flood resilience of telecoms infrastructure but a lack of data to evaluate progress overall.	• The Oxford Flood Alleviation Scheme aims to reduce flood risk in Oxford.	Flood resilience assessment Design considerations Adaptation reports
	System level resilience	• Ofcom does not have a statutory remit for climate resilience. • There is limited consideration of climate resilience in existing industry standards. • There is a lack of data to evaluate progress.	• Unknown	Regulatory gaps Industry standards
	Interdependencies identified and managed	• ARP3 reports demonstrate an awareness of sources of interdependency risk at an overall sector level. • There is a lack of data to evaluate progress.	• Unknown	Lack of data
Transport	Asset & system level reliability of rail network	• Rail infrastructure operators have credible climate resilience and adaptation plans and have reported under the latest round of the Adaptation Reporting Power (ARP3). • Indicators show some increased impacts on rail infrastructure from heat and wind, but reduced impacts from flooding.	• Network Rail have published their Weather Resilience and Climate Change Adaptation Plan.	Rail climate resilience

Asset & system level reliability of strategic road network	• The second Road Investment Strategy includes a vision for climate resilience. National Highways has reported its climate change risk assessment and adaptation plans under ARP3. • Overall road condition is unchanged since our last assessment and around 80% of inspected road structures in 2021/22 were rated as being in 'good' condition.	• The Local Transport and Connectivity Plan aims to reduce transport emissions by decarbonising all forms of transport.	Major roads (good condition) Major roads (resilience plans)
Asset & system level reliability of local roads	• There is a lack of credible plans for local roads. Compliance with the Code of Practice for climate change is not known. Defra has proposed to include some local authorities in ARP. • No significant change in road condition, but additional indicators are needed for a more robust assessment.	• Unknown	Lack of data (local) Local roads (resilience plans)
Asset & system level reliability of airport operations	• The two largest UK airports have mandatory resilience plans. • Eleven UK airports, including the seven largest, have reported their climate change risk assessments and adaptation plans in ARP3. • Unable to evaluate progress due to lack of indicators.	• It is unclear what initiatives London Oxford Airport has in place to address the impacts of climate change on airport operations.	Local airport (resilience plans)
Interdependencies identified & managed	• Identification of interdependency risks has improved in ARP3 reports for rail, strategic roads, airports and some ports, but interdependencies are not being consistently assessed in sufficient detail. • Unable to evaluate local roads progress due to lack of data.	• Unknown	Interdependencies

(green)	Credible policies and plans	(yellow)	Partial policies and plans	(amber)	Limited policies and plans	(red)	Insufficient policies and plans

D.2. Health, communities, and the built environment

National progress on heath communities and built environment		Summary of national policies and plans	Summary of OCC policies and plans	Progress assessment of policies at OCC level
Health	Protect population health from the impacts of climate change and utilise potential benefits	• Heat-related mortality was estimated at an all-time high in 2022. Data on flood related mortality and flood and heat related morbidity and disruption is not always regularly recorded. There is also little evidence of monitoring of indoor air quality. • A new Centre for Climate and Health Security within the UKs Health and Security Agency (UKHSA) has been created to leads efforts to protect health in the context of a changing climate. UKHSA has introduced enhanced testing and surveillance of invasive mosquitos. • The current Heatwave and Cold Weather Plans do not constitute long-term adaptation plans to reduce the risk of heat and cold related mortality and illness. UKHSA published a single adverse weather plan[154] in 2023 that outlines the responsibilities of organisations in developing climate change related health policies.	• The Oxfordshire Green Infrastructure Framework and Oxfordshire Joint Health & Wellbeing Strategy 2018-2033 should encourage people to reduce their emissions in a way that improves health and quality of life. • The Sustainable Warmth Grants been OCC have been able to upgrade low-income houses to be more energy efficient.	Temperature related adaptation Healthcare policy guidance Low-income house protection (local)
	Quality and accessible healthcare delivery during extreme weather	• Indicators for this outcome demonstrate unclear progress. Overheating incidences are occurring in hospitals. There is no recording of overheating incidences in other healthcare settings such as care homes, domiciliary care or GP surgeries. • The update to Part O of the Building Regulations is a step forward for new residential care homes. The 2023 NHS Net Zero Building Standard requires an assessment of thermal comfort to minimise overheating risk. • There remains a lack of policy and funding to address climate change impacts in existing healthcare buildings and to incentivise uptake of adaptation interventions. • All NHS Trusts have Green Plans in place. Long-term adaptation should be included in Green Plans going forward, for all Trusts and Integrated Care Systems (ICSs). • There remains a need for a long-term adaptation plan that spans the care sector, including domiciliary care.	• The Oxfordshire Strategic Plan highlights that they aim to use assistive technology to improve access to services for vulnerable people. This may improve health service access during periods of extreme weather.	Access to healthcare Healthcare building adaptation policies Healthcare building adaptation funding

Town and cities	Towns and cities are prepared for and resilient to river and coastal flooding	• Current flood and coastal erosion risk management policy and current levels of funding represents significant progress in adaptation, allowing the Environment Agency and other risk management actors to deliver adaptation actions. • The updated Environment Agency strategy is integrated across all sources of flooding, which is positive progress. • It is too early to assess the effectiveness of implementation of many of the policies and plans.	• The Oxford Flood Alleviation Scheme aims to reduce flood risk in Oxford. • The Oxfordshire Green Infrastructure Framework, linked to the Oxfordshire Local Flood Risk Management Strategy, will improve the flood resilience of urban areas.	Flood resilience plans
	Towns and cities are prepared for and resilient to surface water and groundwater flooding	• Recent policy progress has included local surface water management planning and commitments to better model surface water flood risk. The implementation of Schedule 3 and engagement with water and sewerage companies through drainage and wastewater plans are also key positive policy progresses. • However, more buildings are at risk of surface water flooding and trends suggest urban impermeable surfaces are increasing. Schedule 3 does not provide mechanisms for slowing increase in unplanned impermeable urban surfaces. Risk mapping of urban surface water and groundwater flooding still lags other flood risk sources. • It is too early to evaluate progress towards delivering new policies and current plans lack consistent monitoring frameworks to ensure future climate change is considered.	• The Oxford Flood Alleviation Scheme aims to reduce flood risk in Oxford. • The Oxfordshire Green Infrastructure Framework, linked to the Oxfordshire Local Flood Risk Management Strategy, will improve the flood resilience of urban areas.	
	Urban heat risks to Towns and Cities are mitigated	• Urban heat risk management at the settlement scale lacks overarching vision within policy. • National planning policy, combined with emerging policies for biodiversity net gain and management of green and blue space, could enable urban design which promotes cooling measures, but these policies are currently inconsistently applied. • Monitoring delivery of adaptation measures, such as green infrastructure, is lacking, resulting in limited evidence to evaluate.	• The Oxfordshire Green Infrastructure Framework should reduce the urban heat island effect.	Urban heat management Monitoring of green infrastructure

