ITEM No …3……..

REPORT TO: **CLIMATE, ENVIRONMENT AND BIODIVERSITY COMMITTEE**

REPORT ON: **DUNDEE CLIMATE RISK AND VULNERABILITY UPDATE**

REPORT BY: **EXECUTIVE DIRECTOR OF CITY DEVELOPMENT**

REPORT NO: **76-2025**

1 PURPOSE OF REPORT

1.1 To inform the Committee of the results of the Dundee Climate Risk and Vulnerability Assessment (CRVA) update that took place during 2024, including progress on the action to establish a regional adaptation partnership.

2 RECOMMENDATION

2.1 It is recommended that the Committee:

a. notes the adverse risks highlighted in the CRVA 2024; and

b. endorses the recommended adaptation options proposed.

3 FINANCIAL IMPLICATIONS

3.1 The CRVA highlights the financial risk incumbent in not taking measures to adapt people and places to the climate change that is already happening, as well as the Met Office projected increases. Funding will be required to implement the recommended interventions, and these will be explored at a local and regional level.

4 BACKGROUND

4.1 Dundee City Council launched the city-wide Climate Action Plan in 2019; co-designed by public, private and community partners across the city and covering the themes of Energy, Transport, Waste and Climate Resilience (adaptation). The Climate Resilience Actions were based on Hazards, Risks and Impacts identified in a Climate Risk and Vulnerability Assessment (CRVA) in 2018 as part of the Dundee Climate Action Plan 2019.

4.2 The Dundee Climate Leadership Group (DCLG) identified climate adaption as a workstream that merited collective attention. As a first step to future adaptation planning in Dundee, a Natural Capital Baseline Assessment was commissioned by the DCLG in January 2023, providing a full account of the ecosystem services and biodiversity in the city's green space.

4.3 Following this assessment, it was subsequently agreed by the DCLG that an update of the CRVA was required, due to the time that had lapsed since the first CRVA was conducted, which should also consider:

a our increased understanding of risk since the COVID-19 epidemic;

b the increased urgency of the climate and nature emergency;

c the broader expertise we now have access to through our expanded networks and partnership working as well as new tools that are available;

d and the need to understand the impact of climatic changes since the last risk assessment.

4.4 The final CRVA was commissioned in January 2024 and completed in November 2024 containing four sections:

a Climate Change profile of Dundee.
b Update to the Climate Change Risk and Vulnerability Assessment. This includes:

- Updated approach
- Business and Industry
- Health, Communities and Buildings
- Infrastructure
- Nature
- Risks to Dundee City Council
- Opportunities

c Assessment of costs of recent local climate events.
d An evaluation and presentation of relevant adaptation options.

4.5 Council Officers will review the adaptation options presented and identify next steps for the Council. The Sustainability and Climate Change team will take lead responsibility for the coordination of relevant Council Officers and ensuring that actions are progressed.

4.6 The CRVA highlights the financial risk incumbent in not taking measures to adapt people and places to the climate change that is already happening, as well as the Met Office projected increases. Funding will be required to implement the recommended interventions, and these will be explored at a local and regional level.

4.7 Running parallel to the CRVA has been the development of a regional adaptation partnership for Tayside, including Perth and Kinross and Angus Local Authorities, supported by Adaptation Scotland. This partnership has been developed in recognition of the need (and advantages) of working on a regional basis to address many climate impacts. Climate risks are not contained within local authority boundaries. Risks, vulnerabilities and resilience measures can have a large impact on neighbouring areas. Work to date on this has included:

a Four workshops with different sectors to identify priorities for regional adaptation. These were attended by over 60 people, from 34 organisations.
b Out of the 367 suggestions proposed, 6 priorities were identified and were used to form a Vision for the partnership.

- Share clear communications to raise awareness of climate impacts.
- Support the development of regional projects and innovative pilot projects.
- Promote nature-based solutions and landscape scale restoration.
- Advocate for fair and joined-up adaptation.
- Share knowledge data and resources across the region.
- Attract funding and maximise existing resources.

c A Business Case for the formation and continuation of the Regional Partnership was commissioned by Adaptation Scotland and a five-year route map based on the priorities set out in the Vision document.
d Branding and a website for “Climate Ready Tayside” was developed: Climate Ready Tayside - Partnership helping prepare people and places for a thriving future
e A Climate Resilience Behaviour Change workshop held on 17th February 2025 at Dundee House with representatives from the three Local Authorities facilitated by the Scottish Government.
f Shareback Event held on 11th March 2025 with 50 partners from across the region, launching the branding, vision and website as well as identifying next steps in delivering priorities and involvement level of partners. Results of this are currently being collated and next steps will be identified.

4.8 A Memorandum of Understanding and Terms of Reference between the three Local Authorities is currently being developed.

5 POLICY IMPLICATIONS

5.1 This report has been subject to the Pre-IIA Screening Tool and does not make any recommendations for change to strategy, policy, procedures, services or funding and so has not been subject to an Integrated Impact Assessment. An appropriate Senior Manager has reviewed and agreed with this assessment.

6 CONSULTATIONS

6.1 The Council Leadership Team were consulted in the preparation of this report.

7 BACKGROUND PAPERS

7.1 None

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RP/GH/BW/NC 19/03

Image: Broughty Ferry Source: Visit Scotland

Dundee City Council

Climate Change Risk and Vulnerability Assessment

4th November 2024

Joanna Corrigan | Charlotte Brown

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1. Introduction

1.1 Overview and context

1.2 Approach overview

1.3 Tayside Adaptation Partnership

1. Introduction

1.1 Overview and context

Global carbon emissions need to be reduced to limit climate change. The Climate Change Act and its Net Zero targets commit the UK to reducing emissions by at least 100% by 2050. However, despite efforts to reduce emissions, changes to our climate are already being observed. In the last two decades the UK's climate has been warmer, wetter, and sunnier than any other decade of the 20th century[1]. Nine out of ten of Scotland's hottest years on record have occurred since 2002 and winters over the last decade have had 29% more rain compared to the 1961-1991 average[2]. These changes to our climate and associated risks mean it is vital that the UK prepares for climate change, adapting and becoming more resilient. Recently, Dundee has seen extreme events such as storms bringing flooding and extreme winds which have caused disruption, damage and many other negative impacts. Dundee must become more resilient to climate change.

Climate resilience relates to the ability to anticipate, prepare for, respond and recover from climate induced events. Taking early action to adapt will help increase resilience and reduce risks. There is also strong evidence that investing in adaptation can save money in the long-term.

There are also national drivers for understanding climate risk. The Climate Change (Scotland) Act 2009[3] places a legal duty on public bodies such as Dundee City Council to adapt to the impacts of climate change. Statutory climate change reporting requirements also include provision for public bodies to report on how they are contributing to national objectives for climate change adaptation and resilience.

Dundee City Council is fully committed to addressing the climate change emergency and has so far made good progress by setting ambitious emission reduction targets and implementing its climate action plan. Alongside its mitigation plans, a Climate Change Risk and Vulnerability Assessment (CCRVA) was produced in 2018. However, six years have passed, evidence on climate change and associated risks has changed, and Arup have been commissioned to update the previous risk assessment.

Along with the update of the CCRVA this work also provides a comprehensive overview of how Dundee's climate and the associated climate hazards are likely to change. This reviews the costs of past extreme events to help contextualise the future changes and risks. Finally, a high-level assessment of several adaptation options is presented.

1. Introduction

1.2 Approach overview

Step 1: Create a climate change profile of Dundee

Likely changes to climate in Dundee and the associated changes in climate hazards were analysed using the UKCP18 climate change projections and other relevant Met Office information. The findings of this work are presented in Section 2.

Step 2: Update the Climate Change Risk and Vulnerability Assessment

The 2018 risk and vulnerability assessment was reviewed alongside the latest UK Climate Change Risk Assessment (UK CCRA) and Scotland's national summary to create a new updated list of risks covering the same sectors as the UK CCRA as well as risks specific to the Council as a key organisation. Stakeholder engagement was then used in the form of interviews and a workshop to gather insights from a wide range of stakeholders on which risks were most relevant to the city and how prominent the risks were. Using this information, risks were scored. The risk assessment's key findings are summarised in Section 3.

Step 3: Assess the cost of past extreme weather events in Dundee

The UN's loss and damage framework was tailored to the city and applied to Storms Babet and Arwen to better understand the financial and non-financial costs of damage, disruption and other negative impacts of such events. The risk assessment's key findings are summarised in Section 4.

Step 4: Evaluate and present relevant adaptation options

Nine relevant adaptation options which would make the city more resilient to the four most prominent future hazards are presented. Adaptation options that can be owned by the Council or heavily influenced by the Council were chosen. Multiple characteristics of these options, such as upfront and ongoing costs, staff time, feasibility etc. were assessed and compared. The findings of this work are presented in Section 5.

1. Introduction

1.3 Tayside Adaptation Partnership

Running parallel to this project has been the development of a regional adaptation partnership for Tayside, including Perth and Kinross and Angus Local Authorities[4].

This partnership has been developed in recognition of the need (and advantages) of working on a regional basis to address many climate impacts. Climate risks are not contained within Local Authority boundaries. Risks, vulnerabilities and resilience measures can have a large impact on neighbouring areas.

The Partnership is at a very early stage in its development, an initial working group of the three Local Authorities and Scotland & Northern Ireland Forum for Environmental Research (SNIFFER) has been formed, and work is ongoing to identify synergies in the respective Climate Risk and Vulnerability Assessments, with longer term aims to develop actions and strategies to tackle climate risks at a regional scale.

This work and the findings within this report will be used to help inform the next steps of the partnership, particularly highlighting key risks that are common across the region.

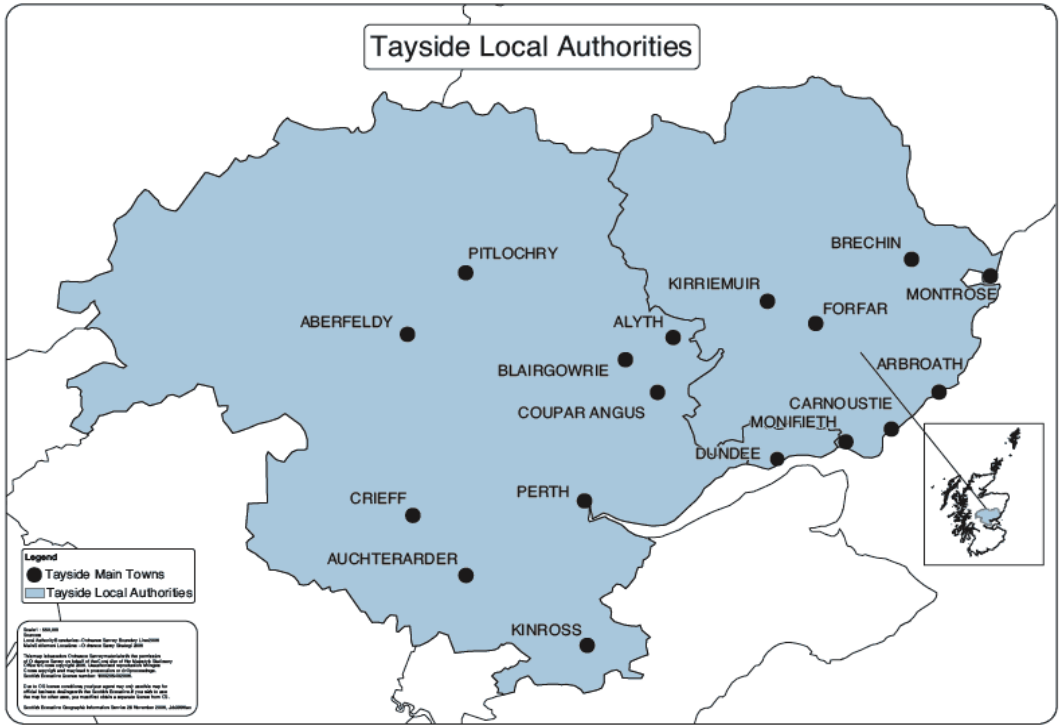


Figure 1. Map of Local Authorities and major towns included in the Tayside Adaptation Partnership. Source: Tayside Adaptation Partnership.

2. Climate change profile of Dundee

2.1 Introduction

2.2 Changes to winter temperatures and extreme cold

2.3 Changes to summer temperatures and extreme heat

2.4 Changes to precipitation

2.5 Changes to growing degree days and storms

2.6 Sea level rise and coastal erosion

2.7 Climate change hazards

2. Climate change profile of Dundee

2.1 Introduction

Understanding how the climate is projected to change locally within the city is an important process in understanding future climate hazards and likely associated risks. Having a better understanding of the future climate helps to add more detail to local risks and is a vital tool in understanding the extent and intensity of impacts.

To help inform the CCRA, climate data was gathered for the city using the UKCP18 climate change projections at a 12km scale as well as UK observation data from HadUK Data[5,6]. Two climate scenarios were used representing both the equivalent to 2°C and 4°C of warming. Multiple metrics that represent changes to temperature and rainfall were gathered. Data on sea level rise and Met Office information on storms and changes to snowfall were also reviewed.

The key changes to climate, the resultant climate change hazards and how they are likely to change are presented in this section. The headline findings are presented within the report, full results of the analysis can be found in the appendix.

Key definitions used in this work:

- **Climate Change** describes the long-term changes to the climate due to global warming (not just temperature change but an overall disruption to weather systems)
- A **Climate Hazard** is a weather-related hazard which is either a result of climate change or has been altered by climate change i.e. flooding is a hazard increased by changes to climate.
- A **Climate Risk** is something negative which may occur as a result of a hazard happening i.e. flooding might cause homes to be damaged.

What is UKCP18?
The UKCP18 is an array of climate models which uses cutting-edge climate science to provide updated observations and climate change projections out to 2100 in the UK.

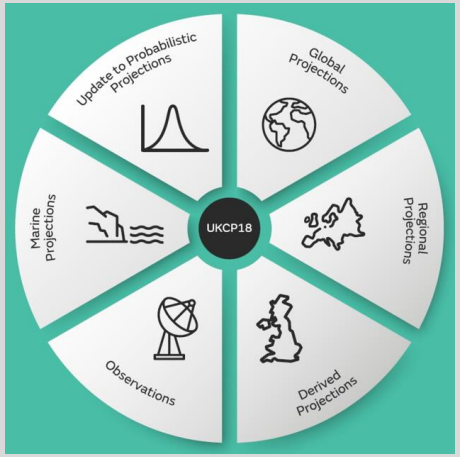


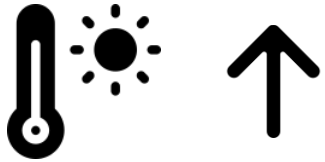
Figure 2. Image: UKCP18 logo, Source Met Office.

2. Climate change profile of Dundee

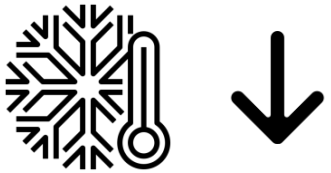
2.2 Changes to winter temperatures and extreme cold

As expected, general warming patterns are found in both average and extreme winter temperatures:

- The number of frost days are expected to halve under a 2°C scenario and reduce by nearly 70% under a 4°C scenario. This has a knock-on impact of a reduction in the number of days with freeze-thaw cycles (number of days above and below freezing).
- The average daily minimum temperature is projected to increase nearly four-fold under the 2°C scenario and by more than five-fold under the equivalent of 4°C of change.
- Mean winter temperatures will increase by nearly 1.5°C (2°C scenario) and by 2.5°C (4°C scenario).
- Additionally, there will be a significant decrease in both falling and lying snow. This will happen in the city, but to a greater extent across highlands in the wider region.

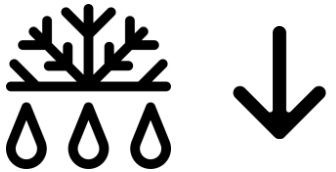


Both average and daily minimum temperatures will increase during the winter



Reduction in the number of days where temperature drops below 0°C (frost days)

Reduction in both falling and lying snow



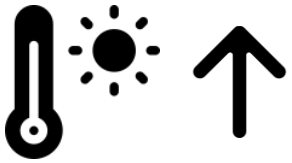
Reduction in freeze-thaw cycles

2. Climate change profile of Dundee

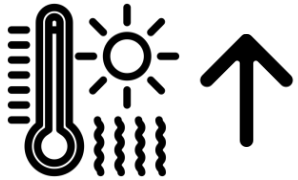
2.3 Changes to summer temperatures and extreme heat

Clear trend in increasing average and extreme summer temperatures:

- Average summer temperatures are projected to increase by 2.35°C under a 2°C scenario, and by 3.7°C under a 4°C scenario.
- Average daily maximum temperatures, are projected to increase by 2.65°C under a 2°C scenario, and by 4.25°C under a 4°C scenario.
- The average number of Met Office defined heatwaves experienced in a year will increase from 0 in the baseline period (1981-2010) to almost 2 a year on average under the 4°C scenario.
- Number of days reaching above 25°C will increase significantly under a 4°C scenario from just over one on average to nearly 14 on an average year, an increase of 1016%.



Both average and daily maximum temperatures will increase during the summer months



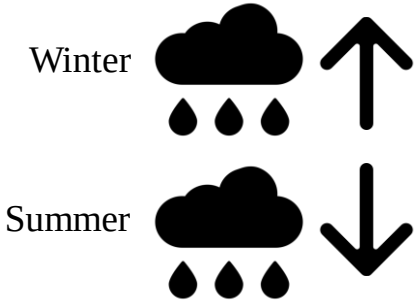
Both the number of days and the temperatures of heatwaves will increase, causing increase in heat stress

2. Climate change profile of Dundee

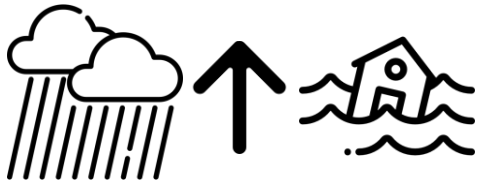
2.4 Changes to precipitation

Seasonal rainfall patterns are projected to change, heavy rainfall events and dry periods are likely to increase.

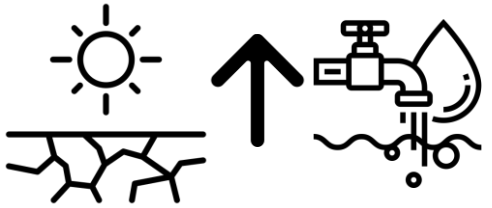
- Under the 2°C scenario winter precipitation is expected to increase by over 16% and summer precipitation will decrease by over 7%. Under the 4°C scenario winter precipitation is expected to increase by nearly 25% and summer precipitation will decrease by 21%.
- Heavy rainfall events are also projected to increase, With both 5-day max rainfall and days over 20mm increasing under both scenarios.
- The number of dry spells per year (10 days or more with no precipitation) are likely to increase.
- East Scotland projections show increased drought conditions in a warmer climate which may require adaptation measures.



There will be an increase in average winter precipitation and a decrease in summer precipitation



Heavy rainfall events are expected to increase in frequency and intensity, this is likely to increase flood risk



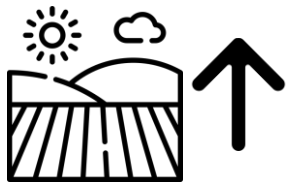
The decrease in summer precipitation and an increase in dry spells, combined with higher temperatures will make drought and water scarcity more prominent

2. Climate change profile of Dundee

2.5 Changes to growing degree days and storms

The combined changes to precipitation and temperatures will result in an increase in the number of growing degree days under both a 2°C and 4°C scenario.

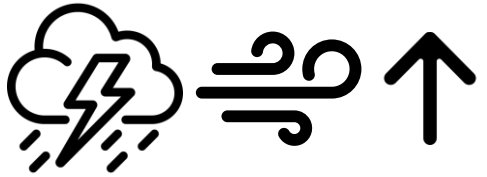
- Growing degree days are projected to increase by 39% under a 2°C and by 59% under the 4°C scenario.



Both higher temperatures and greater precipitation are likely to increase plant growth in the future

Changes to storms are more uncertain but they are likely to increase in the future.

- UK Climate Projections show an increase in windstorm numbers and intensity over the UK by the late 21st century.
- From 2050 onwards, there is an increase in near surface wind speeds over the UK during the winter season.
- This is accompanied by an increase in frequency of winter storms over the UK.



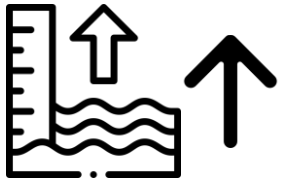
Freqeuncy and intensity of storms are likely to increase

2. Climate change profile of Dundee

2.6 Changes to sea level and coastal erosion

The sea level around Dundee is expected to increase under both scenarios to varying degrees.

- Mean sea level is projected to increase by 0.14m under a 2°C scenario.
- Mean sea level is projected to increase by 0.41m under a 4°C scenario.
- Due to changes to mean sea level, extreme sea level will also increase.



The projected increase in sea level rise could result in more coastal flooding, higher storm surges and more intense coastal erosion.

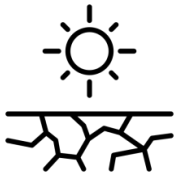
Coastal erosion may increase in the future due to sea level rise.

- Coastal erosion is the loss or displacement of land, or the long-term removal of sediment and rocks along the coastline due to the action of waves, currents and tides.
- Climate change and sea level rise may make coastal erosion more prominent in Dundee, especially along parts of the coastline to the which are not protected by hard engineering.
- Coastal erosion threatens nature, buildings and infrastructure near to the coast.

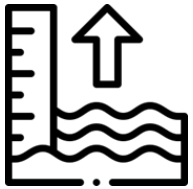
2. Climate change profile of Dundee

2.7 Climate change hazards

- The changes to temperature and precipitation that have been described result in multiple climate change hazards.
- Seven key hazards have been identified for the city of Dundee; all will increase with climate change apart from extreme cold which will decrease.
- All seven hazards are considered in the Risk and Vulnerability Assessment which is presented in Section 3.

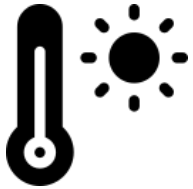


Drought & water scarcity



Coastal flooding and erosion

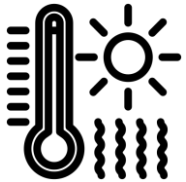
Storms and high winds



Average warming

River and surface water flooding

Frost days



Extreme heat

3. Climate Change Risk and Vulnerability Assessment

3.1 Section introduction

3.2 Update approach

3.3 Business and industry

3.4 Health, communities and buildings

3.5 Infrastructure

3.6 Nature

3.7 Risks to Dundee City Council

3.8 Opportunities

3.Climate Change Risk and Vulnerability Assessment

3.1 Introduction

In 2018 Dundee's first Climate Change Risk and Vulnerability Assessment was developed.

