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Angus Council
Comhairle Aonghais

Climate Change Risk and Vulnerability Assessment

ANGUS

December 2025

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1. Introduction

1.1 Overview and context

Carbon emissions and the resultant climate changes are increasing climate hazards and risks throughout the UK. The UK and Scotland's Climate Change Acts commit to reducing emissions to net zero by 2050 and 2045, respectively. 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]. As a result, it is vital that Scotland prepares for climate change, adapting and becoming more resilient. Recently, Angus has seen extreme events such as storms bringing flooding as well as extreme winds which have caused disruption damage and many other negative impacts.

Climate resilience relates to the ability to anticipate, prepare for, respond to 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 measures can save money in the long term[3].

There are also national drivers for understanding climate risk. The Climate Change (Scotland) Act 2009[4] places a legal duty on public bodies such as Angus 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.

Angus Council is fully committed to addressing the climate change emergency and has so far made good by setting ambitious emission reduction targets and implementing their climate action plan[5]. However, in the years since the Climate Change Scotland Act was ratified, evidence for climate change and associated risks has changed.

Arup have been commissioned to undertake this climate change risk and vulnerability assessment. This work provides a comprehensive overview of how Angus' climate and the associated climate hazards are projected to change. This report also provides case studies showing the cost of past events to help contextualise the future changes and risks. Finally, a high-level assessment of six adaptation options is presented.

1. Introduction

1.2 Approach

As part of this commission, the following steps have been taken:

Step 1: Create a Climate Change Profile of Angus

The climate change projections for Angus, and the associated changes in climate hazards, were analysed using the UKCP18 projections[6] and other relevant Met Office information. The findings of this work are presented in Section 2.

Step 2: Map the vulnerability around Angus

The vulnerability, using Scottish Index of Multiple Deprivation and flooding data, of Angus has been mapped to inform further assessment. The methodology and outputs of this work are presented in Section 3.

Step 3: Present the Climate Change Risk and Vulnerability Assessment

The latest UK Climate Change Risk Assessment (UK CCRA)[7] and Scotland's national summary[8] were reviewed, alongside the updated risk descriptors from the Met Office[9] to create a 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 risk were most relevant to the region and how prominent the risks were. Using this information, risks were scored. The risk assessment's key findings are summarised in Section 4.

Step 3: Assess the Cost of Past Extreme weather events in Angus

The UN's loss and damage framework was tailored to the region 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 5.

Step 4: Evaluate and present relevant adaptation options

Six relevant adaptation options which would make the region more resilient to the three most prominent future hazards are presented. Adaptation options were chosen that can be owned by various stakeholders in the region, and where the Council can collaborate with stakeholders has been identified. Multiple characteristics of these options, such as upfront and ongoing costs, staff time and feasibility were assessed and compared. The findings of this work are presented in Section 6.

1. Introduction

1.3 Climate Ready Tayside

A regional adaptation partnership for Tayside, including Perth and Kinross and Dundee City Local authorities[10] was developed in 2024, see Figure 1.

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 priorities for the partnership include:

1. Share clear communication to raise awareness of Tayside specific climate impacts and solutions
2. Support the development of regional projects and innovative pilot projects for Tayside
3. Promote nature-based solutions and landscape scale action
4. Ensure adaptation action is fair and inclusive
5. Make climate resilience business as usual in Tayside
6. Share knowledge, data and resources across the region
7. Attract regional funding and maximise existing resources
8. Create sustainable and resilient food growing systems that feed local people