	A planning system which prioritises future climate resilience	• Recent updates to guidance on floodplain planning is limiting new development at risk of flooding, although some development is still occurring against advice. New guidance for green infrastructure is also in progress, but overall, climate resilience is not embedded nor sufficiently enforceable within spatial planning policy. • Climate resilience measures are largely considered as guidance, resulting in inconsistent implementation and delivery. There is potential for planning and environmental improvement policies to enable planning decisions to consider adaptation, but clear mechanisms are currently lacking. • Planning policy lacks standards and mechanisms for monitoring the inclusion and maintenance of climate resilience measures.	• The Oxfordshire Strategic Plan 2022-2025's first strategic priority is to address the climate emergency, which includes prioritising climate action and community resilience in planning. • All the local district Local Plan's identify that building resilience to climate change is a priority.	Enforcement of floodplain planning guidelines Implementation of climate resilience measures
Community preparedness	Communities are prepared for climate shocks	• The level of planning for adaptation is low within local councils but public awareness of climate impacts appears relatively high. • More people are now covered by flood warning systems but household preparedness is low. • Mandatory reporting by local authorities, public information and engagement and support for vulnerable groups are not yet in place. There are warning systems in place for flooding and heat waves. Annual resilience reports to Parliament are a positive development.	• Cherwell District Council's Local Plan and Cherwell Sustainable Community Strategy 'Our District Our Future' sets out mitigation and adaptation actions for the community.	Adaptation planning
				Warning systems
	Communities can respond to climate shocks	• Indicator data for this outcome is mostly available for flood events; data for other extreme weather events are very limited. Most people act after receiving a flood warning. • Some of the key policy milestones are in place, but consideration of vulnerable groups is missing and resilience standards could be strengthened. • The UK Government Resilience Framework was a positive step forwards since 2021 to improve local level resilience.	• Unknown	Household preparedness Vulnerable population resilience
	Cultural heritage is sustained	• Outcome-level evidence is very limited. • The new UK Government Resilience Framework has suggested several potential steps forward for local-level adaptation which would be positive if implemented.	• Unknown	Reporting from key cultural organisations

		• Mandatory reporting from key organisations is missing.		

	Credible policies and plans		Partial policies and plans		Limited policies and plans		Insufficient policies and plans

D.3. Natural environment and assets

National progress on natural environment and assets	Summary of national policies and plans	Summary of OCC-related policies and plans	Progress assessment of policies at OCC level

Nature	Terrestrial habitats in good ecological health	• The Environmental Improvement Plan (EIP) details ambitious targets for thriving plants and wildlife to boost the resilience of terrestrial habitats to climate change but is vague on how the policies and investments will meet the targets. • The Nature Recovery Network encourages habitat connectivity to support species resilience and states that climate adaptation will be an outcome of increased connectivity and species protection. • The Nature Strategy outlines funding for nature-based solutions, environmental targets, and legislative reform. • The GB Invasive Non-Native Species Strategy sets our actions to reduce their threat due to climate change. • Biodiversity Net Gain will become a legal condition in November 2023 whereby all new developments must create 10% net gain for biodiversity. • Natural England's Green Infrastructure Framework is aimed at local planning authorities to increase greenspace in urban environments.	• The Oxfordshire Biodiversity and Planning Guidance provides information on protecting biodiversity in Oxfordshire such as wildlife sites, habitats and species. • 3 AONBs ensure environmental protection for large natural areas in the county through local, national planning policies and legislation. • 37 Conservation Target Areas in the county provide a focus for delivering biodiversity enhancements. • One of the priorities of the OCC Strategic Plan is preserving and improving access to nature and greenspaces.	Biodiversity enhancements
		•	•	Nature preservation
	Freshwater habitats in good ecological health	• The third cycle update of the River Basin Management Plan (RBMP) underpins water regulation and delivering clean water. The EA incorporated findings from risk assessments for climate change under 2°C and 4°C scenarios. • Natural England published Nutrient Neutrality advice to address nutrient pollution from existing developments, agriculture and wastewater.	• Building Oxfordshire's Freshwater Network[295] is funded by the Green Recovery Challenge Fund to protect freshwater wildlife and create a network of healthy freshwater landscapes. For example, the project aims to create Floodplain Wetland Mosaics.	Freshwater network

[295] Building Oxfordshire's Freshwater Network - Freshwater Habitats Trust Freshwater Habitats Trust

Working land	Climate resilient agricultural production	• The Food Strategy does not include sufficient consideration of the risks and impacts of climate change on food supply. • The EIP details farm-specific commitments to build resilience such as supporting farmers to create/restore hedgerows. • The National Pollinator Action Plan includes ways to build evidence on how resilient agricultural systems are to changes in pollinator populations. • New government funding for farm innovation and improved water management. £10 million water management grant is for improvements to efficient water use and reduce the risk of drought to the sector. £168 million in grants will support food production, drive innovation, protect the environment and improve animal welfare.	• The University of Oxford developed 'The Oxford Principles for Net Zero Aligned Carbon Offsetting' that provides guidelines on how carbon offsetting can contribute to net zero strategies particularly in sectors that are challenging to decarbonise, such as agriculture.	Food strategy Farm resilience
Forestry	Climate resilient commercial forestry sector	• The UK Forestry Standard Practice Guide details how to assess risks associated with climate change and adapt forest and woodland management but relies on uptake of forestry and woodland managers. • The Woodland Creation Accelerator Fund with £9.8 million will support over 60 local authorities to enable woodland creation projects. • The Tree Health Pilot scheme tests different ways to slow the spread of pests and diseases affecting trees in England. • The Tree Health Resilience Strategy aims to protect trees from pests and diseases. The Government is set to update the Strategy in 2024 to improve the adaptive capacity of woodlands under climate change.	• The Oxfordshire Treescapes Project aims to create opportunities to maximise nature recovery alongside food production. They work with farmers and landowners to create treescapes to address biodiversity loss, capture carbon, reduce flood risk, and contribute to human wellbeing. • Oxford City Council published the Oxford Urban Forest Strategy Master Plan to 2050 which aims to grow and expand the city's urban forest to tackle climate change.	Forestry resilience Tree health schemes