The core task of this work has been to update this assessment. This section describes in more detail the approach taken to do this and presents the key results by sector. The update focuses on integrated information and data which has been published since 2018, such as the most recent UK Climate Change Risk Assessment and Scotland's national summary[7,8]. The update also takes a more comprehensive approach to the understanding of the climate hazards (presented in Section 2) and integrates this information into the risk scoring. Finally, the updated risk assessment integrates lessons learnt from recent past extreme events and the COVID pandemic, as well as a general improvement in the understanding of climate change and the need to better understand risk and work towards increasing resilience.

The updated assessment focuses on, and is arranged into, four key sectors highlighted by the UK Climate Change Risk Assessment;

- Business and industry
- Nature
- Infrastructure
- Health, communities and buildings

In addition, due to its importance in the functioning of the city, risks specific to the Council as an organisation were also assessed.

3.Climate Change Risk and Vulnerability Assessment

3.2 Update approach

Once the climate information for Dundee had been fully analysed and the key climate hazards were identified, work began on the risk assessment update. Five key steps were followed and are discussed below:

1. **Background research:** a small review of recent information relevant to climate risk within Dundee was conducted to provide a detailed context for the work and a better understanding of the nature of local risks.
2. **Initial list of risks:** from the background research and analysis of other risk assessments such as Dundee's 2018 assessment, UK national assessment and risk assessments from other Local Authorities in Scotland and an initial long list of risks was identified.
3. **Stakeholder workshop:** a workshop with stakeholders from diverse backgrounds working in climate resilience or with deep knowledge of the risks in a local context was conducted. This focussed on identifying which risks of the long list were most prominent in Dundee, how Dundee was vulnerable given its local characteristics and if any other relevant risks had not yet been identified.
4. **Focussed interviews:** several focussed interviews were conducted with key stakeholders to help gather further information on specific hazards and risks. This helped add to and compliment the information gathered in the workshops.
5. **Refined list and scoring:** the initial list of risks was then refined further based on the findings of steps 3 and 4. A scoring approach was then applied to the risks; this approach scored both the likelihood and the impact. These two elements were combined to give an overall risk score for both scenarios. Detail of the scoring process and the scoring narrative for the risks can be found in an accompanying spreadsheet.

3.Climate Change Risk and Vulnerability Assessment

3.3 Business and industry

Sector overview

This section considers how changing climatic conditions will negatively impact on business and industry in Dundee. This work focuses primarily on domestic risks and opportunities, both arising directly and indirectly from climate change. This includes impact on staff, assets, customers, local disruption with knock-on impacts and changes to demand. International risks, particularly to supply chains from climate hazards elsewhere in the world are also an issue and have been highlighted by the UK's Climate Change Risk Assessment. However, due to their complexity and international nature these risks were considered beyond the scope of this work.

Business and industry in Dundee

According to a 2019 study, the most prominent occupation sectors in the city are health (21.3%), education (10.7%), retail (10.7%) and accommodation and food services (10.7%)[9]. Risks to both health and education sectors are covered in Section 3.4. Other key industries considered are construction and manufacturing. These risks consider larger organisations with a presence in the city as well as local businesses. The wider regional context is also considered for tourism and other sectors as they have strong regional links, such as visitors to the Cairngorms and areas within neighbouring Local Authorities.

3.Climate Change Risk and Vulnerability Assessment

3.3 Business and industry

Key findings

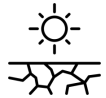
- In total, six key climate change risks to business and industry were identified.
- The highest scoring risks under both the 2℃ and 4℃ scenarios were “risks to business from flooding” – these risks were scored as very high for both scenarios. These risks already impact the city and are anticipated to increase in intensity and frequency due to climate change. The impacts of these risks are also high and include direct damage, loss of custom, the cost of closures and knock on impacts of wider disruption. Any business located within flood risk areas can be impacted.
- “Risks to winter tourism” were also scored as high, though this only impacts the local economy via the tourism industry due to the dramatic changes to winter temperatures and snowfall (both within the city and wider region), these risks are highly likely to occur.
- Storms can cause damage and closure for businesses – past examples of this are discussed in Section 4.
- “Risks to productivity from higher temperatures” rise from a score of medium (2℃) to high (4℃), these risks will become more prominent as the climate warms.
- “Risks to business from water scarcity” were scored lowest in this assessment. This finding is based on the assumption that despite the changes to the climate, significant water restrictions are unlikely to happen due to the water management and long-term plans put in place within the water industry.

3.Climate Change Risk and Vulnerability Assessment

3.3 Business and industry

All risks

Table 1. All climate risks identified for business and industry along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard (s)	Overall score (2°C)	Overall score (4°C)
Risks to business from water scarcity	Future water restrictions would impact businesses, especially those that are water intensive. Production of goods could be slowed or in the worst-case scenario, temporarily closed.		Medium	Medium
Risks to business from reduced employee productivity due to infrastructure disruption and higher temperatures in working environments	High temperatures can impact staff and productivity in many ways and cause wider disruption to transport or other infrastructure services that may delay or prevent staff from reaching their place of work. High temperatures can also bring restrictions to working such as longer breaks or breaks during the hottest part of the day. Lack of energy in high temperatures can reduce productivity, especially in physical roles.		Medium	Medium
Risks to business from flooding	Flooding can impact businesses directly by causing damage to assets and increasing insurance costs. Flooding can indirectly impact businesses by preventing staff, customers and supplies from reaching the businesses.		High	High

3.Climate Change Risk and Vulnerability Assessment

3.3 Business and Industry

All risks

Table 1 continued. All climate risks identified for business and industry along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard (s)	Overall score (2°C)	Overall score (4°C)
Risks to business locations and infrastructure from coastal change	Coastal flooding and erosion can cause damage to and permeant loss of land as well as temporary closures of access routes. All these could potentially impact businesses located near the coast.		Medium	High
Risks to winter tourism	Dundee as a city sees significant winter tourism due to its proximity to areas which focus on winter activities such as skiing at Glenshee. Reduction in cold days and snowfall is likely to reduce the desirability of the region as a destination for winter sports.		Low	Medium
Increased energy costs due to additional cooling needs	Projected increases in summer extreme heat events and higher average temperatures may result in the need for businesses to install cooling or increase cooling capacity. This will have an associated financial cost to the business, for both installation and running.		Low	Medium

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

Sector overview

This section summarises the evidence regarding the key risks and opportunities that climate change brings to the population of Dundee. This section specifically focuses on health and wellbeing, as well as risks to the built environment. It covers the risk for local communities including residential buildings, as well as climate change's impact on key public services namely education, and health and social care. Climate hazards can impact negatively on individuals by bringing health risks, while buildings can be damaged during extreme weather events and are not always designed to function within the projected future climate scenarios. This sector also includes risks to cultural heritage from climate change.

Health, communities and buildings in Dundee

Dundee's current population is approximately 150,000. Education and health are important sectors within Dundee, with Dundee being home to multiple, regionally important hospitals such as Ninewells Hospital and the Royal Victoria Hospital. The city has many schools as well as a sizeable student population as it is home to the University of Dundee, Abertay University and Dundee & Angus College[9].

Dundee also has a rich cultural heritage, with a mix of modern and historic attractions. The first V&A museum in the world outside London is located on the banks of the Tay estuary. Opening in 2018 the museum has had over 1 million visitors. Other attractions include the McManus art gallery, Dundee Science Centre, the Mills Observatory and the RRS Discovery[11].

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

Vulnerability to climate change

Climate change does not impact individuals equally, some people and groups are more susceptible to the negative impacts of climate-related hazards due to differing abilities to deal with them. Areas with high levels of deprivation are more likely to be disproportionately affected by climate change.

The Scottish Index of Multiple Deprivation (SIMD) is a national tool used by the Scottish Government to identify areas with high levels of deprivation. The SIMD ranks data zones across Scotland from the most deprived to the least deprived[12]. Figure 3 to the right shows the index mapped for the city of Dundee. Clusters of high deprivation can be found, represented by the red colour.

This can be used to identify areas of high deprivation where communities may be more significantly impacted by climate change and where adaptation measures can be prioritised.

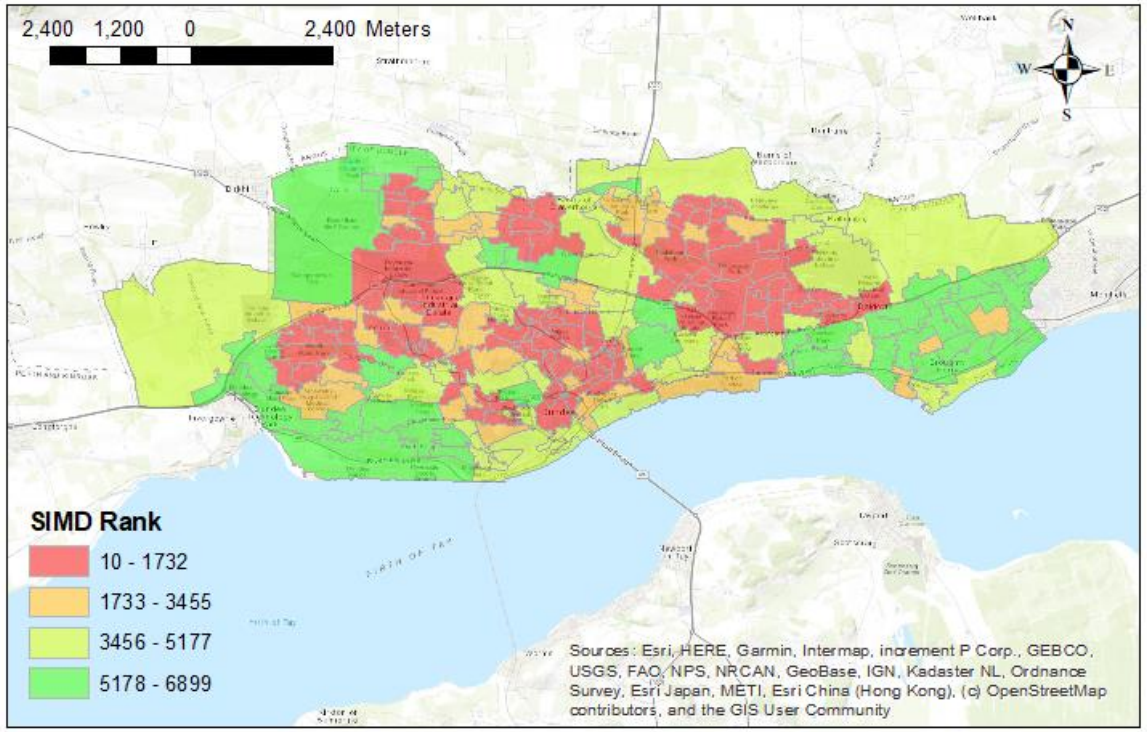


Figure 3. Map of the SIMD ranking across the city of Dundee. Ranks are given for data zones.

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

Flood risk

Flooding is a risk that impacts certain areas more than others. To better understand the locations most at risk, the Scottish Environment Protection Agency (SEPA) has produced multiple flood maps that are a free-to-use public tool showing areas that are likely to flood in Scotland[13]. These maps cover three different types of flooding at three different likelihood scenarios. Maps accounting for some of the future changes to the climate have also been produced for the medium likelihood scenario.

To better understand the extent of flood risk across the city some simple analysis was undertaken to understand how much of the city is threatened by flooding according to these maps. The results are shown in the table to the right. Further analysis showed that two schools were at risk of river flooding, as well as 36 education facilities falling into low likelihood surface water flood zones. In addition, a small number of healthcare facilities were located in flood zones, including a care home. The full results of this analysis can be found in the appendix.

High likelihood - each year this area has a 10% chance of flooding.

Medium likelihood - each year this area has a 0.5% chance of flooding.

Low likelihood - each year this area has a 0.1% chance of flooding.

Flood type	Percentage of the city's land which is impacted
River flood (low likelihood)	2.88%
River flood (medium likelihood)	2.52%
River flood (medium likelihood including Climate change)	2.82%
Coastal (low likelihood)	7.02%
Coastal (medium likelihood)	6.37 %
Coastal (medium likelihood including Climate change)	7.56%
Surface water flood (low likelihood)	10.03%

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

Flood vulnerability

The organisation ‘Climate Just’ have investigated community vulnerability to flooding across the UK and developed a flood vulnerability index[14]. The Neighbourhood Flood Vulnerability Index (NFVI) provides insight into the social vulnerability of a neighbourhood should a flood occur, based on their susceptibility, ability to prepare, respond and recover, and community support. It estimates how far individuals may experience a loss in wellbeing if exposed to a flood as well as their ability to prepare, respond and recover from a flood (without significant emergency support from the authorities).

Figure 4 to the right indicates areas of the city with a flood vulnerability above the national average. The worst areas are represented in red. These areas are where the greatest losses are likely to occur during a flood event. These areas are where community resilience to flooding could be improved.

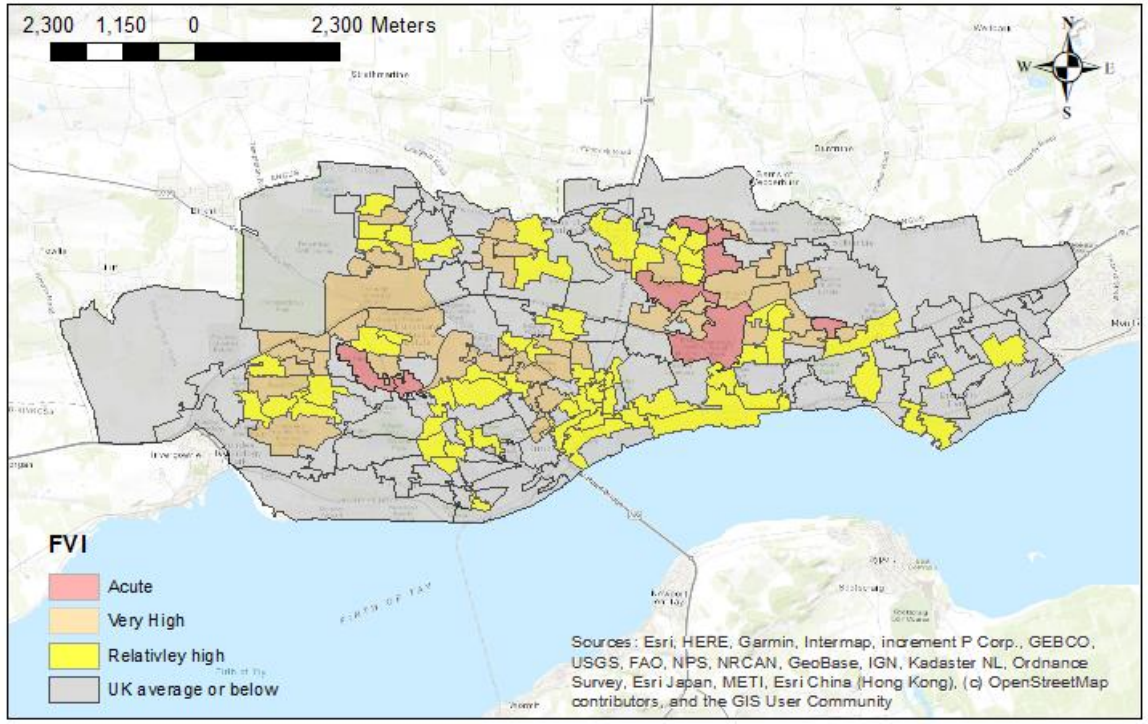


Figure 4. Map of areas in Dundee which scored above the UK average on the neighbourhood flood vulnerability index.

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

Key findings

In total, 16 risks were identified for this sector and can be roughly split into four different areas: People and Communities; Health and Social Care Delivery; Education; Buildings and Cultural Heritage. The key findings are as follows:

People:

- All identified future climate hazards cause risk to the people of Dundee. Flooding poses a direct safety risk, as well as indirect longer-term impacts through the damage to homes and community facilities. Flood risks to communities are therefore scored as very high.
- Heat as a hazard is likely to become a greater threat as temperatures rise. Heat can pose direct risks to people's health during heatwaves in the form of heat-related illnesses, as well as indirectly by worsening air quality and creating a more favourable environment for the spread of diseases, such as Lyme disease due to increased tick populations.
- “Risks to the viability of coastal communities from sea level rise” were scored as very high for both scenarios. Coastal erosion could cause permeant loss to these communities, although this only directly impacts the coastal areas of the city.

Buildings:

- Buildings in Dundee are designed for past climates. Most existing buildings were not designed with future climate scenarios in mind, therefore several risks to the city's buildings have been identified in this assessment. During future extreme heat events, buildings are likely to overheat and become uncomfortable for residents or users. This may result in an increase in energy needed to keep the buildings at a functional temperature.

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

Key findings

- Warmer, wetter winters and increased storms are also likely to cause physical damage to buildings. Damper and warmer winters could result in greater water ingress, increased condensation, damp and mould within buildings. Heavy rainfall and storms could cause damage to roofs and facades, as well as ground cracking and erosion of sandstone walls, and flooding of basements, all of which could result in risks to the safety and structural integrity of a building.

Cultural heritage:

- The city's rich cultural heritage assets face similar risks as those identified to buildings. However, damage to listed and historically important buildings may be harder and more costly to repair. Additionally, risks to delicate historic artefacts have also been identified, either as a result of building damage (such as basement flooding) or due to greater difficulty keeping temperature and humidity at the desired levels under warmer and wetter climates.

Education:

- Grounds and buildings of education facilities face the same risks as other buildings with regard to damage and closures as a result of storm damage and flooding. The new Drumgeith Campus has been designed to provide a flood resistant building based on the flood modelling undertaken as part of the planning approval process. This in-built resilience ensures future proofing against ongoing climate change.
- Similarly, school buildings are not likely to be designed for future extreme heat and may overheat, causing risk and discomfort to staff and students, with children being a particularly vulnerable group to extreme heat. However, it should be noted that schools are generally closed for a significant proportion of the year during the hottest summer months.

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

Key findings

Health care:

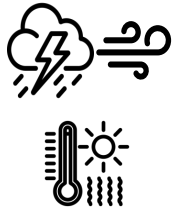
- The city's healthcare facilities include hospitals, care homes and GP surgeries as well as other facilities. Climate change poses risks to the functioning of healthcare services and their assets. Flooding and storms pose direct threats to assets, with the potential of causing closures and damage. However, wider disruption due to these hazards within the city and beyond may have cascading impacts on healthcare such as transport and infrastructure damages or road closures which may hinder services and vital deliveries.
- Heat also poses threats to healthcare, as healthcare buildings are again not designed to function within some of the projected high temperatures in the future and could overheat, causing discomfort and danger to staff and patients. High indoor temperatures may also cause malfunction of medical equipment if design thresholds are surpassed. Heat risks to health are therefore scored as very high under a 4°C scenario.

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

All risks

Table 2. All climate risks identified for health, communities and buildings along with the associated climate hazard, and scores for both scenarios.

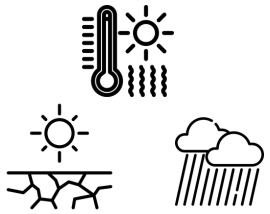
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to cultural heritage from flooding	Flooding can damage cultural heritage assets such as historic buildings. It may also cause temporary closures of attractions to the public for safety reasons, and longer-term closures if more extensive repairs are needed.		High	High
Damage to culturally important and historic buildings	Increased heavy precipitation and storms, including high winds, can cause direct and indirect damage to the building fabric of historically and culturally important buildings. Water ingress and damage to facades are likely. These impacts are likely to be costly and repairs made difficult due to the protected nature of the buildings.		High	High
Risks to historic artefacts due to temperature and humidity changes	Historic artefacts often need to be kept within specific temperatures to prevent deterioration. This range is often between 16°C and 18°C (though not always). Increasing summer temperatures are likely to make maintaining these temperatures within buildings more difficult. Additionally, warmer winters and increased winter precipitation may increase humidity, also negatively impacting upon these artefacts.		High	High

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

All risks

Table 2 continued. All climate risks identified for health, communities and buildings along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to health and wellbeing from changes in air quality	Climate change is likely to have a negative impact on air quality both directly and indirectly, as higher temperatures are likely to create atmospheric conditions favouring ozone formation. This causes risks to both air quality and health.		Medium	Medium
Risks to water quality and household water supplies	Climate change and reduced summer precipitation resulting from climate change will increase the likelihood of periods of water scarcity and droughts. Together with demand increases from economic and population growth, these may lead to interruptions of household water supplies and associated health, social and economic impacts, particularly for vulnerable households. In addition, climate change may increase the risk of contamination of drinking water through increased runoff and flooding events that overwhelm current water treatment approaches. Risks to health from contact with bathing water (sea, lakes and rivers) and harmful algal blooms may also increase with climate change.		High	High

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

All risks

Table 2 continued. All climate risks identified for health, communities and buildings along with the associated climate hazard, and scores for both scenarios.

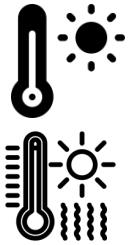
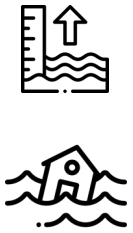
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to the viability of coastal communities from sea level rise	Sea level and coastal erosion can cause risks to property and assets on the coast if not properly protected. This is also linked with coastal flooding.		Very high	Very high
Risks to education from high temperatures	Very high temperatures can cause school closures and risk of heat-related illness to children, vulnerable adults (vulnerable to heat) or staff, especially in buildings prone to overheating.		Medium	Medium
Risks to health and wellbeing from high temperatures	Higher summer temperatures and particularly heatwaves have an established link with premature deaths and illnesses. Heat-related morbidity in the form of specific heat illnesses is also a problem, these include common heat-induced illnesses such as heat stroke, sunburn and dehydration. These are more likely to affect older and younger people who are more vulnerable, as well as exacerbate existing illnesses such as cardio-vascular and respiratory diseases.		High	High

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

All risks

Table 2 continued. All climate risks identified for health, communities and buildings along with the associated climate hazard, and scores for both scenarios.

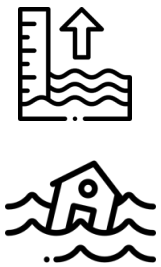
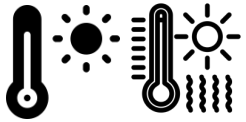
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to health and social care delivery from high temperatures	Staff and patients may be negatively affected by higher summer temperatures. Buildings and equipment could also overheat. Health impacts of higher temperatures on the population may increase the pressure on healthcare services due to higher demand during heatwaves.		High	Very high
Risks to education from flooding	There is a risk of short-term disruption and closure to education if parts of the city are flooded. Some damage may also cause longer-term closure or loss of facilities, impacting on the educational experience. Playing fields could be particularly at risk. Disruption of education has known impacts on children's development.		High	High
Risks to health and social care delivery from flooding	Flooding may affect access to critical care services such as A&E departments. It may also impact social care services such as home visits and visits to care homes due to cascading impacts from transport infrastructure disruption. Furthermore, in times of flooding, demand for healthcare services may be higher, adding to existing pressure.		High	Very high

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

All risks

Table 2 continued. All climate risks identified for health, communities and buildings along with the associated climate hazard, and scores for both scenarios.

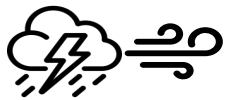
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to people, communities and buildings from flooding	Flooding of homes may have severe short-term consequences during and immediately after a flood event. Extreme cases could lead to loss of life if, for example, rivers burst banks unexpectedly. There is also a range of medium- to long-term consequences for people and communities, such as water contamination or damage to housing. Finally, there are severe mental health impacts, such as stress, which could be caused by flooding or its subsequent impacts, such as financial worries.		Very high	Very high
Risks to households from increased summer energy demand	Higher summer temperatures could cause an increase in summer energy demand within households due to increased use of mechanical cooling devices (AC, fans). There may be a disparity between those able to afford cooling and those that cannot, exacerbating current inequalities.		Medium	High
Risks to building fabric from warmer, damper winters	Warmer, wetter winters leading to higher levels of damp and condensation in homes, can result in mould and damage, with knock-on health impacts for residents. Homes most prone to this are those with poor ventilation, leaking roofs, poor plumbing and significant sources of moisture within the home.		Medium	Medium

3.Climate Change Risk and Vulnerability Assessment

3.4 Health, communities and buildings

All risks

Table 2 continued. All climate risks identified for health, communities and buildings along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to health and social care delivery from storms	Storms can have both a direct and an indirect impact on social care delivery. Direct impacts include damage to buildings or facilities. Indirect impacts include wider disruption, i.e. staff commuting or deliveries being prevented or delayed.		Medium	High
Risks to building fabric from storms	Storms and especially high winds can damage buildings directly and indirectly via debris picked up in winds. Roofs are often particularly vulnerable. Heavy intense rainfall associated with storms may also damage the building fabric.		Medium	Medium

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

Sector overview

This section summarises the evidence regarding the key risks that climate change brings to infrastructure within Dundee. Infrastructure is a key enabler of Scotland's economy and underpins many vital activities. Infrastructure services such as heating, lighting, mobility and sanitation are essential for modern society. The city, including its people, services and businesses are heavily reliant on infrastructure to function effectively. Infrastructure's assets and services can be damaged or disrupted by various climate hazards. For this section, the topic of infrastructure includes several different types of infrastructure:

Water – water infrastructure refers to systems and processes used to manage water within the city and includes the collection, treatment, storage and distribution of water and all associated assets.

Transport – transport infrastructure refers to assets and services which facilitate the movement of people, goods and resources across land, water and air. Within Dundee this includes the city's public transport (buses and trains), key roads within the city such as the A90 and A92, the city's train station and airport as well as the city's port.

Energy - Energy infrastructure is the physical networks and systems that generate, transmit, and distribute energy. For the city of Dundee this would include electricity, gas and oil and associated network components such as pipelines, electricity lines and substations.

Digital - digital infrastructure encompasses the physical components which facilitate the flow of digital products and services, and information and communications. This includes fixed physical assets such as broadband cables and software centres.

Waste – includes the assets and activities related to the management (including collection, treatment and disposal) of various forms of waste, such as solid or non-solid industrial or household waste, as well as contaminated sites.

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

Key findings

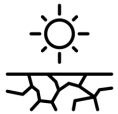
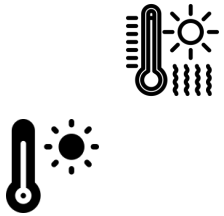
- Storms and high winds are of concern to above ground infrastructure assets as strong winds have the potential to cause damage to buildings and infrastructure, from structural damage to falling debris. Wind can impact transport, impacting high-sided vehicles, causing debris to block roads and rail tracks. Risks to transport from storms are scored as high. Overground assets in the energy and digital systems are also at risk of damage from high winds therefore the risks to energy from storms were scored very high in both scenarios.
- Due to warming, risks from low temperatures for all infrastructure sectors will reduce significantly, most being scored as low or medium under a 4°C scenario.
- Drought and water scarcity are both projected to increase in the region however, on the assumption that industry planning and adaptation will take place and prevent severe shortages to public water supplies, the level of risks is scored medium for both 2°C and 4°C scenarios.
- All types of infrastructure are at risk to surface water flooding which can inundate and damage assets. Therefore, this risk is scored as very high for both 2°C and 4°C scenarios. In areas along the coastline where less hard engineered protection exists, the city's infrastructure is at risk of coastal flooding and coastal erosion – this risk is scored high for both scenarios.

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

All risks

Table 3. All climate risks identified for infrastructure along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Damage to water infrastructure from drought	There is an increased risk to infrastructure from drought, as drought may cause severe drying and cracking of the ground. Subsidence may then occur, threatening subterranean water infrastructure located in these areas.		Low	Medium
Increased cooling energy demand causing shifts in energy consumption	Higher temperatures, particularly during summer, could lead to an increase in electricity demand. This will shift seasonal and peak demands and possibly cause additional pressure on the electricity production at these times of the year.		Low	Medium
Extreme high temperatures affecting active transport use, e.g. less walking and cycling	Higher temperatures and the increased frequency of heatwaves could be a disincentive for the use of active transport. Extreme heat makes active transport uncomfortable. Exercising in such heat could lead to heat-related health issues for some people.		Low	Medium

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

All risks

Table 3 continued. All climate risks identified for infrastructure along with the associated climate hazard, and scores for both scenarios.

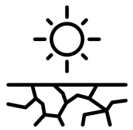
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to transport from storms	Storms including high winds and flash flooding causing disruption to transport or damage to transport infrastructure.		High	High
Flooding on transport	This risk includes the impacts of flooding (both direct and indirect) on transport including damage and disruption. This risk includes all types of transport apart from active travel which is covered elsewhere.		High	High
Risks to digital from low temperatures	Low temperatures can have a detrimental impact on digital networks such as telecommunications. Low temperatures could cause damage to infrastructure, subterranean assets could be at risk from freeze-thaw action.		Medium	Low

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

All risks

Table 3 continued. All climate risks identified for infrastructure along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to digital from storms	Storms and specifically high winds can cause damage to digital assets. This could be directly on assets such as overhead lines or indirectly via wind-blown debris damaging assets.		Medium	Medium
Risks to transport from low temperatures	Despite the expected reduction in low temperatures, they can still have a detrimental impact on transport infrastructure. In the longer-term frost and snow could reduce the lifespan of the asset.		Medium	Low
Risks to public water supplies from reduced water availability	Drought could place strain on public water supplies. Restrictions would have significant impact on infrastructure, especially those that require a significant amount of water.		Medium	Medium

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

All risks

Table 3 continued. All climate risks identified for infrastructure along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Damage to water infrastructure from flooding	There is an increased risk of damage from flooding to above ground water infrastructure. Drainage is also at risk from increased heavy rainfall and of being overwhelmed and subsequently damaged.		Medium	Medium
Risks to energy from storms	Above ground energy infrastructure, such as overhead lines, is at risk of damage caused by high winds.		Very high	Very high
Risks to energy from low temperatures	Despite the expected reduction in low temperatures within the climate change projections, low temperatures will still occur under the future climates and can still have a detrimental impact on energy infrastructure, causing damage and potential outages. In the longer-term, frost and snow could reduce the lifespan of assets. Frost could cause freeze-thaw action and cause roads to crack.		High	Medium

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

All risks

Table 3 continued. All climate risks identified for infrastructure along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to energy from high temperatures	At a national level, high temperatures can affect energy systems, for example by reducing electricity generation from thermal generators and increasing the likelihood of faults on the electricity network.		High	High
Risks to infrastructure services from coastal flooding and erosion	The rise in sea levels due to climate change will increase coastal erosion and flooding. Coastal communities will be particularly vulnerable. Flooding can impact key infrastructure networks such as water, wastewater and energy.		High	High
Risks to infrastructure services from surface water, river and groundwater flooding	There is an increased risk to all infrastructure from surface water flooding.		High	Very high

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

All risks

Table 3 continued. All climate risks identified for infrastructure along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to bridges and pipelines from flooding and erosion	The increased likelihood of storms and heavy rainfall due to climate change may result in an increased risk of damage to bridges and pipelines, with high river flows thought to be contributing to this. Damage and reduction in asset lifetime are both possible impacts.		High	Very high
Risks to transport networks from slope and embankment failure	The increased incidence of high rainfall, combined with periods of lower-than-average rainfall, are expected to contribute to shrinking, cracking and subsidence of the ground causing subsequent increased rates of slope and embankment failure. These deterioration processes are not well understood and areas at risk are hard to identify. The UK's transport network, particularly rail, relies on engineered cuttings and embankments, so failure can have a significant impact. Areas within the city will likely be at risk, but cascading impacts can also occur from embankment failure outside the city on major train or roads that connect to the city.		High	High
Risks to transport from high temperatures	High temperatures can cause a range of detrimental effects to transport infrastructure, such as rail buckling and road surface expansion and asphalt melt.		High	High

3.Climate Change Risk and Vulnerability Assessment

3.5 Infrastructure

All risks

Table 3 continued. All climate risks identified for infrastructure along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to waste from high temperatures	High temperatures can impact negatively on waste staff, particularly those working outside or in physically demanding roles where heat-related health risks may occur. High temperatures can also alter waste patterns. High temperatures could increase the risk of fire at waste treatment facilities where large quantities of waste are stored.		Medium	Medium
Risks to waste from storms and subsequent flooding	High winds can cause rubbish and debris to be blown around, causing hygiene problems. In extreme circumstances, high winds could also cause delays to collection services if unsafe for HGVs. Flooding due to heavy rain in storm events is also a risk, causing damage, delays and disruption to collection and waste treatment. Heavy rainfall and flooding could also cause leachate to occur, leading to possible contamination.		Medium	High

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

Sector overview

Climate change has already begun, and will continue, to impact the natural environment across the UK. This sector encompasses individual species and a wide range of habitats, including terrestrial and freshwater.

A healthy, functioning natural environment is important not just for biodiversity, but also for the continued provision of key ecosystem services to the economy and to the health and well-being of our society. The natural environment constitutes our natural capital, which directly and indirectly produces goods and services for people. It underpins provisioning services such as agriculture and forestry as well as water, air and soil regulation, whilst also providing opportunities for recreation and the enjoyment of wildlife and landscapes.

Understanding how climate change will impact nature is difficult, whether species and habitats suffer, or benefit will not just depend on climate change, but a range of other factors including human disruption, pollution, competition between species, land use pressures and ecological connectivity. Therefore, this work describes the general trends and impacts that climate change will bring to the natural environment, highlighting these changes and the possible risks, rather than an in-depth study. This work will be used to help understand the wide range of risks to nature and prioritise the next steps which may include further and more specific research as well as conservation measures.

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

Nature in Dundee

Despite having large built-up urban areas, Dundee has many valuable natural assets. According to a recent natural capital baseline assessment, less than half of the city's dry land was classified as "built-up areas and gardens" (with the addition of private gardens themselves likely to mean even more nature)[15].

It has also been identified that natural assets within the city offer significant benefits such as flood prevention, carbon sequestration and storage, and supporting pollinators. The assessment also calculated 550 ha of important biodiversity areas within the city[16]. Part of the Firth of Tay and Eden Estuary RAMSAR site sits within the city of Dundee as well as three local nature reserves; Trottick Mill Ponds, Broughty Ferry and the Inner Tay Estuary.

The parks and natural areas of Dundee also have huge recreational value: parks such as Baxter Park and the Riverside Nature Park provide spaces for locals and visitors to enjoy nature. The botanical gardens are also a key visitor attraction with a large collection of trees, shrubs, tropical and temperate glasshouses, as well as water and herb gardens. Dundee is the only city in the UK to have an urban population of native Red Squirrels. Many other threatened species such as hedgehogs, sparrows, starlings and bats can be found in Dundee as well as marine wildlife such as dolphins in the Tay estuary.

Figure 5. Image of Slessor Gardens, Source: Dundee City Council

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

Ecosystem services

Nature is essential for human life. Nature provides us with water, clean air and food, and raw materials for medicines, industry and buildings. Our crops rely on insect pollination and the complex biological processes that create soil. Enjoying parks, landscapes and wildlife improves our health and well-being. All of these benefits, known as ecosystem services, depend on a healthy environment[17].

Therefore, to comprehensively score the potential impacts of climate change risks in the future an understanding of current ecosystem services and how they may be lost or altered by future climate hazards is vital. As such, a high-level exercise was undertaken to identify impacts for each risk on ecosystem services this was then integrated into the scoring.

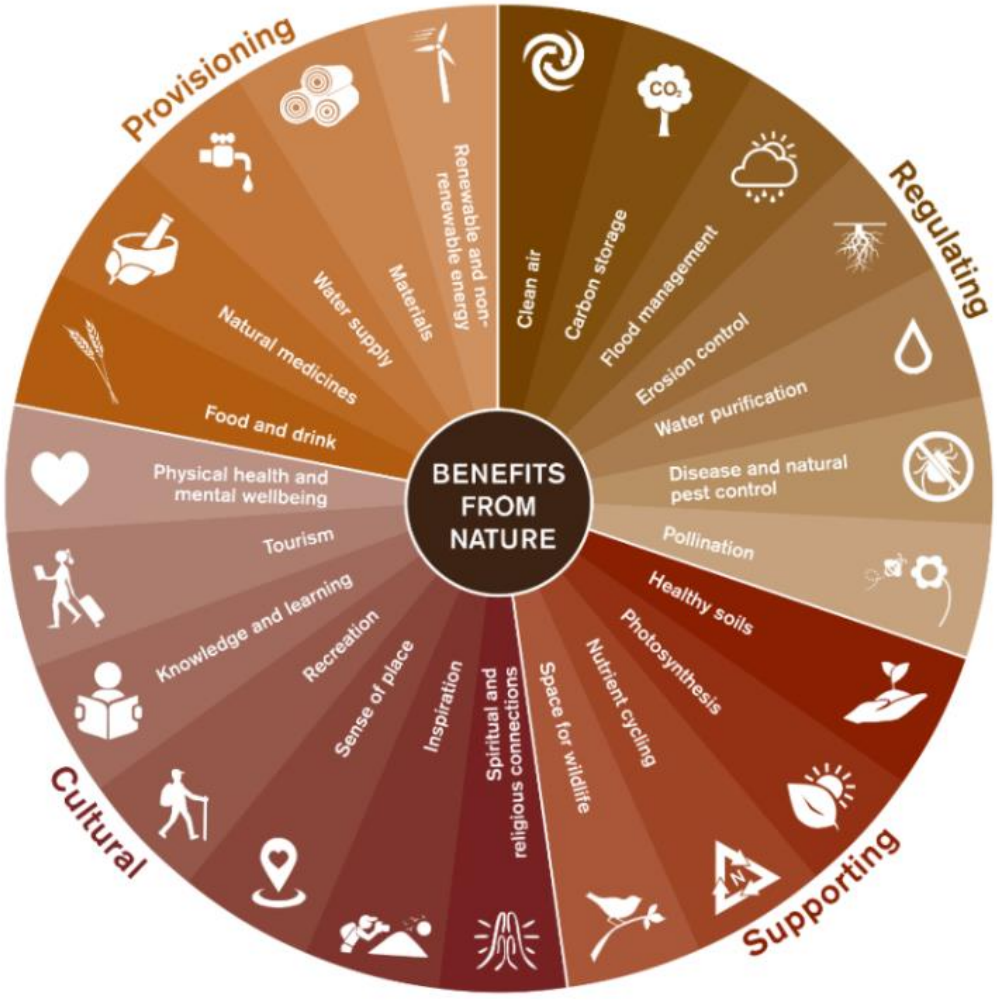


Figure 6. Components of ecosystem services, Source: NatureScot

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

Flood risk to nature

For the hazard of flooding, a similar approach to the work presented for the building communities and health sector was taken. SEPA flood maps at various likelihood levels and for 3 types of flooding were analysed alongside key areas of nature within the city, this included any local nature reserves and dedicated sites such as RAMSAR and SAC as well as all greenspaces within the city. Full results can be found in the appendix, but the key results are as follows:

- It was found that the city's greenspaces have some risk of flooding, with a low likelihood for surface water. Just over 5.8% of all the city's greenspaces are impacted by this surface water flood risk. This includes some risk for all of the city's local nature reserves and designated sites.
- There were also sections of all three of the city's nature reserves (Broughty Ferry, Inner Tay and Trottick Mill Ponds) which lie within a river flood zone.
- Similarly, designated areas such as the Firth of Tay and Eden Estuary (RAMSAR sites) are at risk from coastal flooding due to their position in the estuary.

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

Key findings

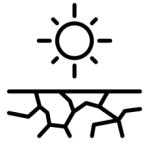
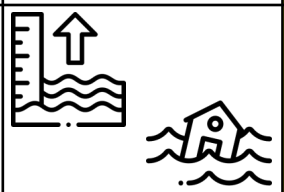
- In total 10 key climate change risks to nature were identified.
- All risks to nature were scored as high or very high. These scores reflect how sensitive nature can be to changes in climate and how important nature is to the city. Degradation or negative impacts to nature have wide ranging consequences, impacting human health, the environment, city life, services and incurring financial costs for repairs or replacements.
- One risk to score very high was risks to nature from storms. Recent storms have already shown how devastating storm winds and flooding can be to the city's natural areas. Storm Babet destroyed many trees, which are not replaceable, and important ecosystems in the city's botanic gardens.
- Other risks scoring very high in this sector are risks from pests, pathogens and invasive species. These risks have the potential to cause serious impacts upon current and native species. These risks could cause the number of species to deplete significantly, and even be lost in extreme cases. These risks are also very uncertain and requires more detailed understanding. Each species will face differing risks from the threats of climate change as well as other contributing factors.

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

All risks

Table 4. All climate risks identified for nature along with the associated climate hazard, and scores for both scenarios.

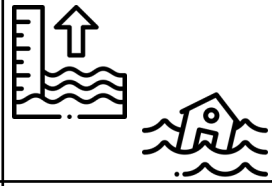
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to terrestrial species and habitats from storms	Storms can cause direct damage to species and habitats, with trees being particularly vulnerable. Damage to trees which provide habitats and food for other species and deliver ecosystem services have already been seen during storms in Dundee.		High	High
Risks to freshwater species and habitats from water scarcity	Freshwater habitats are particularly vulnerable to reduced water availability. Low water levels can change temperature and other properties of water. These risks could lead to aquatic species exceeding their thermal tolerance or bring about detrimental habitat changes which can result in loss of sensitive species, and changes in phenology and species composition.		Medium	High
Risks to freshwater species and habitats from water flooding	Flooding can disrupt freshwater species and habitats, as during a flood event, species can be directly killed or harmed. In the aftermath of flooding, species may be indirectly harmed due to habitat loss.		Medium	High

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

All risks

Table 4 continued. All climate risks identified for nature along with the associated climate hazard, and scores for both scenarios.

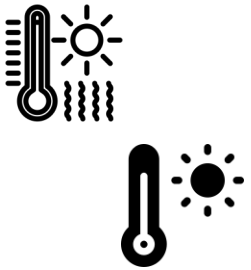
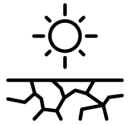
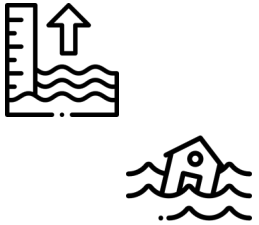
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to coastal species and habitats due to coastal flooding, erosion and climate factors	Natural assets on the city's estuary, including coastal species and habitats, could be harmed or lost due to coastal flooding and erosion. Permanent loss may occur if erosion is significant.		Very high	Very high
Risks to terrestrial species and habitats from pests, pathogens and invasive species	Pests, pathogens and invasive species may become more common due to changes in climate. They have the potential to disrupt key ecosystem functions and cause significant economic damage.	All changes to climate	High	Very high
Risks to freshwater species and habitats from pests, pathogens and invasive species	Pests, pathogens and invasive species have the potential to disrupt key ecosystem functions and cause significant economic damage.	All changes to climate	High	Very high
Risks to freshwater species and habitats from higher water temperatures	Freshwater habitats are particularly vulnerable to higher water temperatures. These risks could lead to aquatic species exceeding their thermal tolerance or bring about detrimental habitat changes which can result in loss of sensitive species and changes in phenology and species composition. The sensitivity varies by species.		High	High

3.Climate Change Risk and Vulnerability Assessment

3.6 Nature

All risks

Table 4 continued. All climate risks identified for nature along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to terrestrial species and habitats from extreme heat and hotter temperatures, including wildfire	Extreme heat can have short-term impacts on species which may suffer during a heatwave. Longer-term impacts and more drastic changes may also occur after extreme heat events. Average changes to temperatures can also cause harm and shifts in species, especially if species are already at the upper end of their temperature tolerance levels.		High	High
Risks to terrestrial species and habitats from drought	A lack of water availability can have a negative impact on species directly causing harm and possible health issues. A lack of water can also cause shifts in habitats, which indirectly impact upon individual species. Soils can also suffer.		Medium	High
Risks to terrestrial species and habitats from flooding	Flooding can disrupt terrestrial species and habitats, as during a flood species can be directly killed or harmed. In the aftermath of flooding species may also be indirectly harmed due to habitat loss. Species located within flood zones are most at risk.		Medium	High

3.Climate Change Risk and Vulnerability Assessment

3.7 Risks to Dundee City Council

Sector overview

Dundee City Council is responsible for providing public services to the community within the city and plays both an integral part of the running of the city and promoting the wellbeing of the population. Just some of the services include social housing provision, waste collection, education, management of leisure facilities and greenspaces, as well as working as a key actor in the planning system for the city. The Council is also a large employer within the city. Therefore, understanding how climate change may impact upon the organisation, its assets, services and staff is an important step in better identifying key risks to the city as well as providing a tool for the Council to begin improving its resilience.