(green)	Credible policies and plans	(yellow)	Partial policies and plans	(amber)	Limited policies and plans	(red)	Insufficient policies and plans

D.4. Business and industry

National progress on business and industry		Summary of national policies and plans	Summary of OCC-related policies and plans	Progress assessment of policies at OCC level
Business	Public and private adaptation measures to minimise risks to business sites	• The Environment Act 2008 did not include a proposed 9% reduction in non-household water demand by 2037 despite support from water retailers. • The British Standards Institute created a standard on 'Adaptation to climate change. Guidelines on vulnerability, impacts and risk assessment'. •	• The Zero Carbon Oxford Partnership is a collaboration between Oxford's major businesses, universities and council to reduce carbon emissions and develop funding bids. For example, Landsec – one of the partners – announced a £135 million net zero transition investment plan. • The Oxford Flood Alleviation scheme aims to reduce flood risk to businesses thereby reducing financial damage to business sites.	• Public adaptation measures • Private adaptation measures
	Access to insurance and capital (for adaptation)	• The UK currently lacks substantial schemes dedicated to providing financial support for businesses to deliver climate adaptation. • Flood Re applies only to households and not to businesses or non-residential buildings. • The UK Infrastructure Bank has focussed on emissions reduction in financing projects but has not demonstrated a firm commitment to Net Zero and adaptation together.	• OCC have invested £40 million in a project for replacing 65% of street lighting with energy-efficient LED's. • OCC have secured £3 million in funding to decarbonise and implement energy efficient measures across OCC buildings.	• Capital for adaptation
	Minimise productivity losses due to physical climate risks	• Health and Safety Executive has guidance on temperatures, heat stress and thermal comfort for businesses. However, it does not contain long-term adaptation plans.	• Unknown.	• Worked productivity mitigation

	Management of supply chain risks	• The government requires domestic suppliers to provide reports through the Adaptation Reporting Power (ARP) which details the effects of climate change on critical infrastructure and their adaptation plans but these remain voluntary. • Climate change is not explicitly considered in the Department for International Trade's resilience framework for building resilience in supply chains. • The EA have taken changing risks from weather and climate into account in their procurement process. •	• Project LEO, supported by the Oxfordshire Strategic Plan, attempts to address disruptions to the energy network by achieving a decentralised energy system. • Energy providers such as SGN and National Grid have published 3rd Rough Climate Change Adaptation Reports. • The OCC have added a new social value procurement policy driving the consideration of a low-carbon supply chain for the OCC's purchases. • OCC use a Renewable Energy Guarantees of Origin (REGO) backed green electricity supply for OCC estate and highways assets.	• Supply chain adaptation policy • • Supply chain resilience - energy
	Disclosing and managing risks and actions	• The Government accounted new Sustainability Disclosure Requirements in 2021 with an accompanying roadmap to sustainable investments.	• Unknown.	• Disclosing risks
Industry	Green Infrastructure	• The National Framework of Green Infrastructure is the government's commitment to deliver more green infrastructure to enhance cities and investable places.	• The Oxfordshire Green Infrastructure Framework demonstrates how investments in green infrastructure can help climate change adaptation efforts and also demonstrate the societal, economic, and environmental value nature can bring to cities. • The Net Zero Carbon toolkit includes considerations on enhancing Green Infrastructure to benefit communities.	• Green infrastructure

Zero-Carbon Targets	• UK Net Zero Strategy[296] will secure over 400,000 jobs in green industries and unlock £90 billion in private investment by 2030. • Government has set out a plan for supporting British businesses in transitioning to clean energy and green technology. • The focus of this plan is on supporting low carbon technologies. •	• Pathways to Zero-Carbon Oxfordshire is a cross-collaboration project that plans to expand the solar generating capacity of Oxfordshire. • OCC are committed to become carbon neutral by 2030 and seeking to be net zero ahead of the national 2050 target.	• Zero-carbon targets • Carbon neutral targets
Electric Vehicles	• The UK Elective Vehicle Infrastructure Strategy sets out the plan for rolling out electric vehicle charging infrastructure by ending the sale of new petrol and diesel vehicles by 2030 and for new vehicles to be fully zero emission at the tailpipe by 2035.	• The Oxfordshire Elective Vehicle Infrastructure Strategy sets out how Oxfordshire's district councils can implement EV infrastructure to support the county's transition to decarbonising transport. • OCC have included investment in a fleet of electric vehicles and charge points in the OCC budget plans for 2023/24 to support climate objectives and reduce whole lifecycle costs.	• Electric vehicle infrastructure

	Credible policies and plans		Partial policies and plans		Limited policies and plans		Insufficient policies and plans

[296] UK's path to net zero set out in landmark strategy - GOV.UK (www.gov.uk)

Appendix E. Additional mapping

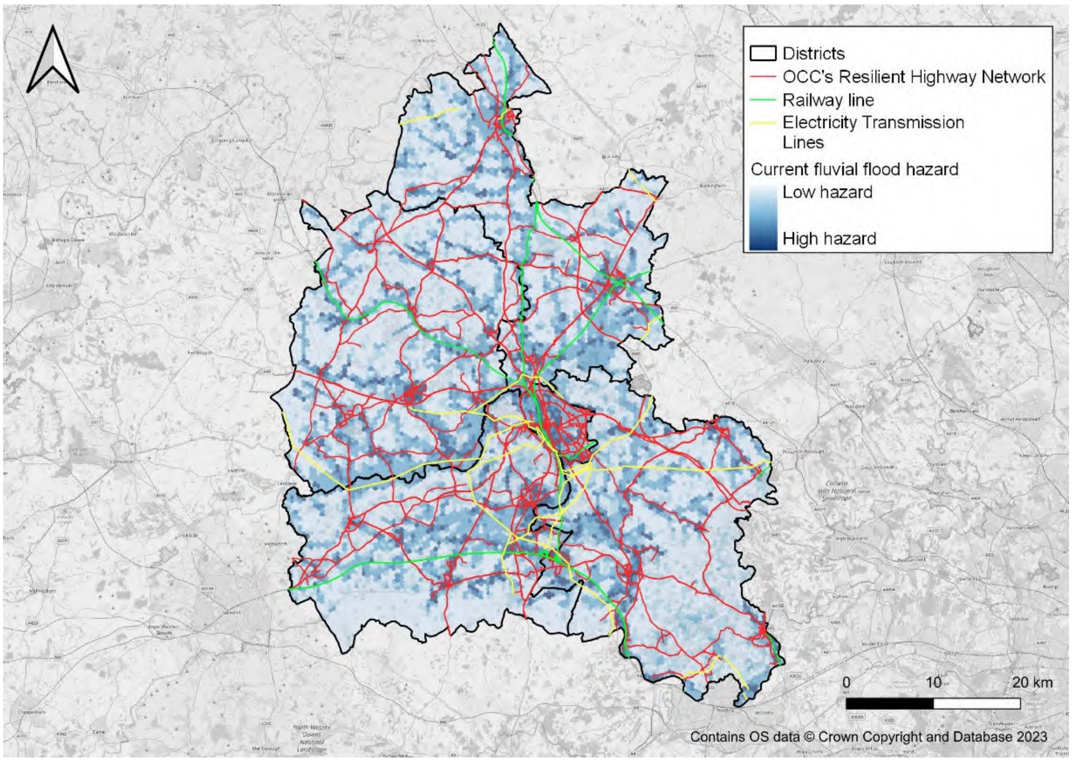

Figure 5-1 – Current fluvial flood hazard in Oxfordshire and critical infrastructure