As part of this work a high-level assessment was conducted to identify key risks and impacts climate change may bring. Much of the evidence was based upon the city's risk assessment with additional specific analysis. Climate change hazard impacts on business continuity, service provision, staff and assets were all considered. An overview of the results are presented in this section.

3.Climate Change Risk and Vulnerability Assessment

3.7 Risks to Dundee City Council

Key findings

- In total 104 key climate change risks to the Council were identified.
- Risks to transport from both flooding and extreme heat have been highlighted, this is particularly relevant for Council-maintained roads, where maintenance and repair costs may increase. This is also similar for Council-maintained greenspaces which are important for the city's population as rising temperatures, flooding and drought may cause damage to these spaces and deem current vegetation less suitable.
- A more general risk to the organisation is the possibility of insurance costs rising due to climate change. This cost could potentially take a much larger proportion of the Council's overall budget in the future and should be considered in longer-term financial planning.
- Risk to the Council's own estates from both high temperatures and flooding were scored as very high under the 4°C scenario.
- Both heat and flooding threaten the Council's housing stock, for this assessment no specific flood analysis was done, this is recommended in the future to better understand these risks. It is also likely the current housing stock is not built to function optimally in future extreme heat. Social housing is also likely to house vulnerable residents and so should be made a priority to better understand the risks they face.
- Risks to waste from extreme events were scored as medium for both scenarios, though multiple climate hazards such as flooding, storms and extreme heat can impact upon waste collection and processing, these scores reflect current mitigation measures which have helped to reduce the impact to waste services during present day extreme events. It is assumed that these mitigation measures will continue and develop as our climate shifts.

3.Climate Change Risk and Vulnerability Assessment

3.7 Risks to Dundee City Council

All risks

Table 5. All climate risks identified for the Council as an organisation along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to Council's own estates from higher temperatures	Overheating of buildings and malfunction of buildings or equipment due to high indoor temperatures.		High	Very high
Risks to Council's own estates from flooding	Direct impacts such as asset damage.		High	Very high
Risks to Council's key supply chains from all future hazards	Global climate induced hazards causing disruption and delay in growing, producing or transportation of goods which the Council relies upon.	All hazards	Medium	Medium
Increased insurance costs	General increases in climate related insurance claims, meaning subsequent rises in insurance costs.	All hazards	High	High
Risks to Council-maintained community spaces from higher temperatures	Higher costs associated with maintenance of greenspaces due to increased and accelerated vegetation growth under warmer conditions.		Medium	High
Risks to Council-maintained community spaces from flooding	Higher costs associated with maintenance of greenspaces due to flood damage.		Medium	High

3.Climate Change Risk and Vulnerability Assessment

3.7 Risks to Dundee City Council

All risks

Table 5 continued. All climate risks identified for the Council as an organisation along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard (s)	Overall score (2°C)	Overall score (4°C)
Risks to housing and housing provision from high temperatures	Council houses may overheat, causing discomfort and possible health risks for residents.		Medium	High
Risks to housing and housing provision from flooding	Direct damage from flooding to houses, may results in higher premiums and repair costs and subsequent impacts on social housing residents.		High	High
Risks for Council staff from higher temperatures	Heat-related health risks to staff, especially those who are vulnerable, working outdoors and/or in physically demanding jobs.		Medium	Medium
Risks to road infrastructure from higher temperatures	Risks of damage caused by extremely high temperatures, leading to increased repair and maintenance costs.		Medium	High

3.Climate Change Risk and Vulnerability Assessment

3.7 Risks to Dundee City Council

All risks

Table 5 continued. All climate risks identified for the Council as an organisation along with the associated climate hazard, and scores for both scenarios.

Risk	Description	Hazard (s)	Overall score (2°C)	Overall score (4°C)
Risks to road infrastructure from flooding	Damage and disruption to road infrastructure due to flooding. Increased costs of maintenance and repair.		High	High
Interrupted waste collections due to extreme events	Possible damage to waste assets, delays in collection and subsequent problems catching up on delays.		Medium	Medium
Increased maintenance of green space due to rising temperatures and extreme weather	Higher costs associated with maintenance of greenspaces due to increased vegetation growth. Higher temperatures and dry periods may require more maintenance and additional watering of greenspaces in the future.		Medium	High

3.Climate Change Risk and Vulnerability Assessment

3.8 Opportunities

Overview

So far, this section has dealt with the risks that changes to climate and climate hazards are likely to bring. However, some of these changes may also bring benefits and opportunities for the city of Dundee. Both general warming and reductions in the number of extreme cold events are the most prominent examples of this, with such shifts possibly creating several opportunities for both the city and the Council. Opportunities were assessed separately to risks; due to less study and large uncertainties they were scored using an altered and more high-level method. For each opportunity, an estimate of the potential benefit to the city which would result if the opportunity occurred was made using a simple low, medium and high scale – this included both economic and health benefits. Additionally, a similar simple low to high rating was given for the likelihood of the opportunity occurring for each scenario. The likelihood scores were based on a combination of the extent of change in climate projected under each scenario and other factors such as likely uptake or complexity. The key findings in this opportunity assessment are presented below.

3.Climate Change Risk and Vulnerability Assessment

3.8 Opportunities

Key findings

- Reduction in winter extreme weather may bring opportunities for human health and energy use. Winter excess deaths are strongly correlated to cold weather, this is particularly relevant for individuals living in fuel poverty and struggling to pay energy bills. An increase in winter temperatures may help with reducing health impacts and fuel poverty burdens.
- Reduction in carbon emissions may also occur due to a reduced need for winter heating.
- Less frost, snow and freeze-thaw cycles are likely to mean less winter disruptions and damage to assets such as roads.
- Though extreme heat brings many risks, average warmer temperatures and drier summers may also bring some economic and health benefits. Outdoor activities such as walking and other forms of active travel may become more common, resulting in physical and mental health improvements, though weather is not the only barrier to this uptake and is only one factor.
- Tourism in the UK may generally benefit from warmer drier summers. Dundee with its many cultural sites and easy access to regional national parks may benefit from this.
- Finally, though there are significant threats to nature as already discussed, the warming may allow for new species to populate the city leading to greater biodiversity and enhanced ecosystem services. However, this is difficult to understand with great uncertainty, and new species may bring risks to current species as well as benefits.

3.Climate Change Risk and Vulnerability Assessment

3.8 Opportunities

All risks

Table 6. All climate opportunities identified for the city, the score for potential benefit, and likelihood scores for both scenarios.

Opportunity	Potential Benefit Score	Likelihood score (2°C)	Likelihood score (4°C)
Opportunities for active travel from increased temperature	Medium	Low	Medium
Increased viability/generation of renewable energy due to changing climatic conditions	Medium	Low	Medium
Reduced winter heating demand	Large	Medium	High
Opportunities for local food growing from warmer temperatures and increased growing season	Low	Low	Medium
Opportunities to species and habitats from new species colonisations	Low - *high uncertainty*	Low	Medium

3.Climate Change Risk and Vulnerability Assessment

3.8 Opportunities

All risks

Table 6 continued. All climate opportunities identified for the city, the score for potential benefit, and likelihood scores for both scenarios.

Opportunity	Potential Benefit Score	Likelihood score (2°C)	Likelihood score (4°C)
Increased tourism revenue caused by increased temperatures and drier summers	Medium	Low	Medium
Opportunities for health and wellbeing from higher temperatures	Medium	Low	Medium
Opportunities for road maintenance from warmer winters	Medium	Medium	High

4. The cost of past events

4.1 Introduction

4.2 Approach

4.3 Case studies

4.4 Storm impacts on the business and industry sector

4.5 Storm impacts on the infrastructure sector

4.6 Storm impacts on the health, communities and buildings sector

4.7 Storm impacts on nature

4.The cost of past events

4.1 Introduction

Understanding what costs past extreme weather events have caused is a vital tool to help us appreciate what costs may occur in the future when weather hazards are likely to get worse. As part of this work, we have analysed two extreme storm events from the recent past which caused significant damage and disruption for the city of Dundee.

Storm Arwen and Storm Babet were chosen as case studies due to the fact they both occurred recently. Storm Arwen was characterised by high winds, which caused damage across the city. Whilst Storm Babet's unprecedently heavy rainfall, resulted in flash floods across the city. To put some of the costs into perspective, Storm Babet alone is estimated to have cost Dundee City Council between £1 and 1.5 million in repairs and disruption. This was primarily on the repair of a bridge collapse caused by the storm, but also includes additional costs such as staff costs to deal with the event (estimated at around £150-200k across the Council and partners).

Both flooding and high winds are two key future weather hazards, likely to increase in frequency and intensity in the future as a result of climate change. This means that storm impacts on the city are likely to occur more frequently and even become more devastating in the future.

Figure 7. Flooding in Dundee, Source: Dundee City Council

4.The cost of past events

4.2 Approach

The financial impact of an extreme event is commonly used to understand how disruptive the event was. However, these impacts extended beyond just the financial. To holistically assess the costs of these past events, we have adapted and used the UN's Framework for loss and damage[18]. The image on the left below illustrates the categories of loss that should be considered under this framework. We have adapted this framework to be most relevant for Dundee, the new categories and how they relate to the risk assessment sectors are shown in the table on the right.

Figure 8. Diagram shows all aspects included within the UN's loss and damage framework.

Table 7. Adapted UN loss and damage framework and related CCRVA sectors

UN categories	**UN sectors**	**Dundee City Council's CCRVA Sectors**
Direct economic losses	Business	Business and Industry
	Tourism	
	Infrastructure	Infrastructure
	Services and Transport	
	Property	Health, communities and buildings
	Leisure facilities	
Indirect economic losses and non-economic loses	Loss of life, mental and physical health	
	Cultural heritage	
	Biodiversity	Nature
	Ecosystem services	

4.The cost of past events

4.2 Approach

To understand the holistic losses, damages and disruption, which has occurred due to both storm events, we have reviewed several sources, including data provided by organisations within the city and local and national newspaper articles. We have also spoke to local representatives from some of the different sectors across the city to better understand the impacts they have previously faced.

In this section, we firstly present some background information about the meteorological conditions for each storm and then present the findings on loss and damage by sector.

Figure 9. Storm damage in Camperdown Park, Source: Dundee City Council.

4.The cost of past events

4.3 Case studies: Storm Arwen

Storm Arwen occurred across the 26th to the 27th of November 2021

The storm brought severe winds across the UK, with the Met Office issuing a red warning for wind. The developing storm, tracking south to the north-east of the UK, brought northerly winds gusting widely at over 60Kt (69mph)[19]. This was one of the most powerful and damaging winter storms of the latest decade.

Thousands of trees were felled across the north of the UK – including large mature trees – leading to major disruption. The strong winds also brought various reports of structural damage to buildings.

More than one million homes experienced a loss of power as falling trees brought down power lines, with over 100,000 homes subsequently experiencing several days without power.

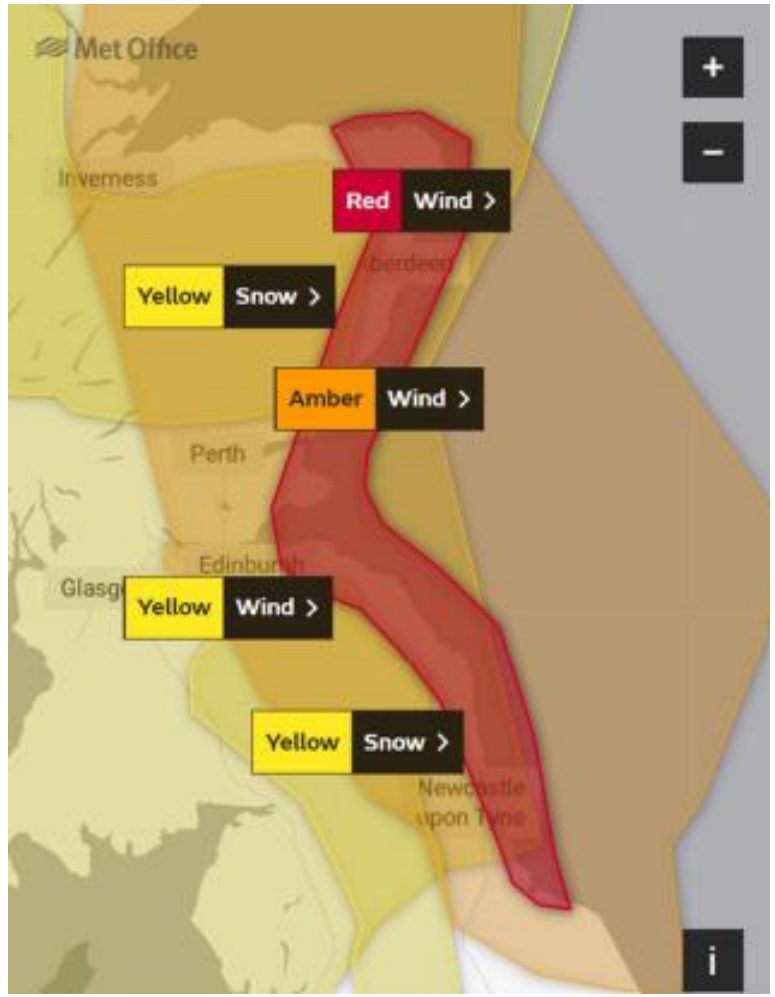


Figure 10. Met Office red warning issued for storm Arwen covering the east coast of eastern Scotland and north-east England, Source: Met Office

4.The cost of past events

4.3 Case studies: Storm Babet

Storm Babet occurred across the 18th to the 21st of October 2023

The storm brought exceptional rainfall to parts of eastern Scotland with 150 to 200mm falling in the wettest areas and two red warnings from the Met Office[20]. This followed very wet weather earlier in October, some central and eastern parts of England and Scotland receiving twice the October whole-month average rainfall in the first three weeks of the month.

Storm Babet also brought some very strong winds, gusting at over 50Kt (58mph) across northeast England and much of Scotland. Storm Babet resulted in the most severe and widespread disruptive weather impacts of 2023.

Multiple severe flood warnings were issued Scottish Environment Protection Agency (SEPA). The heavy rainfall combined with the already wet conditions resulted in hundreds of homes and businesses being flooded in Scotland. Estimates by PwC UK calculated the costs of damage due to the severe weather caused by Storm Babet to be between £450 and £650 million.

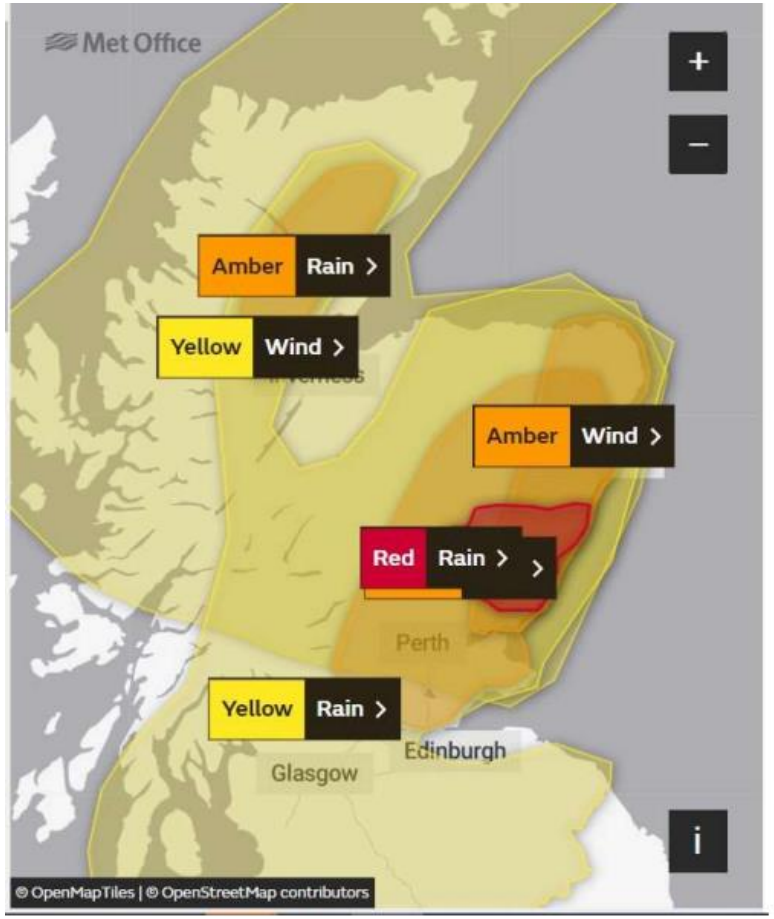


Figure 11. Met Office red warning issued for parts of eastern Scotland from 1800BST Thursday 19 October to 1200BST Friday 20 October 2023, Source: Met Office

4.The cost of past events

4.4 Storm impacts on the business and industry sector

Storms cause significant disruptions to business and industry, such as loss of income caused by closures due to unsafe conditions. Direct damage to assets can also cause temporary loss of income and increased insurance costs. Additionally, customers are less likely to go out during severe weather, which impacts the retail and hospitality sector. Staff may also be unable to commute to work due to wider transport disruptions causing further impacts on businesses, if they can remain open. Tourism may also be impacted with people cancelling or delaying visits during times of severe weather.

Table 8. Impacts on the business and industry sector of storms Arwen and Babet, presented using the adapted UN loss and damages framework.

UN loss and damage framework - category	Examples of storm impacts in Dundee during Storm Arwen and Babet
Business operational	Storm Arwen fell on the opening weekend of Dundee's Christmas markets "Winterfest" in Slesser Gardens. Due to the dangerously high winds, the opening day was cancelled and visitors in the following days were below the level expected due to the severe weather, leading to significant loss of income for local businesses. During Storm Babet, flooding in the city impacted various areas including the centre where many businesses are located. Additionally, flooding caused road closures which were likely to have indirect impact on businesses and staff.

Figure 12. Image of flooding in Dundee, Source: Dundee City Council

4.The cost of past events

4.4 Storm impacts on the business and industry sector

Table 8 continued. Impacts on the business and industry sector of storms Arwen and Babet, presented using the adapted UN loss and damages framework.

UN loss and damage framework - category	Examples of storm impacts in Dundee during Storm Arwen and Babet
Tourism	The botanical gardens closed during both Storm Arwen for over 4 days. This was not just a feature of Storm Arwen between 2021 and 2024, the garden/parks have been closed for over 42.5 days due to extreme weather. The city's Science Centre and V&A Dundee were both closed during Storm Babet. The closure of the Science Centre resulted in a loss of income and productivity, as staff were paid for shifts not worked. The 24-hour building closure also led to roughly £2,000 in lost earnings, with additional losses for their catering partners.

4.The cost of past events

4.5 Storm impacts on the infrastructure sector

High winds and flash flooding during storms causes both direct and indirect impacts on infrastructure. Both wind and flooding can directly damage infrastructure assets, causing wider services to stop working. Infrastructure is often related, with the energy, water and digital sectors all being interdependent, therefore cascading impacts can occur if one service is impacted disruption. Transport infrastructure is often impacted during storms, due to both damage and unsafe conditions which can temporarily halt different types of transportation.

Table 9. Impacts on the infrastructure sector of storms Arwen and Babet, presented using the adapted UN loss and damages framework.

UN loss and damage framework - category	**Examples of storm impacts in Dundee during Storm Arwen and Babet**
Infrastructure	Power outages occurred during Storm Arwen, across Scotland 80,000 homes which included many homes in Dundee were without power due to infrastructure damage[21].

4.The cost of past events

4.5 Storm impacts on the infrastructure sector

Table 9 continued. Impacts on the infrastructure sector of storms Arwen and Babet, presented using the adapted UN loss and damages framework.

UN loss and damage framework category	Examples of storm impacts in Dundee during Storm Arwen and Babet
Services and Transport	During both storms, the rail sector was impacted. During Storm Arwen, ScotRail also withdrew services between Aberdeen, Perth and Inverness. Passengers in Aberdeenshire were stuck on a train for 17 hours as Storm Arwen swept across Scotland[22]. During Storm Babet, ScotRail said the storm had caused severe disruption with no trains or replacement bus services running on five of its routes[23]. This included the route from Edinburgh to Aberdeen via Dundee. During Storm Babet, many road closures also took place, including closure of some larger roads, such the A90 northbound at Struan Roundabout[24]. High winds cause closures of the Tay Bridge with disruption and delays in and around Dundee.

Total Bridge closures times in Dundee due to extreme winds (2019-2024)

Gusts exceeding 80mph
Bridge closed to all vehicles
1,450 min

Gusts exceeding 60mph:
Bridge closed to pedestrians and restricted vehicles **18,313 mins**

Gusts exceeding 45mph
Bridge closed to double decker buses **109,516 mins**

Figure 13. Tay Bridge closure due to high winds, Source: Dundee City Council

4.The cost of past events

4.6 Storm impacts on the health, communities and buildings sector

Storms have wide-ranging impacts on this sector. Recent storms in the UK have caused fatalities and injuries which have impacted on individuals' physical health. Trauma from storms, loss of facilities, services and damage to homes are also likely to cause stress and anxiety for those impacted. Storms in the UK also frequently cause damage to homes and other buildings, whether from high winds damaging roofs, fallen trees and debris, or flash flooding.. Loss of a homes and having to move to temporary accommodation causes a huge burden on the individual. Health services can also be impacted by storms and wider disruption can cause delays in ambulances, staff getting to work and direct damage to facilities can also occur.

Storms have wide-ranging impacts on all the different components of this sector. There is a direct risk to individuals' safety due to falling trees and flooding, which can cause physical harm and in the worst cases fatalities. Fatalities have occurred across the UK due to extreme storm events. Storms can also have subsequent impacts on the population's mental health, events such as falling trees and crashes can cause PTSD, depression and anxiety. The closure of facilities and general disruption can also take a toll, especially for those who already suffering with mental health illnesses. Additionally, flooding can have a long-lasting impact especially for those whose homes were damaged. Buildings including those of cultural value are at risk of physical damage during storms, this includes historic buildings, homes and those that house important service such as hospitals. All of which would have many subsequent further impacts if damaged or unusable.

4.The cost of past events

4.6 Storm impacts on the health, communities and buildings sector

Table 10. Impacts on the health, communities and buildings sector of storms Arwen and Babet, presented using the adapted UN loss and damages framework.

UN loss and damage framework - category	Examples of storm impacts in Dundee during Storm Arwen and Babet
Property	There were many incidences of trees falling on homes and cars in Dundee during Storm Arwen. Insurance paid out on property totalled £44,200 and for car damage £29,000. It is estimated that around 150 private properties in Dundee were damaged to some extent during the Storm Babet. Most of these were residential (but this also includes a small number of businesses). The main cause of this was flooding due to the Dighty Burn bursting its banks during the storm. The cost of repair is unknown but all properties damaged were eligible to a grant from the Scottish government of up to £1500. Some council properties were also damaged with large budget implications. Due to recent storms the Council's housing maintenance budget has had to increase by £500,000.
Leisure facilities	Many problems in the city's parks and outdoor leisure facilities were caused by the storms. Storm Babet affected 4,220m of the core path network in woodland areas, along with an additional 1,350m of non-core paths. While some routes were cleared within weeks, others took up to six months, and some have yet to be repaired. Storm Arwen in 2021 disrupted over 4,189m of core pathways in woodland areas and a further 2,340m non-core pathways were also disrupted. Templeton Woods, with an area of over 537,000m^2, was closed for over 5 months due to the health and safety risks associated with the storm debris after Storm Arwen.

4.The cost of past events

4.6 Storm impacts on the health, communities and buildings sector

Table 10 continued. Impacts on the health, communities and buildings sector of storms Arwen and Babet, presented using the adapted UN loss and damages framework.

UN loss and damage framework - category	Examples of Storm impacts in Dundee during Storm Arwen and Babet
Loss of life, mental and physical health	**No deaths occurred during Storm Arwen or Babet in Dundee** but during Arwen 3 deaths were recorded within the UK, one death occurred in nearby Aberdeenshire[25]. No evidence is available on the mental health impact of this storm, though it is likely that impacts like closure of greenspaces and leisure facilities, as well as damage to homes, would have a cascading impact on individuals mental health.
Cultural heritage	Several cultural sites closed in Dundee during the worst of the storm i.e. Mills Observatory, Broughty Castle Museum[26]. During past storm events, flooding and high winds have already caused damage to historic and culturally important buildings. This comes at either a great cost to repair or loss of heritage if damage cannot be undone.

Figure 14. Houses flooded in Dundee after the Dighty Burn overflowed, Source: BBC News

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Facility & Service Updates

Updates regarding our Facilities & Services will be posted here as they become available.

Sunday 22 October 2023 14:27

Following Storm Babet, Leisure & Culture Dundee services will resume as normal on Monday, 23 October 2023. If there are any exceptions to this, we will update our website and social media.

Saturday 21 October 2023 09:43

Due to the disruption to travel caused by the extreme weather conditions the Scott Brothers have taken the decision to cancel the concert planned for the Caird Hall tomorrow Sunday 22 October 2023.
All customers are advised to hold onto their tickets and not to travel to the venue.
Dundee City Box Office will contact all customers at the start of the week to advise.

Friday 20 October 2023 17:17

Due to the extreme weather conditions Leisure & Culture Dundee facilities and services will remain closed to the public on Saturday, 21 October and Sunday, 22 October 2023.

This is with the exception of **Dundee Ice Arena** which will be open for the Dundee Stars Ice Hockey match on Sunday evening and **Caird Hall**, where a piano and organ concert is due to take place on Sunday afternoon. Events at both venues are subject to change and any updates in relation to them will be made on our social media and on the venue websites.

DISC - the Dundee International Sports Complex in Mains Loan has been open as a rest centre for residents most in need due to the continuing severe weather. Our partners at Dundee City Council advise residents in need to call their customer services on 01382 434000 to get any more information or if they need assistance to get to the rest centre.

We thank everyone for their patience and support at this time.

Figure 15. Web bulletin of disruption caused to Leisure & Culture within Dundee during Storm Babet, Source: Leisure and Culture Dundee website

Figure 16. Storm damage to Camperdown, where paths were flooded and washed away in 2023, Source: Dundee City Council

Figure 17. Sorm damage to Finalthen Park, where paths were washed away in 2024, Source: Dundee City Council

4. The cost of past events

4.7 Storm impacts on nature

Storms in the UK can cause significant damage to habitats through both flooding and strong winds. Trees are particularly vulnerable in high winds and can be damaged or blown over completely. This causes subsequent danger for other animals that rely on these trees as homes or for food. Flooding can cause wildlife habitats to be destroyed. Contaminated floodwater because of flooding can pollute rivers and habitats. Fast flowing rivers in flood can also cause erosion to riverbanks and threaten freshwater species.

Table 11. Impacts on the nature sector of storms Arwen and Babet, presented using the adapted UN loss and damages framework.

UN loss and damage framework - category	**Examples of storm impacts in Dundee during Storm Arwen and Babet**
Biodiversity	The strong winds during Storm Arwen caused hundreds of trees to be uprooted across the city, fallen trees not only caused damage but had a wider impact on biodiversity. Mature veteran trees were also lost which are particularly significant for local biodiversity. These losses have negative impacts on species, especially those reliant on trees, due to damage to their habitats. Flooding can cause damage to habitat adjacent to flooded rivers or streams, damaging vegetation and threatening other animals that live there. This would have occurred when the Dighty Burn overflowed its banks during Storm Babet.

Figure 18. Left is an image of storm damage to Templeton woods in 2022, Source: Dundee City Council

Figure 19. Below is an image of a mature tree which was blown over during a storm, Source: Dundee City Council

5. Adaptation options

5.1 Introduction

5.2 Building the city's community resilience to climate change

5.3 Improving the Council's resilience

5.4 Becoming resilient to flooding

5.5 Becoming resilient to storms and high winds

5.6 Becoming resilient to extreme heat

5.7 Becoming resilient to drought

5. Adaptation options

5.1 Introduction

This section of the report provides examples and recommendations of adaptation measures that could be undertaken within the city to help tackle some of the risks already highlighted and build resilience of the city to future climates.

The adaptation options chosen are ones that can both influence the city as a whole and help protect residents, and at the same time are either in the control of or can be heavily influenced by the Council.

Nine options in total are presented, including a description of the options and an assessment of cost, time and co-benefits. This work is designed to complement the risk assessment, offer some options for tackling the risks and outline possible next steps for the city. This is not a comprehensive action plan covering all options, nor does it provide in-depth detail on how to implement actions. Instead, it is a high-level assessment of adaptation options and how the Council could begin to implement them.

Two adaptation options provide overarching mechanisms to increase the city's resilience to climate change and to all future climate hazards which have been identified. One is focused on providing the tools to build local-level community resilience across the city. The other focuses on ensuring the Council takes actions to become resilient as an organisation, by reviewing and updating its own business continuity, corporate risks and emergency response plans.

Overall resilience adaptation options

AO1: The development of a community resilience plan for the city

AO2: Integration of the climate change risk assessment into Dundee City Council's business continuity planning

5. Adaptation options

5.1 Introduction

Seven subsequent adaptation options are presented that help build resilience to climate and the resultant hazards that have been identified as being likely to be prominent within the city in the future. Storms and flooding were chosen due to currently being a significant threat to the city. Heat and drought are both developing hazards, which are likely to worsen throughout the coming century, therefore advanced adaptation plans for these hazards would be particularly beneficial.

Changes to precipitation – flooding

AO3: Council supporting community groups in taking on an active role in flood resilience.

Future storms

AO4: Initial steps to integrate storm resilience into the planning system.

AO5: Wind-resilient greenspaces – initial research.

AO6: Preparing for storms – educating business and residents.

Future extreme heat

AO7: Review of overheating risk within council owned housing and creation of an action plan based on the findings.

AO8: Council to set up and run (or be a key partner in) a heat health working group.

Changes to precipitation – drought

AO9: Increasing the Council's resilience to drought – reducing water consumption.

All nine adaptation options are described individually throughout the rest of this section. Summary tables are also provided to help highlight the benefits, costs and possible governance choices for each adaptation option.

5. Adaptation options

5.2 Building the city's community resilience to climate change

AO1: The development of a community resilience plan for the city

Community resilience can be defined as the public's ability to harness local resources and expertise to help themselves and the communities to prepare, respond to and recover from challenges. A community resilience plan is a document that helps and guides the community to prepare for and respond to emergencies.

Due to its importance, the Scottish Government has developed several guidance documents on community resilience[27,28,29]. In response to these, many Local Authorities are beginning to develop their own community resilience plans to help establish community resilience groups and to help them prepare for emergencies. These plans provide guidance, outline actions and define the role of different organisations within the city during emergencies.

Figure 20. Guide to emergency planning for community groups, Source: Scottish Government

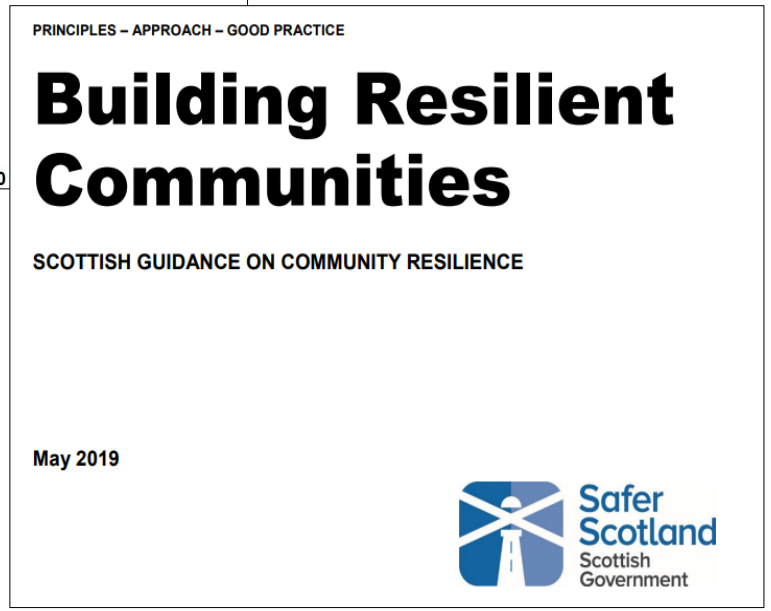


Figure 21. Government guidance on building community resilience, Source: Scottish Government

5. Adaptation options

5.2 Building the city's community resilience to climate change

AO1: The development of a community resilience plan for the city

At present, Dundee does not have a community resilience plan, therefore one of the overarching adaptation actions suggested is to develop a plan for the city and for the Council to provide guidance and support in establishing community resilience groups.

This has already been identified as a regional need by the Tayside partnership and will be developed regionally, however, a more "local" plan relevant and dedicated to Dundee which complements the regional work would be beneficial.

The plan should outline the role of the Local Authority, emergency services and other key organisations during emergencies and identify how they can help enhance and promote community resilience. The plan will also identify how community resilience groups can contribute safely and effectively alongside these agencies. The plan will likely be high-level and include information relevant to all types of emergencies. However, specific guidance, support, tools and information can be produced alongside the plan under the banner of community resilience for the key extreme weather hazards the city currently faces. Examples of this can be found in other suggested adaptation options such as ***AO3: Council supporting community groups in taking an active role in flood resilience.***

The plan can also include guidance from the Council on assessing risk, preparing for emergencies, responding and recovering as a community. This could include guidance on:

- Understanding relevant hazards and local risks
- Ways to identify resources in the community
- How to establish community hubs or places of safety used during emergencies;
- Identification of vulnerable groups;
- Practical resilience solutions
- Simple guidance on household readiness;
- Signposting to the best places, people and information
- Case studies and examples of best practice.

5. Adaptation options

5.2 Building the city's community resilience to climate change

AO1: The development of a community resilience plan for the city

Developing community resilience – key steps

STEP 1 Map support/signposting – An initial exercise in identifying possible support for community groups across the city, as well as understanding where current active community groups exist.

STEP 2 Workshop with residents to find out what they need – Stakeholder engagement to understand the key needs of local residents will be an important step in ensuring the plan is fit for purpose and relevant to the local context.

STEP 3 Workshop with all the services and resilience officers – Understand at a city level who does what already, where skills lie and where possible gaps are will help community resilience groups be as productive as possible and ensure they work alongside current emergency response infrastructure.

STEP 4 Create a plan – The creation of a plan will include drafting, further consultations and reviews.

STEP 5 Create a website – A visible and well-maintained website will be key as a central place for all the information including a plan, contacts and signposting, and subsequent guidance information.

STEP 6 Produce materials –The plan will provide the overarching direction and role of community resilience in the city but will not include detailed guidance on specific events and actions, these will be produced separately and complement the plan.

STEP 7 Disseminate – Time and resources will then need to be allocated to ensure the plan and related guidance materials reach communities.

STEP 8 Review – A review cycle should be established to ensure all materials are up to date, and to integrate best practice and learnings from emergencies after they occur.

Table 12 AO1: Building the city's community resilience to climate change.

Intervention Type:	Governance/community resilience			
Hazard Categories:	All hazards			
Internal Adaptation Owner:	Community, sustainability and climate change teams			
Collaborating Stakeholders:	**Internal:** Emergency response, civil protection	**External:** Community groups, emergency services		
Implementation Timeframe:	The resilience plan will be relevant to all current weather hazards as well as other types of emergencies. It is therefore suggested that work on the plan begins as soon as possible. This will also fall in line with regional work through the Tayside regional partnership.	Short term - < 5 years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	Cost is likely to be medium when factoring in staff time, running workshops, production of plan documentation and setting up and running of a website.	£	££	£££
Cost Indication (Ongoing/Maintenance)	Once established, it is anticipated that costs will be lower, though there will be some costs to updating documentation on a regular basis and maintenance of the website.	£	££	£££
Staff Resource Intensity:	Large amounts of staff time are likely needed during the initial phases of setting up the plan, stakeholder engagement and document preparation will be time-consuming. However, this will reduce as the plan is established and disseminated.	Low	Medium	High
Co-Benefits:	Cost savings for local communities and individuals, resource pooling on a local level. Health and wellbeing benefits for local communities.			
Implementation Feasibility:	The development of the plan is highly feasible; however, it is of medium complexity due to the large number of stakeholders involved, ranging from public, emergency services and other regional partners.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	A key part of developing the plan will be a review process to ensure it is agreed upon and endorsed by the relevant stakeholders. Once finalised a regular review process should be established. This should include the review of emergencies after they happen to review its effectiveness and include improvements.	2-3 years and after significant emergencies.		
Immediate Next Steps:	Step 1 - Map support/signposting as well as identifying key stakeholders and partners.			

5. Adaptation options

5.3 Improving the Council's resilience

AO2: Review of internal business continuity and emergency response by service area in the light of risk assessment findings

The risk assessment presented earlier in this report identified a number of direct risks to the Council, its assets, staff and services. The Council is integral to the running of the city, providing a number of vital services for the city's residents. In order to provide resilient future services these risks need to be reviewed in more detail and relevant actions must be identified and implemented.

Business continuity is a plan to help an organisation maintain or quickly resume operations after a disruption. An emergency response plan is an organisation's plan to prepare, respond to and recover from an emergency. Both are key to a successful and resilient organisation. Therefore, it is suggested here that both are reviewed in light of the findings of this assessment.

A formal review of current business continuity plans should also include an update to normal operating procedures and risks registers where appropriate. An assessment of resilience maturity of the organisations should also take place which can be repeated periodically to evaluate progress. This review should consider the major weather hazards and how they are likely to change as well as the risks highlighted in this report. The review should also include all service areas as well as staff safety and asset vulnerability and some thought of supply chains.

There are some examples of where business continuity already thinks about weather hazards and has altered practices, for example during recent storms waste collection was delayed but managed to catch up with disruption and delays within a week. Similarly, in areas such as waste, summer heat has been considered in PPE selection, with cooler clothing being provided when temperatures become hot during heatwaves, protecting staff against heat stroke.

5. Adaptation options

5.3 Improving the Council's resilience

AO2: Review of internal business continuity and emergency response by service area in the light of risk assessment findings

Emergency planning should also take place for all major weather hazards which were highlighted by this work. Individual plans specific to different hazards will make more efficient emergency response. These plans will primarily address how the Council as an organisation is resilient to emergencies but also its role in helping the city during such events. Examples might include extreme weather plans for extreme cold and extreme heat.

Finally, the findings of the risk assessment, the business continuity and emergency response review need to be integrated into corporate risk assessment. Highlighting such risk within corporate risk registers will ensure they are known throughout the business and fully considered and addressed in business planning and decision making in the future.

Table 13 AO2: Review of internal business continuity and emergency response by service area in the light of risk assessment findings.

Intervention Type:	Procedural			
Hazard Categories:	All hazards			
Internal Adaptation Owner:	Service leads, internal risk teams			
Collaborating Stakeholders:	**Internal:**	**External:**.		
Implementation Timeframe:	Due to the findings of this risk assessment, it is suggested that work on this action occurs in the near future.	Short term - < 5years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	The initial task to update and review the business continuity plan is unlikely to be costly. However, there may be further cost implications due to the prescribed actions or changes needed to ensure future resilience in business continuity.	£	££	£££
Cost Indication (Ongoing/Maintenance)	Depending on the findings of the review, there may be further cost implications due to the prescribed actions or changes needed to ensure future resilience in business continuity.	£	££	£££
Staff Resource Intensity:	Initial review is likely to be highly resource intensive for the dedicated officers, however, initially for the non-lead officers this will be low intensity. Once updates have taken place this will be low resource intensity for all staff involved and will fall into normal operating procedures.	Low	Medium	High
Co-Benefits:	It is difficult to identify specific co-benefits from this work, the main results will be a more resilient Council which can provide services more likely to withstand and recover from future climate hazards. This is likely to reduce city disruption, have some knock on health benefits and cost savings.			
Implementation Feasibility:	Undertaking the review as a task is likely to be low complexity, however, identifying measures to increase resilience and updating the plan is likely to be more complex and is rated as medium complexity.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	Once an initial update has occurred, review should fall into normal timelines for review of operational procedures and business continuity.	To fall in line with current review periods.		
Immediate Next Steps:	Identify the current normal operational procedures and business continuity plans that need updating as well as the individuals best placed to lead on and be involved in the review.			

5. Adaptation options

5.4 Becoming resilient to flooding

AO3: Council supporting community groups in taking an active role in flood resilience

Changing precipitation patterns suggest Dundee will receive more rainfall during the winter months and be exposed to an increase in heavy rainfall events. Overall, this is likely to increase the risk of flooding within the city. Flooding has already occurred in Dundee and is one of the most prominent and tangible climate hazards. Flood damage and subsequent impacts have already been highlighted through this report. Due to its prominence, flooding has already received a lot of attention within the city with numerous schemes currently ongoing to try and reduce flood risks within the city. The Council currently spend around £100,000 per year on flood risk management and have a long list of capital projects which could further alleviate flooding (up to a value in excess of £5 million).

Therefore, this report recommends a single adaptation action focused on the Council's role in supporting residents to take very localised measures to prevent flooding and to cope with its aftermath. With a focus on building community resilience to flooding. This resilience measure proposes that the Council plays a role in supporting the setting up and running of flood community groups.

This work could use the flood vulnerability index to help prioritise areas within the city that are most at need and would benefit most from such support and focus on groups being developed in these areas. The format and scope of groups would be defined on an individual area basis to help ensure the groups meet the specific needs of the local community.

5. Adaptation options

5.4 Becoming resilient to flooding

AO3: Council supporting community groups in taking an active role in flood resilience

The remit of the flood resilience groups may include:

Advice and support with building local physical resilience to flooding – e.g. educating residents in the role and importance of greenery within private gardens in slowing water flow into drainage, or the use of water butts to store water and re-use water within gardens.

Advice and support in preparing flood prone areas for storms – advice on how to protect your home, use of sandbags and other temporary measures. Support in gaining insurance and ensuring that insurance fully covers such events. Safety advice on what to do during a flood event.

Support during a flood event – identification and checking in on those most vulnerable in the community e.g. elderly/chronically ill. Identification and running of a safe space, which is warm and provides basic needs for those whose homes are flooded. Help relocating to a safe space.

Post flood support – support with clearing of homes, repairing damage, help gaining financial support where needed and advice on insurance claims.

Table 14 AO3: Council supporting community groups taking an active role in flood resilience.

Intervention Type:	Community/action based			
Hazard Categories:	Flooding			
Internal Adaptation Owner:	Community or community liaison			
Collaborating Stakeholders:	**Internal:** Flood team, sustainability and climate change team, emergency response/civil protection.	**External:**. Community groups, local charities		
Implementation Timeframe:	This action should be implemented as soon as possible, however, as more groups are established, and their role evolves the initial implementation period may span more than 5 years.	Short term - < 5 years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	One of the first steps is defining the Council's role in supporting community groups. It is unlikely that this will involves direct financial support and will instead focus help on identifying other funding support. Therefore, it is anticipated that financial cost to set up this measures would be low.	£	££	£££
Cost Indication (Ongoing/Maintenance)	This will again be dictated by the Council's role and if any financial aid is included. It is more likely the Council's main role will be coordination and resource support.	£	££	£££
Staff Resource Intensity:	In terms of resources this action will vary depending on how involved within the groups the Council is, initial set up of the Council's role is likely to be short-term high intensity, this would then drop to medium or low intensity in the longer term as groups are established.	Low	Medium	High
Co-Benefits:	**Health benefits:** safer practices and more support in the response during floods are likely to improve health outcomes during flood events. **Biodiversity benefits:** Some measures to enhance flood resilience through nature are likely to improve local biodiversity. **Community moral/sense of place:** Groups such as these can play a role in bringing people together and creating more pride for the local neighbourhood.			
Implementation Feasibility:	This measure is of medium to high complexity. It involves understanding and clearly defining the Council's role in supporting external groups. Finding and working with existing groups or setting up groups will involve a complex range stakeholders, often with different views and priorities so management of groups may be complex.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	A minor review of the groups formed, their work and the benefits should be undertaken regularly, especially to help with business cases for funding. Interim and more in-depth reviews can take place after major flood events to highlight the benefits the community groups played and to identify areas of improvement.	Minor review – every year Additional review after major flood events		
Immediate Next Steps:	Define clearly the Councils role in this work, identify funding possibilities. Collate a list of existing community groups of this nature and their work (if any) on flooding. Review and identify the most at-risk areas of the city.			

5. Adaptation options

5.5 Becoming resilient to storms and high winds

As discussed earlier in this report, storms are a hazard that are already causing negative impacts. Strong winds can cause serious damage to property, greenspaces, they can block roads and damage power and telecommunications lines. Section 4 highlighted that these impacts of storms are wide ranging and interlinked with flooding. This section focuses on adaptation measures to reduce wind damage from storms, while flooding is covered adaptation option AO3 .

High winds brought by severe storms hitting the city cannot be altered or reduced, but measures can be taken to ensure that the city is more resilient to them.