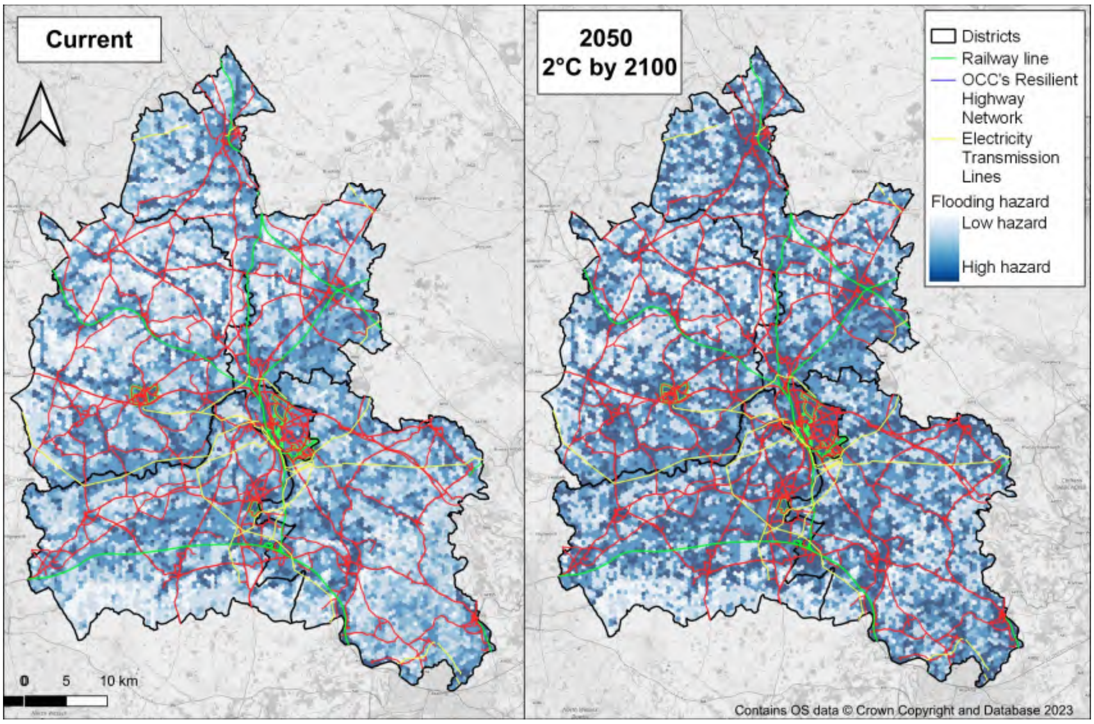

Figure 5-2 - 2050 flood hazard versus current flood (fluvial and surface) hazard and critical infrastructure in Oxfordshire

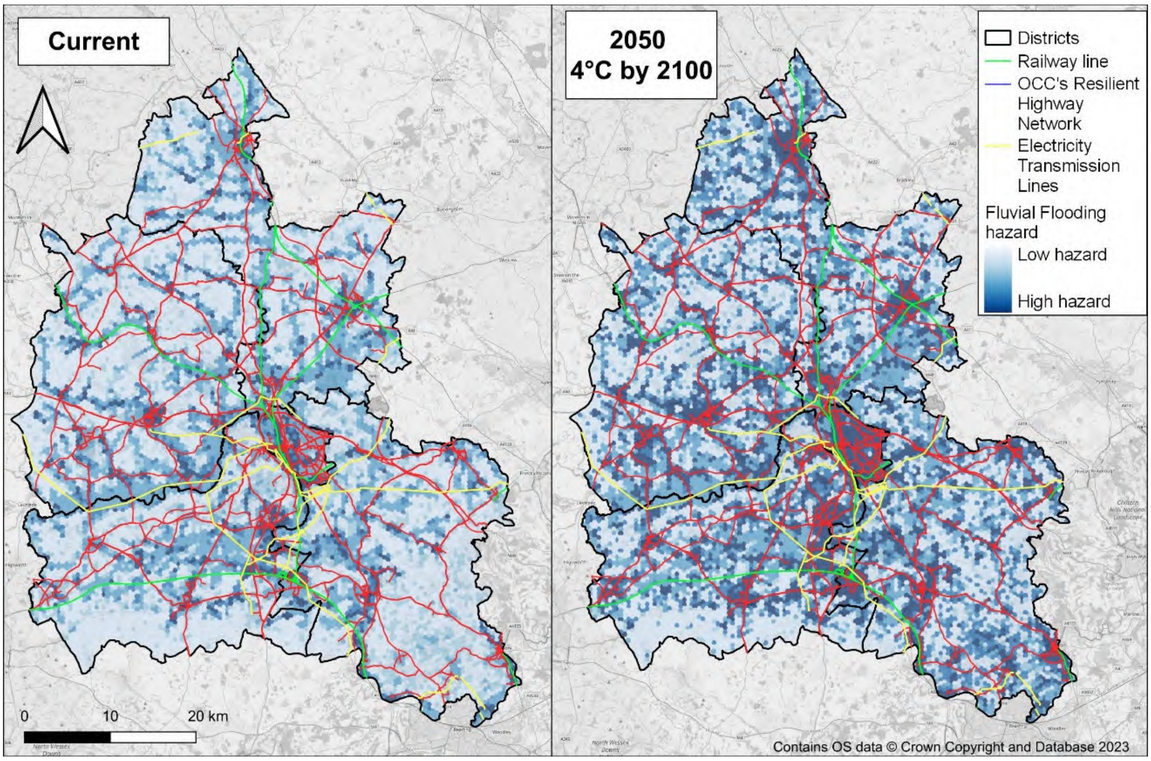

Figure 5-3 – 2050 +4°C warming by 2100 fluvial flood hazard versus current fluvial flood hazard and critical infrastructure in Oxfordshire