Three measures are presented here which the Council could lead or take a leading role in developing:

- **Initial steps to integrating storm resilience into the planning system**
- **Wind resilient greenspaces – further research to understand how the city's green spaces are vulnerable to extreme wind and how they can be protected**
- **Education program for residents and businesses owners – how to prepare for storms**

5. Adaptation options

5.5 Becoming resilient to storms and high winds

AO4: Initial steps to integrating storm resilience into the planning system.

This measure includes the initial steps to understand how and where planning could help Dundee become more resilient to high wind and to better understand the next steps of how such measures could be implemented within the current planning structure, through mechanisms such as the Local Development Plan. The planning system is key to ensuring that development or redevelopment of areas of the city occurs in a manner that enhances resilience to future climate change.

Flooding risk is currently well integrated into planning, with common measures to prevent sites from being located in areas of high risk and new developments not increasing flood risk. However, other climate hazards are less well understood in a planning context. This measure proposes a simple internal research exercise, a collaboration between planners and climate experts to better understand the tools and constraints the planning system has in terms of climate resilience and how they can be harnessed to best increase resilience to high winds. The work will look at the following:

- If the planning system could stipulate that assets are built to withstand windspeeds with climate uplifts (as flooding is currently considered).
- If the planning system can ensure that new developments consider how they can reduce wind and create buffers by clever design, to build wider resilience within the city.

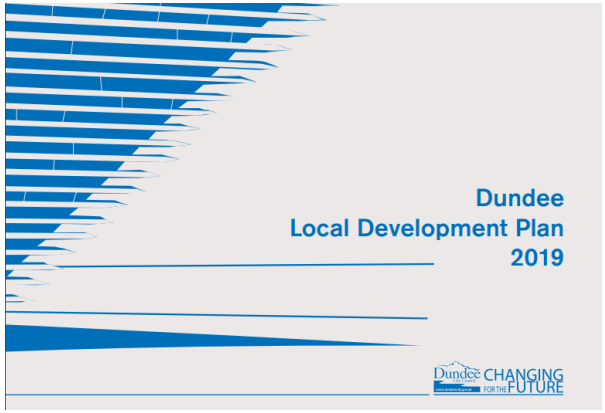


Figure 22. Dundee Local Development Plan, Source: Dundee City Council

Table 15 AO4: Initial steps to integrating storm resilience into the planning system.

Intervention Type:	Internal research/procedural			
Hazard Categories:	Storms and high winds			
Internal Adaptation Owner:	Planning, sustainability and climate change teams			
Collaborating Stakeholders:	**Internal:** Maintenance teams/civil protection – in an advisory role	**External:** Planning teams in neighbouring local authorities		
Implementation Timeframe:	Due to the internal and short-term nature of the adaptation measure combined with the time it would take to integrate any resultant actions into formal planning, it is advised that this measure be undertaken in the near term.	Short term - < 5 years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	The initial exercise would be internal conversations, possibly workshops to better understand the topic and so would have little to no cost associated.	£	££	£££
Cost Indication (Ongoing/Maintenance)	There are no financial costs anticipated for ongoing maintenance regarding this measure.	£	££	£££
Staff Resource Intensity:	Initial staff time would be of low intensity, however subsequent actions may put an additional strain on the planning team if they were to need to integrate resilience measures into local planning policy. This is still anticipated to be low.	Low	Medium	High
Co-Benefits:	No immediate co-benefits from the initial research work however a number of co-benefits may arise from subsequent actions and integration into planning. **Economic:** Cost savings to the city from reduced damage and insurance claims. **Biodiversity:** Some measures may include more vegetation to help buffer winds, with additional biodiversity benefits.			
Implementation Feasibility:	Initial project is highly feasible, however subsequent actions and possible integration of restrictions/ resilience measures into planning will be more complex.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	Once conducted and actions integrated, review would fall in line with current planning cycles such as local plan updates.	In line with planning system requirements		
Immediate Next Steps:	Initial discussion between relevant stakeholders and research to understand if this has been done elsewhere or studied elsewhere.			

5. Adaptation options

5.5 Becoming resilient to storms and high winds

AO5: Wind resilient greenspaces – initial research

Damage to the city's vegetation and greenspaces from high winds during storms has already been highlighted in this report. Loss of veteran trees is particularly detrimental to the city's ecosystems and subsequent closures of greenspace after storms have further impacts on residents and city life.

Greenspaces can be made more resilient to high winds, some specific species of plants and trees are naturally more resilient to higher winds, similarly, ensuring natural areas have a diverse vegetation and do not rely on a single mono-species can also help. Good maintenance practices can also reduce the vulnerability of trees to damage during storms.

However, the city's greenspaces are diverse in their makeup, both in the species present, their size and their exposure to wind. As a result, it is challenging to determine which actions are best suited to enhance resilience in each area. This measure proposes further research into the topic, potentially led by another organisation, but with the Council's collaboration as a key maintainer of greenspaces. The research should not look at increasing resilience to high winds in isolation but also look at co-benefits of actions, such as increased carbon sequestration, flood and cooling protection, protection of rare or native species and enhancement of greenspaces in the most deprived areas.

The work could also investigate if or how greenspaces and vegetation could be used to protect parts of the city against strong winds by slower wind and acting as a buffer. The research should aim to understand:

- **Where the hotspots of vulnerability are within the city's greenspaces.**
- **How the city's greenspaces can be made more resilient to storms.**
- **Whether greening can be used to protect assets against storms and reduce windspeed within the city.**
- **How actions can maximise co-benefits across the city.**

Table 16 AO5: Wind resilient greenspaces - initial research.

Intervention Type:	Research			
Hazard Categories:	Storms and high winds			
Internal Adaptation Owner:	Collaboration between a number of stakeholders – see row below			
Collaborating Stakeholders:	**Internal:** Nature and greenspace, parks maintenance, flooding, sustainability and climate change teams **External:** Local academic institutions, NatureScot, botanic gardens, external consultants, community or volunteer groups with an interest in nature			
Implementation Timeframe:	As storms and damage from high winds are pressing issues, and the proposed research could take several years, it is recommended that work begins as soon as possible. However, due to the time needed to define scope, apply for funding, collaborate with stakeholders and the possible length of the research, it is likely to take more than 5 years to complete the research, interpret results and devise subsequent informed actions.	Short term - < 5 years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	This project is likely to need significant external funding and so though the project may be costly, it is unlikely to be funded by the Council.	£	££	£££
Cost Indication (Ongoing/Maintenance)	This is a finite research project so there is not significant ongoing costs anticipated.	£	££	£££
Staff Resource Intensity:	The time and resourcing cost to the Council would depend heavily on the structure of the project, the involvement of other stakeholders and the Councils role (whether leading or as a collaborating stakeholder). However, regardless of the setup, staff resource requirements are likely to be medium to high, particularly during the initial stages and when applying for funding.	Low	Medium	High
Co-Benefits:	Part of this research would focus on co-benefits and maximising the benefits and resilience of nature to multiple hazards, as well as maximising ecosystem services that are provided by the city's greenspaces. Therefore, actions which are developed from the project's conclusions should inherently contain a wide number of co-benefits.			
Implementation Feasibility:	This kind of research is likely to be medium to high complexity due to the large number of stakeholders needed, the involvement of field work and the large amount and diverse nature of the city's greenspaces.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	This is likely to be a one-off research project, how the outputs are used in the future and updated where needed will need to be identified during the project or after the full conclusions are made.	Standalone project with limited time Subsequent actions would then have review periods assigned.		

5. Adaptation options

5.5 Becoming resilient to storms and high winds

AO6: Preparing for storms – educating business and residents

This suggested adaptation measure involves help in preparing the city's population for storm events, both for residents and local business owners. This measure would involve Dundee City Council researching current best practice to prepare individuals and properties for storms with severe wind. Then producing some simple guidance for residents on measures they can take to be safer and more resilient in such events. Safety guidance is commonplace in countries such as the USA that are regularly hit by hurricanes and tornadoes. The image to the right is an example of some guidance from the American Red Cross, this could be adapted and made applicable to Scotland.

American Red Cross

Be **Red Cross** Ready
Prepare so you can protect.

Hurricane

Preparedness Checklist

Hurricanes and tropical storms are rotating storms that form over warm waters. These storms bring high winds, heavy rain, storm surge (rise in water level), flooding and tornadoes. Climate change has caused hurricanes to strengthen faster and bring heavier rainfall. The most common cause of death during a hurricane is from drowning. These storms are dangerous and can damage places far inland. But we can take action to prepare. Prepare now to protect yourself, your loved ones and your home.

What to Do: Before

Make Plans to Stay Safe
Determine your best protection from high winds and flooding.
Have a plan to evacuate and a plan to shelter safely.

If advised to evacuate, do so immediately
- You may have to leave your home quickly and go to a safe place.
- Know where you will go, how you will get there and where you will stay.
- Plan well in advance if you will need help leaving or use public transportation.
- Mobile, manufactured, trailer homes and recreational vehicles (RVs) are not safe in high wind events. Plan ahead by preparing to evacuate to a safe location.

Plan to shelter safely
- Be ready to live without power, water, gas, phone and internet for a long time.
- Practice going to a designated safe shelter for high winds. The next best protection is a small room with no windows on the lowest level of a sturdy building that is not likely to flood.
- Be aware that flooding can happen quickly. Have a plan to evacuate fast before floodwaters reach you.
- Create a personal support team of people you may assist and who can assist you.

Plan to stay connected
- Sign up for free emergency alerts from your local government.
- Plan to monitor local weather and news.
- Have a backup battery or a way to charge your cell phone.
- Have a battery-powered radio during a power outage.
- Understand the types of alerts that you may receive and have

- Alerts you may receive include: Hurricane Watch & Warning, Tropical Storm Watch & Warning, Extreme Wind Warning, Storm Surge Watch & Warning, Flash Flood Watch & Warning, Flood Watch & Warning.

Learn emergency skills
- Learn First Aid and CPR.
- Be ready to live without power. Utilities may be offline. Be ready to live without power, gas and water. Plan for your electrical needs, including cell phones and medical equipment. Talk to your doctor. Plan for backup power.

Gather emergency supplies
Gather food, water and medicine. Stores and pharmacies might be closed. Organize supplies into a Go-Kit and a Stay-at-Home Kit.
- Go-Kit: at least three days of supplies that you can carry with you. Include backup batteries and chargers for your devices (cell phone, CPAP, wheelchair, etc.)
- Stay-at-Home Kit: at least two weeks of supplies.
- Have a 1-month supply of medication in a child-proof container and medical supplies or equipment.
- Keep personal, financial and medical records safe and easy to access (hard copies or securely backed up). Consider keeping a list of your medications and dosages on a small card to carry with you.

Protect Your Home
Wind
- Secure or bring inside outdoor items, such as lawn furniture and trash cans, that could be picked up by high winds and hurt someone.
- Anchor objects that would be unsafe to bring inside, such as

Figure 23. Hurricane safety guidance from the USA, Source: American Red Cross

5. Adaptation options

5.5 Becoming resilient to storms and high winds

AO6: Preparing for storms – educating business and residents

Residents can increase their safety by taking simple measures, such as following advice to stay indoors, having plans in place for power or communication outages, and maintaining access to emergency supplies of food and medication. They can also improve the resilience of their properties by keeping trees and vegetation well maintained, and by securing or bringing indoors items such as bins and outdoor furniture to prevent them from becoming wind-blown debris that could damage their own or neighbouring properties and vehicles.

These guidelines can also be adapted for local businesses. Taking such steps not only reduces safety risks during a storm but also helps minimise damage and supports a faster recovery for the city.

Education on the importance and safety of trees

Trees coming down and causing damage during storms has caused a lot of recent anxiety about trees, especially older ones with a trend to remove trees on private property. As part of this education drive, clear guidance on how to maintain older trees to ensure they are safe during storms, and signs of weakness to look out for would help mitigate people's fears.

Similarly, the importance to an ecosystem and the biodiversity of the city that such trees bring needs to be highlighted to help ensure that veteran trees on private land are looked after and not removed.

Table 17 AO6: Preparing for storms – educating business and residents.

Intervention Type:	Educational/guidance			
Hazard Categories:	Storms and high winds			
Internal Adaptation Owner:	Civil protection/emergency response, sustainability and climate change team			
Collaborating Stakeholders:	**Internal:** Health and safety, civil protection, greenspace and nature team, public health	**External:**. Chamber of Commerce, residents groups		
Implementation Timeframe:	As storms and damage from high winds are pressing issues, and the proposed research could take several years, it is recommended that work begins as soon as possible, ready for the coming year's storm season.	Short term - < 5 years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	Initial costs are likely to be low if this action is kept internally, alternatively the initial production of guidance could be outsourced but at a greater cost. If internal cost will mainly be time of officers involved.	£	££	£££
Cost Indication (Ongoing/Maintenance)	Once the guidance has been produced, the costs will be minimal. Some expenses may arise from producing physical leaflets and from using other channels, such as social media, to ensure the guidance regularly reaches residents—especially just before and during the storm season each year.	£	££	£££
Staff Resource Intensity:	In terms of staff resources, the initial research and production of the guidance is likely to be of medium intensity for a short period of time. Periodic review and update of the guidance will also take some staff time but will be irregular. Once guidance is produced or updated time requirements will be low, with efforts focussed with the comms team and ensuring the information is visible to the city's residents.	Low	Medium	High
Co-Benefits:	**Economic benefits:** Reduction in damage to residential properties and business will have subsequent positive economic effects for the city. **Health benefits:** Improved understanding of how to stay safe during storms will positively impact residents' health outcomes during such events. **Biodiversity benefits:** Education on the importance of trees on private property and guidance on correct maintenance will help protect the city's trees.			
Implementation Feasibility:	This measure is of relatively low complexity to implement, there is much guidance from other countries already available.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	A major review of the content and its review should be undertaken on a 5-year cycle, ensuring the most up to date guidance is included and lessons learnt from storms in the recent past are also considered.	Major review – every 5 years		
Immediate Next Steps:	Identify the best team or individuals for this to sit with and appropriate timeframes for the initial research phase.			

5. Adaptation options

5.6 Becoming resilient to extreme heat

As discussed earlier in this report, extreme heat is likely to become more intense and more frequent in the future. Future extreme heat is therefore likely to cause greater risks and negative impacts on the city. Heat risks occur across each sector, impacting nature, people, businesses, infrastructure and communities.

Common ways to increase resilience to extreme heat include: using green and blue infrastructure to cool outdoor spaces in the city and reduce the Urban Heat Island effect; retrofitting buildings to remain cooler during higher temperatures; building or upgrading infrastructure to withstand higher temperatures; and preparing people for heatwaves by educating them on the risks and ways to stay cool.

Though there are many ways in which the Council can play a key role in building a more heat resilient city, two specific adaptation measures, which can be owned and driven by the Council have been identified here and will be discussed further. These include:

- **Creation of a heat health working group**
- **Review of council owned homes and the risk of overheating**

5. Adaptation options

5.6 Becoming resilient to extreme heat

AO7: Review of overheating risk within council owned housing and creation of an action plan based on the findings

While there are formal definitions and specific overheating criteria, overheating generally describes the interior of homes reaching temperatures that are uncomfortable for residents. This is expected to become a wider problem as extreme heat worsens in the future. Overheated homes not only cause discomfort but can also lead to a lack of sleep and various health problems.

Council houses are often home to residents who are more vulnerable to heat, such as those on lower incomes, the elderly, and the chronically ill. Therefore, understanding the risk of the Council's current housing stock can help identify homes most in need of retrofit and specific retrofit measures to maximise effectiveness.

Some homes are more prone to overheating than others. Factors such as building age, insulation levels, roof type, orientation and type of home (e.g. flat or terrace) can all influence the risk of overheating. This research measure involves the Council undertaking analysis of its own housing stock to assess the potential scale of overheating risk in the future and identify which homes are most vulnerable due to their characteristics.

The research could consist of in-depth modelling to understand likely indoor temperatures during future heatwaves, or a simpler assessment of risk based on the characteristics present in each home.

5. Adaptation options

5.6 Becoming resilient to extreme heat

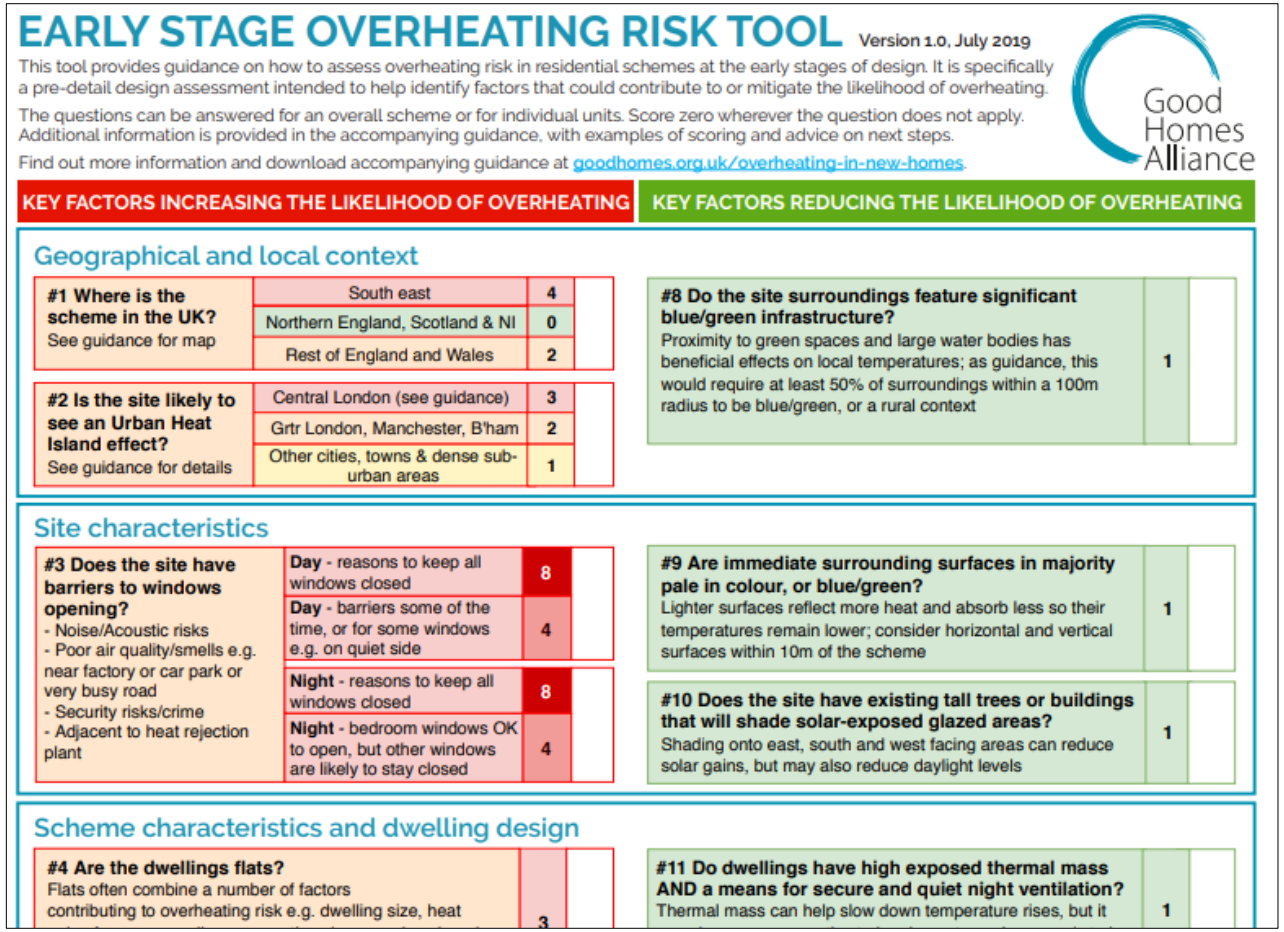
AO7: Review of overheating risk within council owned housing and creation of an action plan based on the findings

Example: using the Good Homes Alliance *Early stage overheating risk tool*[30].

Based on the results, an action plan should be made to identify specific and targeted measures to reduce overheating and help social housing residents during heatwaves.

Measures may include physical retrofit such as adding insulation, new glazing or shutters to the most at-risk homes. Other interventions such as education of residents on how to best manage heat within homes and greening of areas surrounding the homes to reduce local air temperature and provide shading during times of extreme heat.

If successful, this process could be extended to other council owned and ran buildings such as schools and offices.



EARLY STAGE OVERHEATING RISK TOOL Version 1.0, July 2019

This tool provides guidance on how to assess overheating risk in residential schemes at the early stages of design. It is specifically a pre-detail design assessment intended to help identify factors that could contribute to or mitigate the likelihood of overheating.

The questions can be answered for an overall scheme or for individual units. Score zero wherever the question does not apply. Additional information is provided in the accompanying guidance, with examples of scoring and advice on next steps.

Find out more information and download accompanying guidance at goodhomes.org.uk/overheating-in-new-homes.

Good Homes Alliance

KEY FACTORS INCREASING THE LIKELIHOOD OF OVERHEATING			KEY FACTORS REDUCING THE LIKELIHOOD OF OVERHEATING		
Geographical and local context					
#1 Where is the scheme in the UK? See guidance for map	South east	4	**#8 Do the site surroundings feature significant blue/green infrastructure?** Proximity to green spaces and large water bodies has beneficial effects on local temperatures; as guidance, this would require at least 50% of surroundings within a 100m radius to be blue/green, or a rural context	1	
	Northern England, Scotland & NI	0			
	Rest of England and Wales	2			
#2 Is the site likely to see an Urban Heat Island effect? See guidance for details	Central London (see guidance)	3			
	Grtr London, Manchester, B'ham	2			
	Other cities, towns & dense sub-urban areas	1			
Site characteristics					
#3 Does the site have barriers to windows opening? - Noise/Acoustic risks - Poor air quality/smells e.g. near factory or car park or very busy road - Security risks/crime - Adjacent to heat rejection plant	**Day** - reasons to keep all windows closed	8	**#9 Are immediate surrounding surfaces in majority pale in colour, or blue/green?** Lighter surfaces reflect more heat and absorb less so their temperatures remain lower; consider horizontal and vertical surfaces within 10m of the scheme	1	
	Day - barriers some of the time, or for some windows e.g. on quiet side	4			
	Night - reasons to keep all windows closed	8	**#10 Does the site have existing tall trees or buildings that will shade solar-exposed glazed areas?** Shading onto east, south and west facing areas can reduce solar gains, but may also reduce daylight levels	1	
	Night - bedroom windows OK to open, but other windows are likely to stay closed	4			
Scheme characteristics and dwelling design					
#4 Are the dwellings flats? Flats often combine a number of factors contributing to overheating risk e.g. dwelling size, heat		3	**#11 Do dwellings have high exposed thermal mass AND a means for secure and quiet night ventilation?** Thermal mass can help slow down temperature rises, but it	1	

Figure 24. High level overheating risk tool for houses, Source: Good Homes Alliance

Table 18 AO7: Review of overheating risk within council owned housing and creation of an action plan based on the findings.

Intervention Type:	Research/planning			
Hazard Categories:	Heatwaves and extreme heat			
Internal Adaptation Owner:	Housing			
Collaborating Stakeholders:	**Internal:** Sustainability and climate change team	**External:** Housing associations		
Implementation Timeframe:	Heatwaves have already increased in frequency and intensity, and understanding how the Council's housing stock will react is important. However, extreme heat and overheating of home may not become a significant risk until later in the century, and so this action could occur in the medium term.	Short term - < 5 years	Medium - 5- 10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	Cost would depend on the method deployed, internal teams and expertise could be used to conduct the research at low cost. However, consultants or external expertise may be needed to conduct specialist surveys, this would come at a medium cost.	£	££	£££
Cost Indication (Ongoing/Maintenance)	No ongoing cost after initial research and report. However, likely to identify actions and next steps which may include retrofitting of houses and so would be a medium to high cost to the Council. Though some actions may be lower cost such as education of residents.	£	££	£££
Staff Resource Intensity:	Resource and time costs would depend on the method deployed. If external consultants or contractors were to conduct the majority of the work strain on Council staff would be low. If Council staff were to conduct the majority of the work, time costs would be medium too high for a short period.	Low	Medium	High
Co-Benefits:	**De-carbonisation:** Recommendations for retrofit are likely to both reduce overheating and reduce energy use within homes. **Possible benefits to nature:** Some adaptation options likely to be highlighted may include greening of the local microclimate			
Implementation Feasibility:	The initial research into overheating risk is likely to be low complexity especially if outsourced. However, implementing subsequent recommendations and actions are likely to be more complex.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	Lessons learnt and plan updates from each major heatwave experienced. Formal review of the plan should be on a cycle of every 5 years.	Initial research – one off project Action plan – updated every 5 years		
Immediate Next Steps:	Identify funding and/or internal expertise and key research questions.			

5. Adaptation options

5.6 Becoming resilient to extreme heat

AO8: Dundee City Council to set up and run (or be a key partner in) a heat health working group

Though extreme heat brings a number of risks to nature, business and infrastructure as mentioned in section 3, for the public the biggest risks are related to negative health impacts. Extreme heat can cause excess deaths and heat related illness, rises in the frequency and intensity of heatwaves in the future will make these health risks more prominent.

These health risks can be reduced in several ways, such as cooling the city and indoor spaces to reduce exposure. However, this adaptation measure focuses on more direct interventions, with measures such as educating people on heat risks and staying safe during heatwaves, protecting vulnerable people during heatwaves and improving the readiness and resilience of health and other emergency services during heatwaves.

Effectively protecting vulnerable individuals and our health services during heatwaves would require a large and diverse group of stakeholders to work together or in conjunction. Therefore, one of the first actions suggested to improve the city's resilience to heat health risks is the formation of a heat health working group.

This working group will help to coordinate an approach to reduce heat health risks in the future across the city. The group will bring together organisations and individuals across the city that can help increase the resilience of people to heat and foster conversations on the topic and eventually coherent action. The group will offer a space where both experts in the topic and individuals on the front line can combine knowledge to both enhance understanding of the problem across the city and devise effective action. This action could also be implemented at a regional level.

5. Adaptation options

5.6 Becoming resilient to extreme heat

AO8: Dundee City Council to set up and run (or be a key partner in) a heat health working group

The group structure could be flexible depending on need but is likely to consist of an initial set up phase where research is conducted on key problems and current actions.

Focus on 3 key areas:

- Resilience and the continuation of health services during heatwaves – both reducing pressure on health services from heat related injury or illness and making sure the health service can function during times of extreme heat (i.e. are hospitals able to function in extreme high temperatures).
- Educate the general public on heat health risks and how to manage them.
- Protection of vulnerable people (those with chronic illness, elderly especially living alone and young children) during times of extreme heat.

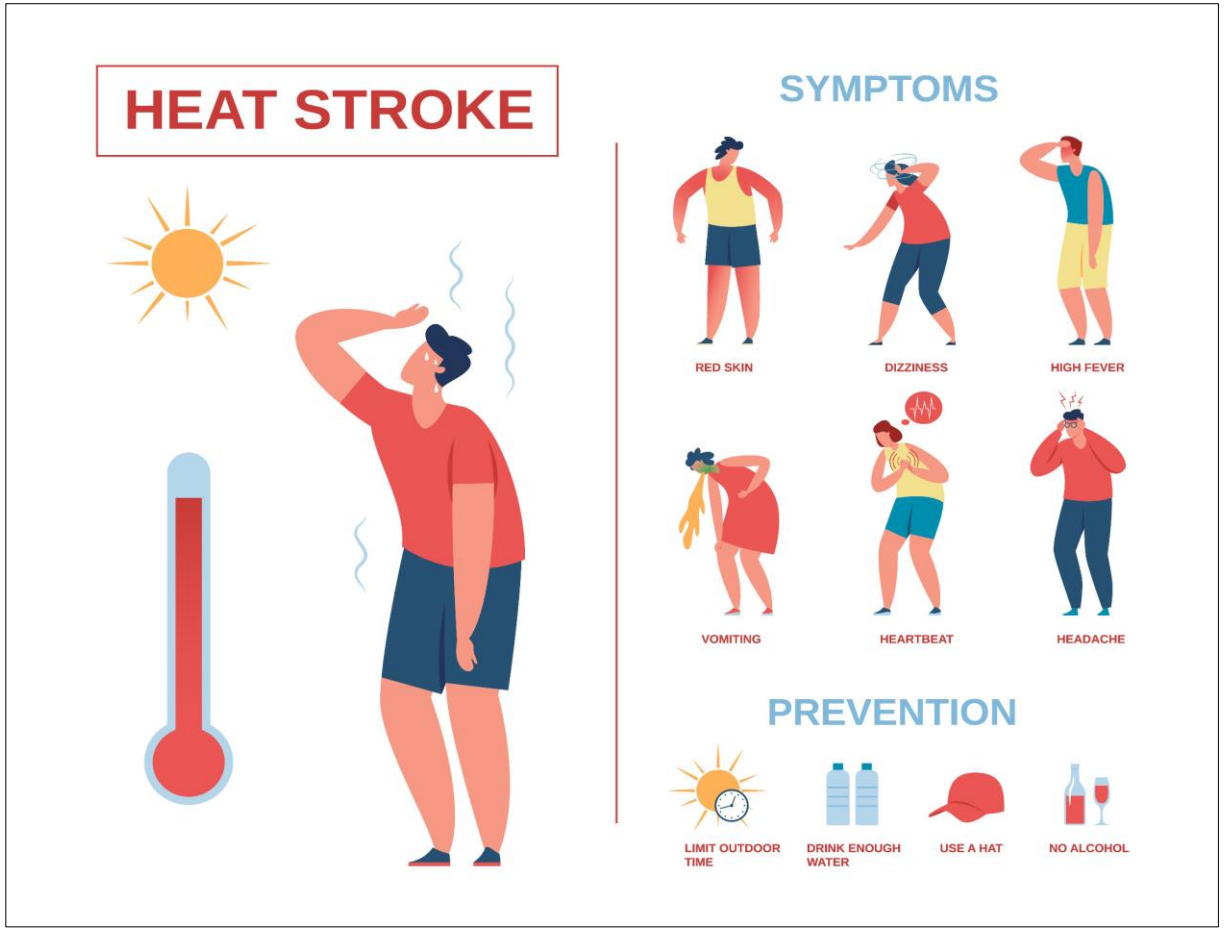


Figure 25. Example of simple heath health guidance that could be produced and distributed, Source: Thurston Fire Service, USA

Table 19 AO8: Dundee City Council to set up and run (or be a key partner in) a heat health working group.

Intervention Type:	Procedural/planning			
Hazard Categories:	Heatwaves and extreme heat			
Internal Adaptation Owner:	Sustainability and climate change team, public health			
Collaborating Stakeholders:	**Internal:** Social work, public health	**External:** Local NHS trusts (hospital and GP representatives), care homes, police, fire service, education providers, local relevant charities, academic representatives.		
Implementation Timeframe:	Though the hazard of heat is a developing hazard and will become more of a threat, it is still advised that this group is set up in the near future. This is because of the complexity of working across organisations and sectors. Additionally, some actions identified may take several years to fully implement.	Short term - < 5 years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	There may be some upfront costs for hosting initial workshop(s), though this is likely to be small. Hosts could rotate between stakeholders when the working group is set up or online meetings could be held.	£	££	£££
Cost Indication (Ongoing/Maintenance)	The running of the group alone will have low ongoing cost, only the officers time. However, ongoing costs are likely to occur from the identified actions if any involved physical changes or additional resources/expertise.	£	££	£££
Staff Resource Intensity:	Resourcing is likely to be medium intensity for a Dundee City Council lead during the set-up phase, where co-ordinating stakeholder and developing actions will require more time (possibly the first full year). If one individual took on this role this could even be high intensity. However, this is likely to drop to low intensity during subsequent phases, Where check-ins would be less regular, and work would be actions only assigned to Dundee City Council.	Low	Medium	High
Co-Benefits:	**Reputational benefits:** Leading by example and taking a chief role in enhancement of the city's resilience to heat health risks will provide reputational benefits **Cost savings:** coherent action across organisations could lead to cost savings by preventing duplication. Educating and protecting vulnerable people from heat health risks is also likely to reduce costs for medical services (prevention over cure).			
Implementation Feasibility:	Due to multiple different organisations with different processes and priorities, setting up and effectively running the working group could have some complexities. Especially when it comes to coordinating actions across the city due to multiple interdependencies and possibly conflicting approaches.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	After the initial group is set up and key actions are identified, yearly reviews would provide updates on progress. A major review after 5 years would assess the overall effectiveness of the group and its structure, this review would thoroughly assess progress against goals identified within the first year of the working group.	Minor review/ updates annually Major review – every 5 years		
Immediate Next Steps:	Identification of internal stakeholders and Councils role within the running of the group. Identification of external stakeholders and initial introduction workshop to gather interest and discuss format/goals of the working group.			

5. Adaptation options

5.7 Becoming resilient to drought

AO9: Increasing the Councils resilience to drought – reducing water consumption

Climate change projections and work by others has highlighted the likelihood of future reduction in summer rainfall and an increase in dry spells. Together and combined with the expected rise in summer temperatures drought is likely to become a more frequent and intense in the region. As a city reducing water consumption will help increase resilience. This measure proposes that the Council take a leading role in this by auditing its water consumption as an organisation, setting reduction targets and creating and action plan to reduce the organisation's overall consumption of water. Reducing the organisation's water consumption will provide a number of co-benefits beyond simply reducing exposure to drought. These additional benefits include:

- **Carbon savings -** The water industry is high carbon intensive, reduction in consumption will therefore help reduce emissions.
- **Cost savings –** Water is a significant utility cost to the Council, money saved can be distributed to other areas
- **Increase in reputation and the ability to credibly push other city organisations to follow:** By taking a leading role in reducing water consumption the Council will increase its reputation across the city and be able to lobby other organisations and businesses to do the same by creating a best practice example.

Table 20 AO9: Increasing the Council's resilience to drought – reducing water consumption.

Intervention Type:	Governance/physical actions			
Hazard Categories:	Drought			
Internal Adaptation Owner:	Maintenance, facilities team			
Collaborating Stakeholders:	**Internal:** Sustainability and climate change team	**External:**. Scottish Water, possible collaboration with academics for advice/research opportunity		
Implementation Timeframe:	An initial audit of current water consumption should take place in the next 1-2 years, creating a baseline. Targets and realistic reductions mechanisms and subsequent action plan will then be developed and may take a number of to be finalised. Actions to actually reduce water consumption is likely to take place between 5 and 10 years from now and continue past the 10-year mark.	Short term - < 5 years	Medium - 5-10 years	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	Though the audit and action plan development is likely to be medium cost, actions may include significant capital investment in assets to make them more water efficient or to develop ways of storing water this is likely to be more costly.	£	££	£££
Cost Indication (Ongoing/Maintenance)	Ongoing costs are high, as mentioned as this work develops money will need to be invested into assets and infrastructure to help enhance water efficiency.	£	££	£££
Staff Resource Intensity:	Resource intensity is likely to be high, especially during the audit and action plan phase. As actions are implemented resources intensity may dip but will peak when actions become live. The resource intensity during the action phase is likely to vary depending on the action. If new systems are in place maintenance of those systems should also be considered.	Low	Medium	High
Co-Benefits:	**Carbon:** Reducing water consumption saves carbon due to the carbon intensity of producing clean water **Cost savings:** There will also be cost saving for the council by reducing their own utility bills **Reputations enhancement:** Achieving a significant reduction in water use and being a good example for the city will have reputational benefits.			
Implementation Feasibility:	Feasibility of the audit and target phase is likely to be of low to medium complexity. However, undertaking measures to significantly reduce the organisations water consumption is likely to be more complex, with some actions being more feasible than others.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	Targets once established should be reviewed every 5 years, including progress to meet those targets. Action plans should then be adapted according to progress against targets.	In depth review: every 5 years		
Immediate Next Steps:	Identify if water consumption data is available in the detail needed for such a project. Identify a working group and refine scope and timelines.			

6. Conclusions and next steps

6.1 Conclusions

6.2 Next steps

6.Conclusions and next steps

6.1 Conclusions

Analysis of the UK's latest climate change projections for the city of Dundee has highlighted a number of climate hazards which are likely to increase over the coming century. The work to analyse past events has highlighted that recent storm events have caused significant costs to the city, through both flooding and wind damage. These costs are wide-ranging and include financial costs, disruption to services, city life, and the city's nature, as well as impacts on physical and mental wellbeing.

The Climate Change Risk and Vulnerability Assessment has also highlighted several risks and opportunities which these changes are likely to bring. These key findings include:

- Changes to precipitation patterns are likely to increase flood risk within the city. Flooding can have devastating impacts with sometimes irreversible damage and threatens communities, education, health care, cultural heritage and nature.
- Changes to summer temperatures and summer rainfall will likely increase the intensity and occurrence of both extreme heat and drought. Both are new and emerging hazards, drought may have significant implications for water scarcity within the city, or agriculture in the wider region. Water scarcity could be particularly impactful to infrastructure and businesses which are water intensive. The developing threat of extreme heat is dangerous to all sectors. The city's buildings are generally ill-equipped to deal with temperatures projected for the future, this could cause overheating, malfunction of equipment and the need for air conditioning.
- Extreme heat as well as shifting average temperatures also threaten the city's nature, due to the city's northern location some species are already near to their comfortable temperature thresholds. Generally, warming also opens up opportunities for new invasive species to colonise the city which may be detrimental to native or existing nature.
- Storms are also likely to increase in intensity and frequency, though this is less certain. This can result in flash flooding and damage to the city's assets from both wind and lightning.
- Sea level is rising, this is likely to have knock on impacts to the city due to its estuarine position, possibly increasing both coastal erosion and coastal flood risk. This is a particular problem for communities, nature and assets located along the coast. Some of the city's key transport assets such as the airport and train station are located along the banks of the Tay and are particularly vulnerable.

6.Conclusions and next steps

6.1 Conclusions

- Winter temperatures are warming, extreme cold events and snow are likely to reduce in the future. This will bring a mix of risks and opportunities. Opportunities include winter health benefits and winter heating reduction, less winter disruption and maintenance for transport. However, a lack of frost may also have subsequent risks, such as increasing the prevalence of pests and diseases which are usually kept under control by cold weather spells.
- Finally, these hazards also bring risks to the Council as an organisation. Direct risks to employees, assets, and services have been identified. Wider risks such as changes to the insurance sector and threats to supply chains could also occur, though these changes are less certain.
- Finally, a number of diverse adaptation options have been identified which will help the city and the Council become more resilient to these future hazards. These options include a range of practical, governance measures as well as some further research on key areas of uncertainty. All were selected as options which the Council can either lead or play a significant role in developing. These adaptation measures are not a complete adaptation action plan and neither address all risks or explore all possible adaptation measures and will be used as a starting point to develop further action. Starting to incorporate these actions and investing in prevention rather than responding after events occur will save the Council money in the long run.

6.Conclusions and next steps

6.2 Next steps

- Publicise new risk assessment and work with key partners in the city to ensure the findings reach a wide range of relevant groups and organisations.
- Conduct further work within the regional partnership and use the risk assessment to help further identify regional synergies and priorities.
- Use the work on past events to help build a robust business case for future action.
- Review adaptation options and next steps in terms of developing adaptation plans for the city.

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Appendices

A1. Climate change projections in full

A2. Flood risk analysis

A1. Climate change projections in full

Scenario approach

An academic paper Hanlon et al, was used to covert the 2 and 4 degree warming to an equivalent year and produce Representative Concentration Pathways (RCPs) which were compatible with the UKCP18 projections – see image to the right.

All UKCP18 land projections were therefore taken at the 50th percentile for RCP8.5 at two time periods.

- 2030 to 2060 representing 2°C of warming
- 2050 to 2080 representing 4°C of warming

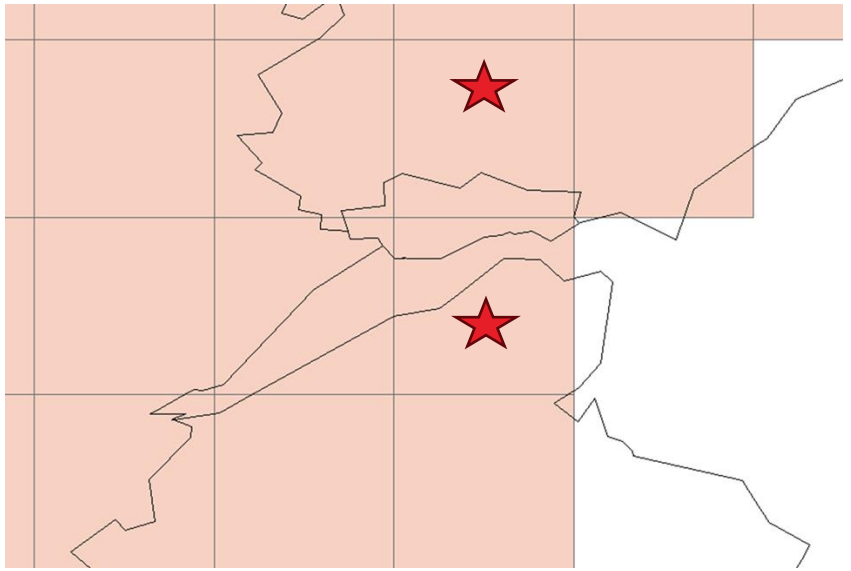


Figure A1.1. Left shows UKCP18 grid cells with local authority boundaries overlaid. Dundee City Council spans 5 grid cells, however the majority of its landcover sits within two represented by a red star, data was taken from both and averaged for a single reading across the city.

Scenarios and timespans

Table 1 Dates for reaching warming levels determined from the UKCP18 probabilistic projections for each emissions scenario at the 90th, 50th and 10th percentile of the global temperature distribution. A warming level not reached by the end of the projection, 2100, is indicated with a "-", but this does not guarantee that this level of warming would not be reached if the scenarios and projections were extended further into the future

Emission scenario	Global warming level											
	1.5 °C			2.0 °C			3.0 °C			4.0 °C		
	90th	50th	10th	90th	50th	10th	90th	50th	10th	90th	50th	10th
RCP2.6	2020	2037	–	2037	–	–	–	–	–	–	–	–
RCP4.5	2020	2036	2060	2036	2056	2083	2066	2095	–	–	–	–
RCP6.0	2021	2040	2062	2041	2059	2075	2067	2082	–	2085	–	–
RCP8.5	2020	2029	2044	2031	2043	2059	2050	2064	2080	2065	2081	–

Hanlon et al (2021) - Future changes to high impact weather in the UK - *https://link.springer.com/article/10.1007/s10584-021-03100-5*

Figure A1.2. Right shows a table taken from Hanlon et al. (2021) used to convert degrees of warming into dates and RCP for projection selection.

A1. Climate change projections in full

Table A1.1. The full climate projection data which was used in this analysis. All data is taken from the UKCP18 12km models, at RCP 8.5 and for the 50th percentile. The number outside of the brackets represents the absolute data, the number inside the brackets represents the anomaly (change from the baseline). Each number is an average taken from the two chosen grid cells which best represent the city.

Climate variable	**Climate metric**	**Unit**	**Baseline (1980-2010)**	**2 °C scenario *(RCP 8.5 at 2030-2060)***	**4 °C scenario *(RCP 8.5 2050-2080)***
				Absolute (change from baseline)	***Absolute (change from baseline)***
Winter temperatures	Number of frost days (daily minimum temperature equal or lower than 0°C)	Number of days per year	57.72	29.33	30.98
	Winter mean min daily minimum temperature	°C	0.58	2.27	3.20
	Freeze-Thaw cycles (Number of days above and below freezing)	Number of days per year	56.28	34.73	23.18
	Winter mean temperature	°C	3.36	4.98	5.87
Summer temperatures	Heatwaves (3 days with maximum temperature higher than 25°C)	Number of heatwaves per year	0.05	0.40	1.60
	Number of hot days (daily maximum temperature higher than 25°C)	Number of days per year	1.25	5.35	13.95
	Summer mean temperature	°C	13.95	16.30	17.65
	Summer mean max daily temperature	°C	18.15	20.80	22.40

A1. Climate change projections in full

Table A1.1 continued. The full climate projection data which was used in this analysis. All data is taken from the UKCP18 12km models, at RCP 8.5 and for the 50th percentile. The number outside of the brackets represents the absolute data, the number inside the brackets represents the anomaly (change from the baseline). Each number is an average taken from the two chosen grid cells which best represents the city.

Climate variable	**Climate metric**	**Unit**	**Baseline (1980-2010)**	**2 °C scenario *(RCP 8.5 at 2030-2060)***	**4 °C scenario *(RCP 8.5 2050-2080)***
				Absolute (change from baseline)	***Absolute (% change from baseline)***
Seasonal precipitation	Mean winter daily precipitation	mm	2.17	2.32	2.56
	Mean summer daily precipitation	mm	2.12	1.88	1.69
Extreme precipitation	Annual number of days per year when precipitation is greater than 20mm	mm	4.60	5.15	5.45
	Maximum of 5-day rainfall	mm	65.50	68.90	70.50
	Dry spells (10 days or more with no precipitation)	Number of occurrences	2.60	2.75	2.95
Other variables	Growing degree days	Index is given in “degree days”	1386.00	1898.55	2205.50

A1. Climate change projections in full

Sea level rise

For sea level rise the mean sea level was taken from the UKCP18 marine projections. Figure A3 to the right shows the areas covered by this data. Data from three cells which cover the closet areas of sea to Dundee were taken and average.