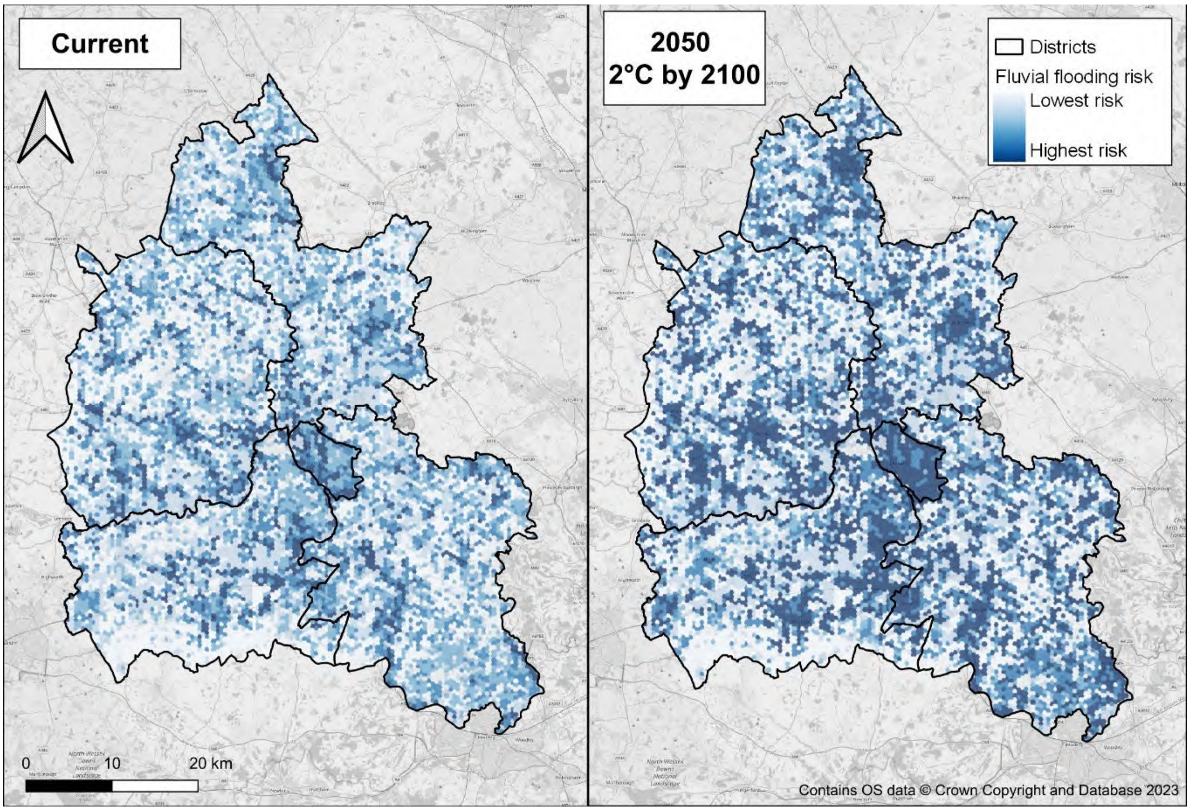

Figure 5-4 - 2050 +2°C fluvial flooding risk versus current fluvial flooding risk

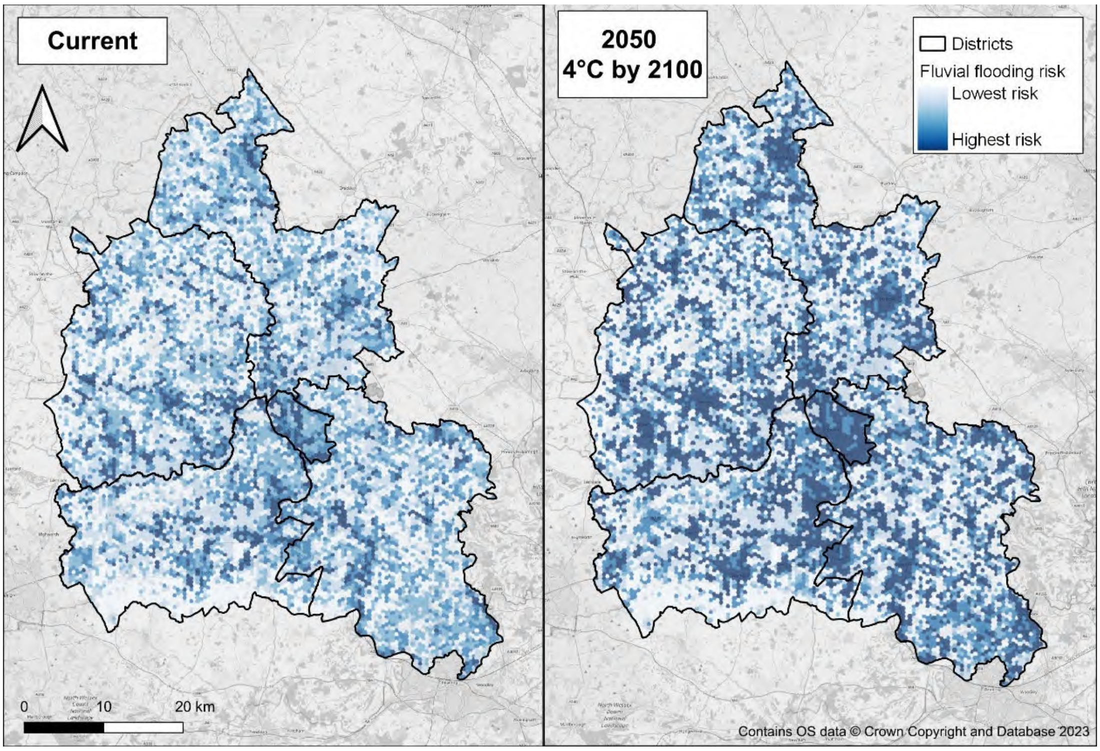

Figure 5-5 - 2050 +4°C fluvial flooding risk versus current fluvial flooding risk