This data comes by year and so the best year to represent the 2°C- and 4°C-degree scenarios were taken from Halon et al's conversion table.

Table A1.2. Provides the full data extracted for sea level rise, this data is for the 50th percentile under the RCP 8.5 scenario.

	Mean sea level rise (m)	
	*Year taken 2043_*	*Year taken 2081*
Cell - A	0.142	0.393
Cell - B	0.144	0.449
Cell - C	0.144	0.397
Average	**0.144**	**0.413**

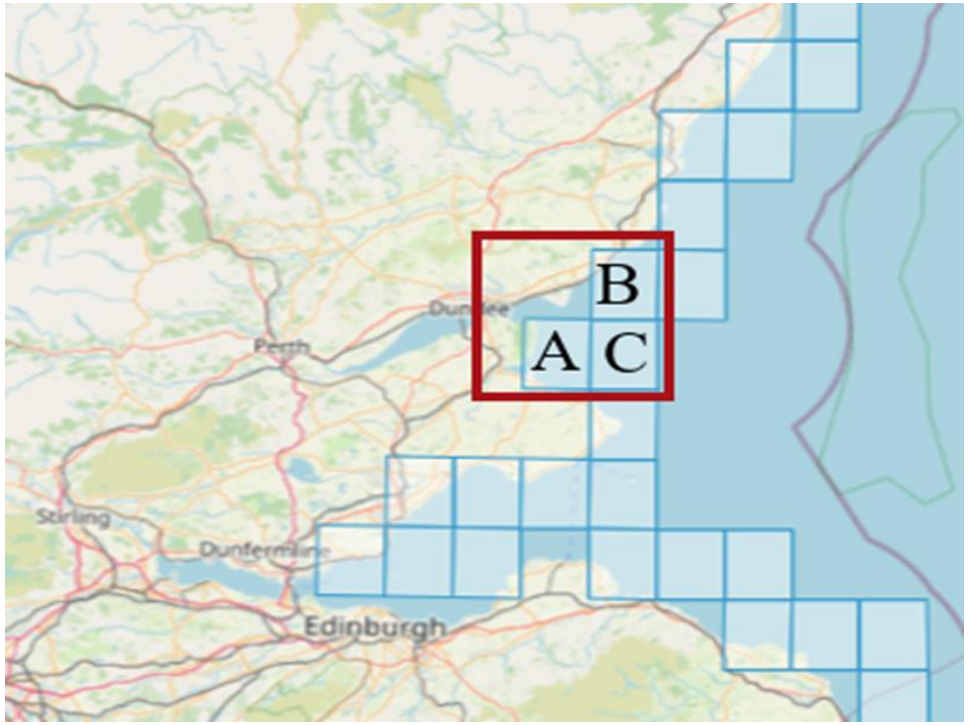


Figure A1.3. The three cells of the UKCP18 marine projections which were taken and averaged to represent sea level rise for Dundee.

A2. Flood risk analysis

Approach

SEPA flood maps were used to understand what of the city's assets sat within a flood zone. This evidence was then used to help understand how much of an issue flooding currently was for each sector assessed in the CCRVA and how likely flooding is in the future.

Table A2.1. The four flood scenarios used, Source: SEPA

Time Horizon	Likelihood of flooding	Return period
Present Day	High	10 year
Present Day	Medium	200 year
Present Day	Low	1000 year
Climate Change 2080s - High emissions	Medium	200 year

A2. Flood risk analysis

Flood risk to education and healthcare facilities

Table A2.2. Full results of the analysis of flood risk to education and healthcare facilities using SEPA flood maps for River and coastal flooding

Flood type	Likelihood level	Education facilities within flood zone	Healthcare facilities within flood zones
River	**Low**	Drumgeith Campus Baldragon Academy	Harestane Care Home Pitkerro Care Centre
River	**Medium**	Drumgeith Campus Baldragon Academy	Harestane Care Home Pitkerro Care Centre
River	**Medium + climate change**	Drumgeith Campus Baldragon Academy	Harestane Care Home Pitkerro Care Centre
River	**High**	Drumgeith Campus Baldragon Academy	Harestane Care Home Pitkerro Care Centre
Coastal	**Low**	University of Dundee - Institute of Sport and Exercise	None
Coastal	**Medium**	University of Dundee - Institute of Sport and Exercise	None
Coastal	**Medium + climate change**	University of Dundee - Institute of Sport and Exercise	Orchard Nursing home
Coastal	**High**	University of Dundee - Institute of Sport and Exercise	

A2. Flood risk analysis

All educational facilities located within the surface water flood zone (low likelihood)

Table A2.3. Full results of the analysis of flood risk to education using SEPA flood maps for surface water flooding, all facilities located within the low likelihood flood zone and so have some flood risk are highlighted here.

- St Pauls Roman Catholic Academy
- St Andrew's Primary School
- High School of Dundee
- Camperdown Primary School
- Craigiebarns Primary School
- Kingspark School
- Tower building, University of Dundee
- St Clement's Roman Catholic Primary School
- Drumgeith Campus
- St John's Roman Catholic Secondary School
- Ballumbie Primary School and early years centre
- Gardyne, Dundee and Angus College
- Grove Academy
- Our Lady's Roman Catholic and Rosebank Primary Schools
- St Mary's Roman Catholic Primary School
- St Peter and St Paul Roman Catholic School
- Braeview Academy
- Morgan Academy
- Northeast Campus
- Institute of Sport and Exercise, University of Dundee
- Eastern Primary School
- Mill of Mains Primary School
- Baldragon Academy
- Craigie High School
- Dens Road Primary School
- Abertay University
- Rowantree Primary School
- Ardler Primary School
- Tayview Primary School
- St Pius Primary School
- Downfields Primary School
- Kingsway campus, Dundee and Angus College
- Harris Academy
- Claypotts Castle Primary School
- St Ninian's Roman Catholic Primary School
- Fintry Primary School

A2. Flood risk analysis

All healthcare facilities located within the surface water flood zone (low likelihood)

Table A2.4. Full results of the analysis of flood risk to healthcare using SEPA flood maps for surface water flooding, all facilities located within the low likelihood flood zone and so have some flood risk are highlighted here.

- Roxburghe House, Royal Victoria Hospital
- Harestane Care Home
- Carseview Centre
- Ballumbie Court
- Pitkerro Care Centre
- Riverside View Nursing Home
- Ninewells Hospital and Medical School
- King's Cross Hospital

A2. Flood risk analysis

Flood risk to nature

Table A2.5 Full results of the analysis of flood risk to nature using SEPA flood maps for surface water flooding, all designated areas or local nature reserves located within highlighted flood zones are show in in the table below

	Coastal flood risk	River flood risk	Surface water flood risk
All greenspace (according to OS greenspace layer).	• Low likelihood – 2.87 % • Medium likelihood – 3.07% • Future medium likelihood – 2.7% • High likelihood – 1.9%	• Low likelihood – 3.88 % • Medium likelihood – 3.86% • Future medium likelihood – 3.86% • High likelihood – 3.11%	• Low likelihood - 5.84% • Medium likelihood – 4.58% • High likelihood – 2.91%
Firth of Tay and Eden Estuary – (SAC and RAMSAR	Yes	None	Yes
Broughty Ferry - LNR	None	None	Yes
Inner Tay - LNR	Yes	Yes	Yes
Trottick Mill Ponds Local Nature Reserve	None	Yes	Yes

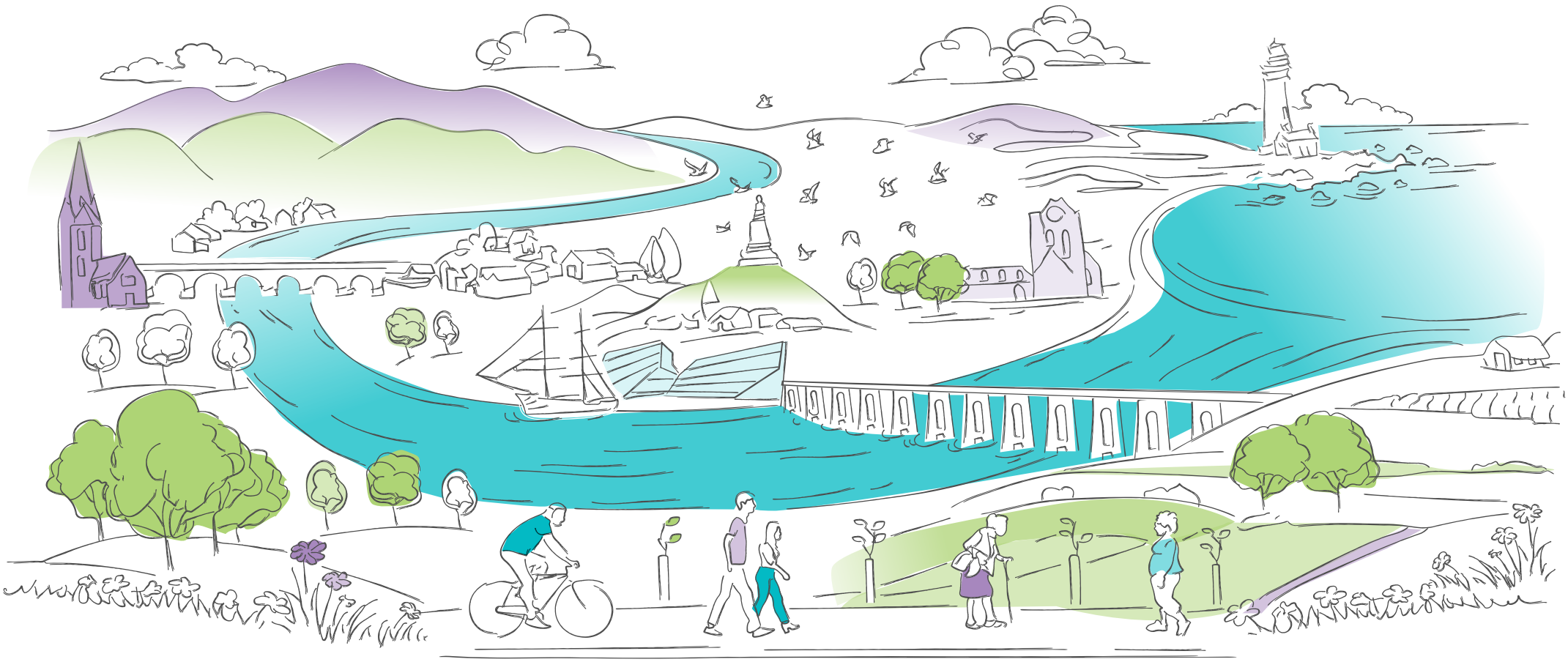
A2. Flood risk analysis

Flood risk extent within the city

Table A2.6. Full results of the analysis of flood risk extent overall to the City of Dundee

Type	Likelihood	% of the city area impacted
Surface water	Low	10.03
	Medium	7.64
	High	2.93
Coastal	Low	7.02
	Medium	7.56
	Medium CC	5.39
	High	7.56
Riverine	Low	2.88
	Medium	2.52
	Medium CC	2.82
	High	2.08

ARUP



Preparing people and places for a thriving future

Climate Ready Tayside

Introducing Climate Ready Tayside

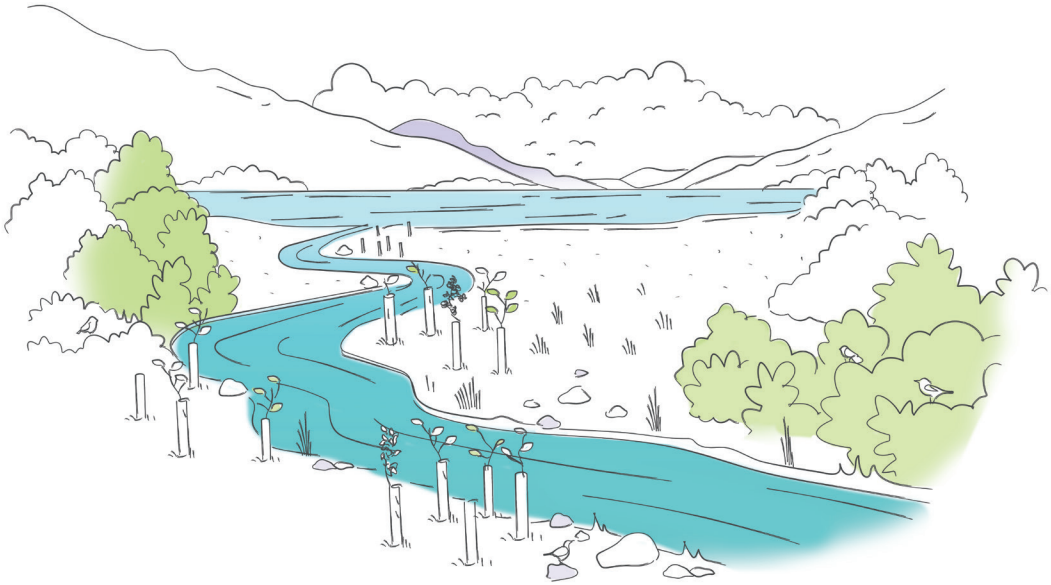
Tayside is a diverse region in Scotland, with thriving cities alongside rural communities.

We have nationally important cultural assets, prime agricultural land and outstanding nature and recreational opportunities. We have a proud history of design and innovation, ports that support the local economy, and a growing movement of locally led climate action. The River Tay shapes our communities, towns and landscape from the river, to the estuary and out into the North Sea.

Tayside's location makes it vulnerable to the impacts of climate change and extreme weather, such as flooding, storms, sea level rise and coastal erosion. The assets that make our region so special are also under threat.

Climate Ready Tayside is a new partnership bringing together public, private and community organisations to prepare people and places for a thriving future, in our changing climate.

This document describes our vision and priority areas for action, which have been co-developed with local people and organisations.



Climate Ready Tayside covers the full local authority areas of Angus, Dundee and Perth and Kinross. The Scottish Government has set an ambition to establish regional adaptation partnerships across all regions in Scotland by 2029.

Creating a vision and priorities

In autumn 2024, four public workshops were held to involve local people and organisations in creating a vision and set of priorities for Climate Ready Tayside.

The Three Horizons futures method was used to explore;

- How prepared is Tayside for the current impacts of climate change? What is working well and what is not working so well?
- What do we want to see in Tayside in 2050, as the result of good adaptation action?
- How can Climate Ready Tayside help make this future happen?

367 comments were collected from 60 people from 34 different organisations, community groups and businesses.

The current situation

We asked everyone:

How prepared is Tayside for the current impacts of climate change? What is working well and what is not working so well?

People said:

1. Tayside's systems, infrastructure and economy are **not resilient** to climate change
2. We are in a climate and nature **emergency**
3. There is **a lack of funding, resources and capacity** for adaptation action
4. There are **examples of good partnership working**, but many sectors and organisations work in isolation
5. Most people have **low understanding of climate risks** and how to adapt
6. Organisations and community **groups are keen to take action and collaborate**
7. Many policies and decision-making **processes do not support or prioritise adaptation action**

The future we want to see

We will use these points as our vision, for Climate Ready Tayside to work towards.

We asked everyone:

What do we want to see in Tayside in 2050, as the result of successful work to prepare for the impacts of climate change?

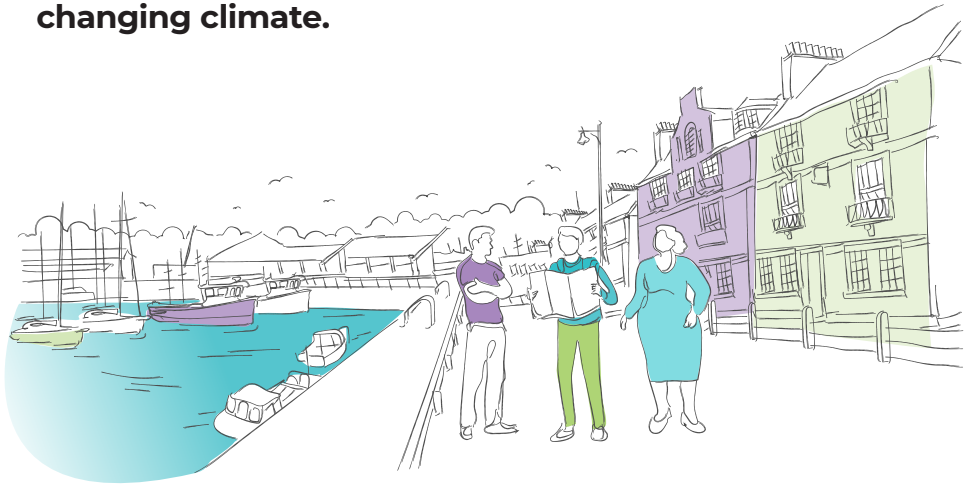
People said:

1. Tayside's food, energy, transport, housing, infrastructure and economy are **resilient**
2. **Nature and biodiversity are thriving**, connected and managed at a landscape scale
3. **Adapting to climate change is sufficiently funded**, to deliver impactful action

4. People, organisations and businesses **understand climate risks and how to respond** to them
5. Groups are **working together** to build healthy, resilient communities and places
6. **Community voices shape local resilience actions** and create co-benefits
7. **Adapting to climate change is business as usual**, mainstreamed into all policies, services, strategies and operation

The role for Climate Ready Tayside

The future we want to see is ambitious and will require large changes. This future is possible if we get everyone behind the goal of creating a Tayside where people and places thrive in our changing climate.



We asked everyone:

How can Climate Ready Tayside help make this future happen? What actions should the partnership prioritise?

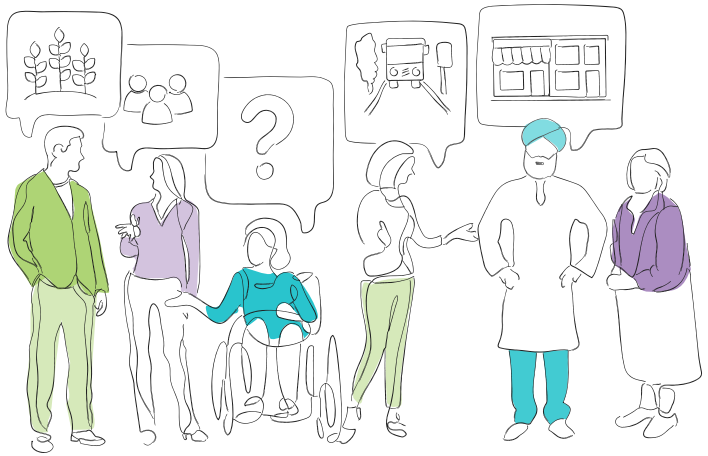
People identified these six priority areas for action:

1. **Share clear communication to raise awareness of climate impacts.**
   a. Share simple and clear communications about climate impacts in Tayside
   b. Develop communication strategies for different audiences
   c. Provide training and education, at all levels

2. **Support the development of regional projects and innovative pilot projects.**
   a. Promote cross-boundary working on adaptation plans and regional resilience projects
   b. Work with infrastructure and housing providers to understand vulnerability and futureproof infrastructure
   c. Create sustainable and resilient food growing systems that feeds local people

3. **Promote nature-based solutions and landscape scale action.**
   a. Seek regional investment to identify, prioritise and fund natured based solutions that will reduce climate impacts
   b. Continue to develop nature networks
   c. Support collaboration between those involved in landscape scale management, from land owners to local authorities and communities

4. **Advocate for fair and joined-up adaptation.**
   a. Act as a voice for vulnerable groups and speak up for fair adaptation action
   b. Make sure communities have a voice in local projects and in the partnership's work
   c. Support adaptation policy integration between national and local levels, and across sectors, providing a valuable feedback loop to Scottish Government



5. **Share knowledge, data and resources across the region**
   a. Help groups and organisations share practical knowledge, climate information, existing resources and best practice
   b. Provide training, upskilling and capacity building for adaptation at a regional scale
   c. Encourage better data sharing (visible, accessible, up-to-date, user friendly)

6. **Attract funding and maximise existing resources**
   a. Pool existing resources between the three local authorities
   b. Collaborate to identify and access funding
   c. Create a business case for long term funding
   d. Leverage new regional scale funding and investment

Appendix

Three horizons map summarising workshop comments

Horizon 1 – the current situation	**Horizon 2** - transformative actions	**Horizon 3** – the future we want to see
Systems, infrastructure and economy are not resilient to climate change	Support the development of regional **exemplars** and innovative pilot projects	Tayside's food, energy, transport, housing, infrastructure and economy are resilient
We are in a climate, nature and biodiversity emergency	Promote **nature-based solutions** and landscape scale action	Nature and biodiversity are thriving, connected and managed at a landscape scale
Lack of funding, resources and capacity for adaptation action	Collaborate to attract **funding** and maximise existing resources	Adaptation is sufficiently funded, to deliver impactful action
Low understanding of climate risks and how to adapt	Clear **communication** to raise awareness of climate impacts	People, organisations and businesses understand climate risks and how to respond to them
Many sectors and organisations work in isolation, but there are examples of good partnership working to learn from	Support the sharing **of knowledge, data and resources** across the region	Groups are working together to build healthy, resilient communities and places
Many policies and decision-making processes do not support or prioritise adaptation action	**Advocate** for fair and joined-up adaptation action	Adaptation is business as usual, mainstreamed into all policies, services, strategies and operation
Organisations and community groups are keen to take action and collaborate		Community voices shape local resilience actions and create co-benefits

Find out more

Climate Ready Tayside is a new partnership bringing together public, private and community organisations to prepare people and places for a thriving future, in our changing climate.

You can find out more and how to get involved in upcoming activities on our website climatereadytayside.org.uk

Acknowledgements

We want to thank everyone who joined our public workshops for contributing their ideas and time to help shape our vision and priorities.

Climate Ready Tayside has been supported in this early phase by Scottish charity Verture through the **Adaptation Scotland programme**, funded by the Scottish Government.

The Three Horizons method created by **H3Uni** was used to structure the public workshops. To find out more and access free facilitation guides visit **www.h3uni.org/facilitation-guide/three-horizon-mapping-guide/**

Climate Ready
Tayside