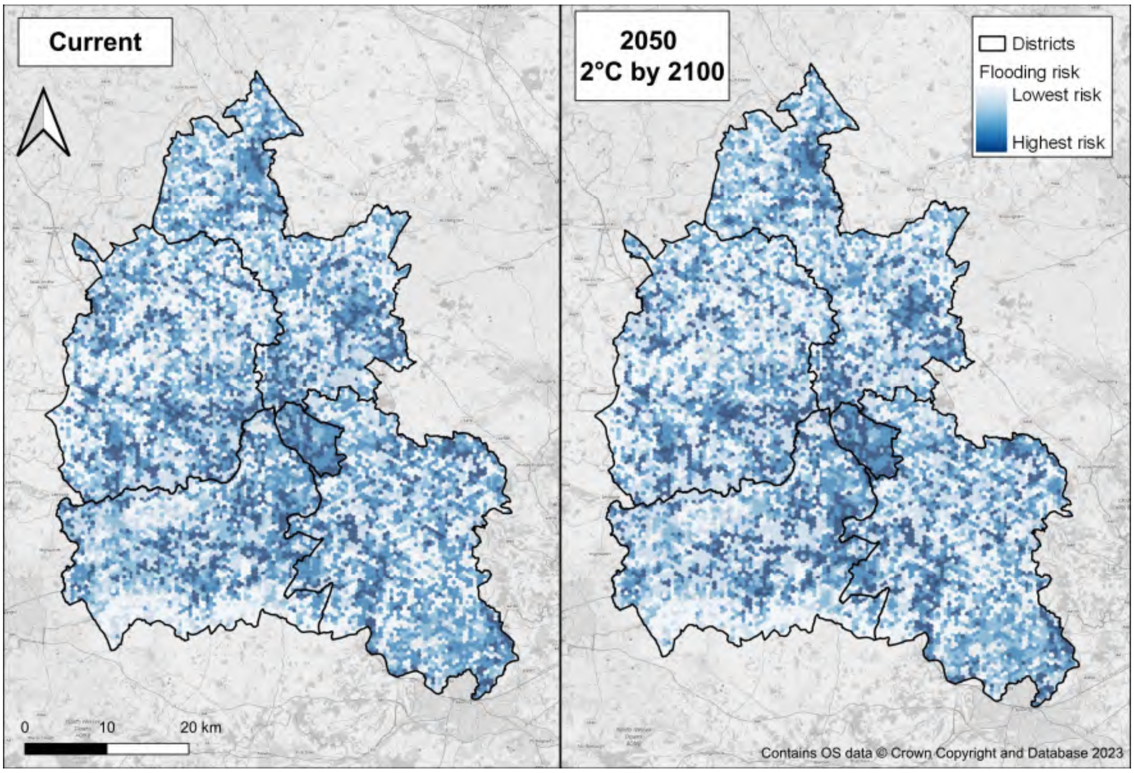

Figure 5-6 – 2050 +2°C flooding (surface and fluvial) risk versus current flooding (surface and fluvial) risk

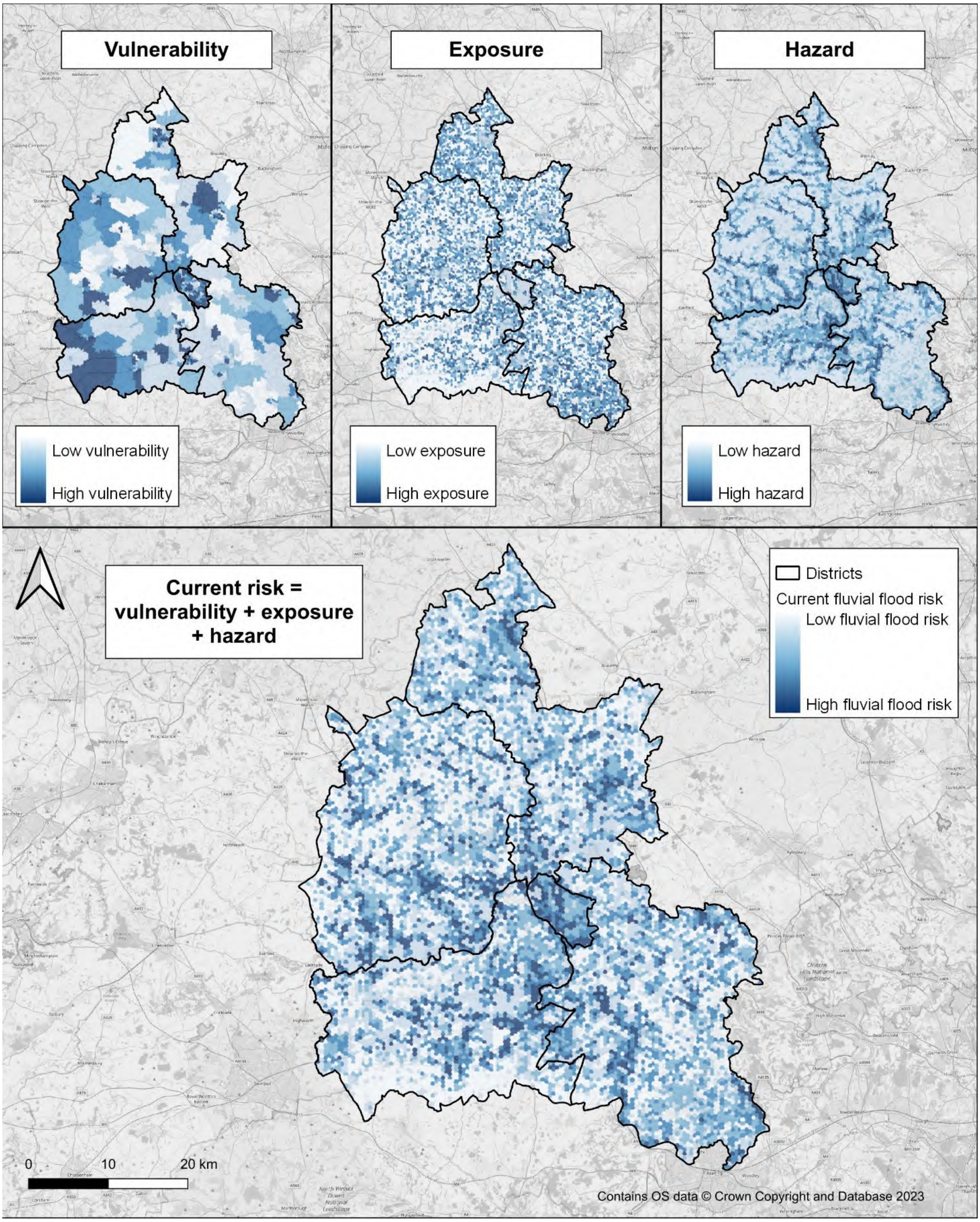

Figure 5-7 – Current fluvial flood risk in Oxfordshire

Appendix F. Analysis of Evidence Gaps

Table 1. Evidence Summary and Gap Analysis by theme

	Evidence in the CRA	Gaps in CRA	Agreed actions for AtkinsRéalis or OCC	Potential further work for OCC, supply chain or research partners
Overview	• Oxfordshire County Council (OCC), Oxford City Council and the four Oxfordshire District Councils declared a Climate Emergency in 2019, making significant commitments towards Net-zero before 2050[297] as well as climate action to improve climate resilience. • The Draft OCC CRA provides an assessment of current and future vulnerability to floods, heatwaves, cold snaps, droughts and windstorms (Table 2). It presents original analysis at the ward scale that can be used to identify the most at risk wards for flood risk and heatwaves risks. • It includes analysis of the baseline climate, major hazard events from 2007 and 2023 and future climate change for the 2050s and beyond. • It provides an assessment under four themes outlined below, based on data from the UKCP18 climate change projections, Environment Agency flood maps and local data provided by OCC and its partners.	• The CRA overs all the major risks in the national CCRA3 assessment, but the strongest evidence, including detailed maps, was presented in relations to floods and heatwaves risks. • More local evidence is needed on future extremes, separation of river and surface water flooding, water supply, droughts, windstorms and interdependencies would strengthen the CRA. • The CRA was completed after the heatwaves of July 2022 but before the recent severe flooding in January 2024, which caused damage and disruption across the County. In addition the 10 named storms recorded this storm season have highlighted risks related to heavy rainfall and windstorms.	• Further work is ongoing on surface water flooding, which should be completed in late February 2024 (OCC and AR floods teams) (AR) • Disaggregation of river and surface water mapping; river flooding evidence to presented alongside new surface water flooding analysis. • Additional summary information will be added on water resources and water supply risks and windstorms (AR) • Handover of selected GIS data showing the results of the climate risk mapping will be provided to OCC for further work.	• Development of a Summary Report to support strategy development • Handover of all GIS layers that were used to create the vulnerability maps with metadata and handover notes. • Extreme value analysis of extreme heat and potential impacts on health (morbidity and mortality) and infrastructure, e.g. road surface damage. • Case study of January 2024 floods and impacts across the County • More detailed work on climate change impacts on the natural environment including land, air and water quality • Completion of Adaptation Reporting Power 4 report for submission to Defra in December 2024 • More detailed systems modelling on interdependencies, compound risks and cascading failures
Critical Infrastructure	• Critical infrastructure was mapped including transport systems, power systems and major water resources features.	• *The report is reasonably strong in this section.* • Some further work on water resources and water supplies requested.	• Additional text on water resources risks signposting Thames Water WRMP and any additional OCC information.	• *As above.* • Water resources systems do not map well on to a local areas in OCC. The main water resources zones in Swindon and West Oxfordshire, and

[297] Enabling a net-zero county | Oxfordshire County Council

	Evidence in the CRA	Gaps in CRA	Agreed actions for AtkinsRéalis or OCC	Potential further work for OCC, supply chain or research partners
	• Flood risk assessment for surface water and river flooding mapped all assets exposed to flooding • Extreme heat and its impacts were assessed using an innovative vulnerability mapping approach • Local and national policies were reviewed, highlighting gaps in plans and progress in the County		• Still reviewing Thames Water supply data. • Some updates are being made to version 5, to reflect the recent windstorms and flood events.	therefore the best available water balance and future climate change assessment is Thames Water's Water Resources Management Plan (although this may be disputed by OCC and the Vale as they don't support the SESRO reservoir scheme). • The best approach for OCC may be to highlight the significant water supply risks and make the links with water demand, water efficiency and water recycling at the household and business level. Moving towards water neutrality for new development and encouraging greater water efficiency will help the County manage future risks. Promoting demand side measures aligns with LLG policies.
Health, Communities and Built Environment	• Population and key indicators were mapped including indices of multiple deprivation, as well as hospitals, GP practices, care homes, schools, all building footprints and listed buildings. • Flood and heat vulnerability mapping identified the most at risk communities • A more detailed assessment was completed on the health impacts of climate change, including making linkages to cardiovascular, respiratory diseases and mental health. • Local and national policies were reviewed, highlighting gaps in plans and progress in the County	• *The report is reasonably strong in this section as additional work on health risks has been completed and the vulnerability mapping approach helps to highlight and target the most vulnerable communities.* • *The proposed EVA work would strengthen this chapter further.*	• *As above.*	• *As above.* • In particular an Extreme value analysis of extreme heat and potential impacts on health (morbidity and mortality) and infrastructure, e.g. road surface damage. • A County Wide Heat Resilience Plan • A review of property level flood resilience and its potential effectiveness to reduce risks • Study making strong links between decarbonisation of estates and need for climate resilience to extreme heat, floods and periods of drought.
Natural Environment and Assets	• Landscape character, land use, environmental designations etc. were mapped.	• *The report is weaker in this section partly due to the lack of available data (e.g. lack of data sharing from TVERC)*	• *None agreed but will add a few further links in the report v5*	• *Landscape Recovery and Natural Flood Management* opportunities study

	Evidence in the CRA	Gaps in CRA	Agreed actions for AtkinsRéalis or OCC	Potential further work for OCC, supply chain or research partners
	• Exposure to high temperatures was explored using selected indicators. • Local and national policies were reviewed, highlighting gaps in plans and progress in the County	• *Make some further links between high air temperatures and river temperatures e.g.* keeping-rivers-cool.pdf (woodlandtrust.org.uk) • *Signposting ongoing work by catchment partnerships and other organisations in Oxfordshire e.g. on erosion risk mapping* • *See AtkinsRéalis work with the Evenlode catchment* Landscape Recovery in the Evenlode (arcgis.com)		• *The use of catchments to store and control water flows, the "whole farm reservoir" concept.* • Working with catchment partnerships to understand impacts on ecosystem services (Evenlode, Windrush, Thame, Ock catchment partnership etc.…) • Blenheim Palace case study what are the risks and how are these being managed? • Highlighting new Biodiversity Net Gain requirements and the need to consider climate change in maintenance of habitats for 30 years. • Linkages to the Trust for Oxfordshire's Environment (the county's BNG brokers) • Environmental permitting climate risk requirements (Environment Agency) • Links with OUCE on their habitat mapping projects, including Professor Pam Berry's "climate space" work.
Business and Industry	• A higher level narrative was provided for business and industry. • Local and national policies were reviewed, highlighting gaps in plans and progress in the County	• *The report is weaker in this section as business and industry impacts are mostly indirect impacts linked to above themes.*	• *As above.*	• Climate Finance Disclosure awareness programme • Review of OCC pension scheme, Paris Alignment and investment choices
Other aspects including disclosure	• An overall risk scorecard summarised the relevant CCRA3 risks and links these to hazards, baseline risk and future risks under a 2 degree and 4 degree pathway. It also summarised current OCC adaptation related policies and plans.	• *The report is primarily and evidence report to support strategy development.* • *It may be published but is not a disclosure document.*	• *As above.*	• ARP4 report submission to Defra may be needed.

Table 2. A high level summary matrix of the evidence, what is in the CRA, what is not, potential gaps and what additional work is ongoing or being considered (Self-assessment by Cara O'Keeffe and Steven Wade)

Clear evidence within the report with minor gaps	**Additional work ongoing or agreed*	*Evidence available with gaps / further work in future*	***Potential to fill gaps with additional work to be confirmed*	*Insufficient evidence provided in WP1*	*Not relevant / data unavailable or high uncertainty in future projections*

Hazard	**Thematic area**							
	Critical Infrastructure		**Health, Communities and Built Environment**		**Natural Environment and Assets**		**Business and Industry**	
	Current baseline	*Future scenarios*	*Current baseline*	*Future scenarios*	*Current baseline*	*Future scenarios*	*Current baseline*	*Future scenarios*
Flooding	Hex mapping of current flood risk presented (fluvial and surface flood risk). Lengths and counts of infrastructure in high risk areas provided. Expected damages based on CCRA3 evidence.	Hex mapping of future flood risk presented (fluvial and surface flood risk combined). Lengths and counts of infrastructure in high risk areas provided. Expected damages based on CCRA3.	Hex mapping of current flood risk presented (fluvial and surface flood risk). Counts of key amenities and vulnerable demographics in high risk areas provided.	Hex mapping of future flood risk presented (fluvial and surface flood risk). Counts of key amenities and vulnerable demographics in high risk areas provided.	Qualitative comments only. Focus on other hazards: heatwaves and drought. Evidence provided at national level in Appendix B.	Qualitative comment on future trends for this thematic area.	Qualitative comment based on literature review and timeline of past events with impacts. Evidence provided at national level in Appendix B.	Qualitative comments based on analysis from other thematic areas.
			Significant research/literature review provided in Health Impact Assessment chapter.					
	**Note that evidence on river and surface water flooding is being disaggregated and further quantification of expected flood damages is ongoing for surface water flooding using local flood maps and buildings data*							

Heatwave	Hex mapping of current heat risk presented based on urban heat island, green space and cooling demand. Lengths and counts of infrastructure in high risk areas provided.	Hex mapping of current heat risk presented based on urban heat island, green space and cooling demand. Lengths and counts of infrastructure in high risk areas provided.	Hex mapping of current heat risk presented. Counts of key amenities and vulnerable demographics in high risk areas provided. Significant research/literature review provided in Health Impact Assessment chapter.	Hex mapping of future heat risk presented. Counts of key amenities and vulnerable demographics in high risk areas provided. *Interest in more detailed heat risk assessment across all sectors*	Baseline max temperature data provided overlaid with Local Wildlife Site and Conservation Target Areas. Evidence provided at national level in Appendix B.	Future Met Office Heatwave analysis over Local Wildlife Sites and Conservation Target Areas. Dairy cattle heat stress and growing degree days also analysed. Wildfire analysis also completed based on future Met Office Fire Danger events.	Qualitative comment based on literature review and timeline of past events with impacts. Evidence provided at national level in Appendix B.	Qualitative comment based on analysis from other thematic areas.
	**Potential for Extreme Value Analysis (EVA) of extreme heat on road infrastructure and water demand.		**Potential for EVA of heatwaves and impacts on health (mortality and morbidity)		**Potential to consider other environmental impacts of extreme heat.		**Potential for EVA of heatwaves and impacts on productivity.	
Low temperatures	Qualitative comment based on timeline of past events and impacts and stakeholder engagement. Evidence provided at national level in Appendix B.	Analysis of future Cold Weather Alerts in OCC provided.	Qualitative comment based on timeline of past events and impacts and stakeholder engagement. Evidence provided at national level in Appendix B.	Analysis of future heating degree days in OCC provided.	Evidence provided at national level in Appendix B.	Scoped out with focus on heatwave, wildfire and flooding.	Scoped out for current baseline	Scoped out for future with focus on key focus on relevant hazards (flooding, heatwave, transition risks and cascading risks)
Drought	Evidence provided at national level only in Appendix B.	Future soil moisture analysis completed.	Evidence provided at national level in Appendix B.	Qualitative comment based on changes in soil moisture deficit.	Qualitative comment based on timeline of past events and impacts and stakeholder engagement. Evidence provided at national level in Appendix B.	Qualitative comment on future trends for this thematic area based on projections presented in other thematic areas.	Evidence provided at national level in Appendix B.	Scoped out for future with focus on key focus on relevant hazards (flooding, heatwave, transition risks and cascading risks)
	*Agreed to write some headline text to strengthen water resources section referring to Thames Water documents and focused on water demand.							
	**Potential further analysis of Thames Water supply data. Looking at this now.							

High winds / storms 	Qualitative comment based on timeline of past events and impacts and stakeholder engagement. Evidence provided at national level in Appendix B.	Qualitative comment on high winds/storms due to highly uncertain trends in future winds and storms. * Agreed to strengthen this section in Exec Summary with latest Met Office thinking. AR - Cara	Evidence provided at national level in Appendix B.	Qualitative comment on high winds/storms due to highly uncertain trends in future winds and storms.	Evidence provided at national level in Appendix B.	Scoped out with focus on key relevant hazards to the natural environment.	Scoped out for current	Scoped out for future with focus on key focus on relevant hazards (flooding, heatwave, transition risks and cascading risks)
Cascading risks	Evidence provided at national level in Appendix B.	Qualitative comment but highly uncertain so not fully assessed.	Evidence provided at national level in Appendix B.	Qualitative comment but highly uncertain/lack of data so not fully assessed.	Evidence provided at national level in Appendix B.	Qualitative comment but highly uncertain/lack of data so not fully assessed.	Evidence provided at national level in Appendix B.	Qualitative comment but highly uncertain/lack of data so not fully assessed.
Other	*** Ongoing work on producing a summary table and pricing a short summary report.*							
	OCC may wish to submit an ARP in December 2024, which would need to use the evidence from the report to fill a template. They may be some logic in structuring a summary report around ARP4 requirements for Local Authorities.							

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