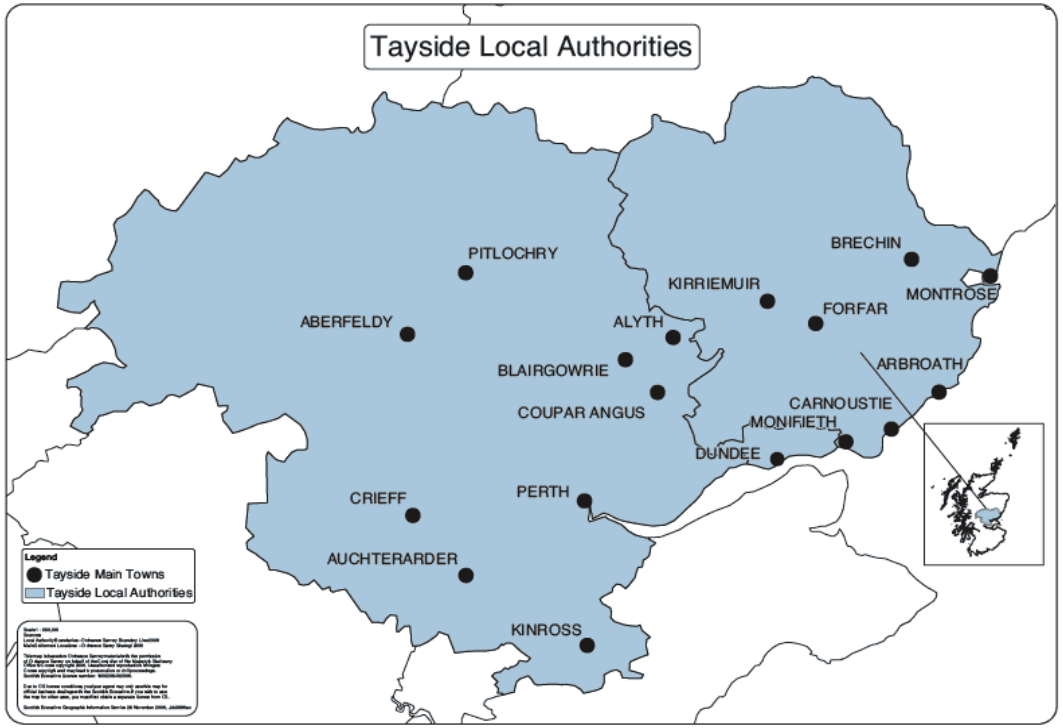

Figure 1. Map of local authorities and major towns included in the Climate Ready Tayside[10]

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2. Climate Change Profile of Angus

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 Changes to sea level and coastal erosion

2.7 Climate change hazards

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2. Climate Change Profile of Angus

2.1 Introduction

The first step to understanding future climate hazards and the associated risks is identifying how the climate is projected to change locally within the region. 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 region using the UKCP18 climate change projections and UK observation data from HadUK Data at a 12km resolution[11,12]. This data is provided by Met Office in a raster (grid) format and one if its limitations is that these grid cells do not cover certain coastal areas, such as Arbroath. In such cases, a reasonable assumption is to take data from the nearest available grid square. Further details on the methodology for this are provided within Appendix A1.

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 guidance 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 Appendix A1.

2. Climate Change Profile of Angus

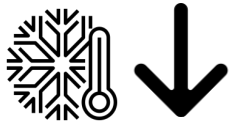
2.2 Changes to winter temperatures and extreme cold

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

- The number of frost days are expected to reduce by nearly 40% in the uplands (from app. 150 to 92 days/year) and by 70% in the lowlands (from 50 to 12 days/year) 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 in winter is projected to increase by 3-4 °C under a 4°C of scenario, exceeding 0 °C in the majority of the Angus area. This contributes to reduction in freeze-thaw cycles.
- Mean winter temperatures will increase by approximately 1.5°C (2°C scenario) and by 2.5°C (4°C scenario).
- Additionally, from the Met Office's UKCP18 factsheet on snow[13], there will be a significant decrease in both falling and lying snow. In general, the decreases are smaller in both falling and lying snow in mountainous regions (e.g. upland areas in the west and north of Angus) than in low-lying regions (e.g. flatter plains in the east of Angus, along the coast).

Highlights:

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

Further details on winter temperatures and extreme cold, including associated mapping are provided within Appendix A1.

2. Climate Change Profile of Angus

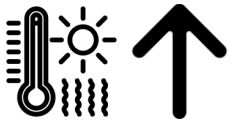
2.3 Changes to summer temperatures and extreme heat

Clear trend in increasing summer temperatures, both average and extreme.

- Average summer temperatures are projected to increase by approximately 2°C under a 2°C scenario, and by 4-4.5°C under a 4°C scenario in both the uplands and lowlands.
- Average daily maximum temperatures are projected to increase by approximately 2°C under a 2°C scenario, and by 3.5-4 °C under a 4°C scenario in both the uplands and lowlands .
- The average number of Met Office defined heatwaves experienced in a year will increase from 0 in the baseline period (1981-2010) to 1 occurrence 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 an average of 0 to nearly 4 in the uplands, and from 1 to 12 in the lowlands.

Highlights:

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



Number of heatwave occurrences per year will increase under a 4°C scenario.

Further details on summer temperatures and extreme heat, including associated mapping are provided within Appendix A1.

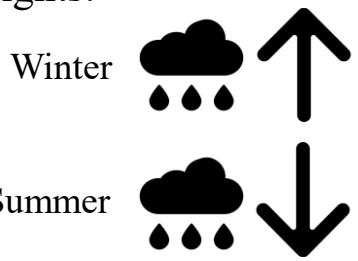
2. Climate Change Profile of Angus

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 approximately 0.2 mm/day and summer precipitation will decrease by approximately 0.2 mm/day.
- Under the 4°C scenario, average winter precipitation is expected to increase by 0.4mm/day. Average summer precipitation will decrease by approximately 0.4-0.5mm/day.
- Heavy rainfall events (days with precipitation exceeding 20mm/day) are projected to increase in frequency by approximately 1-2 more occurrences a year. Dry spells (10 days or more with no precipitation) are projected to become about 10% more likely compared to the baseline.
- East Scotland projections show increased drought conditions in a warmer climate.

Highlights:



There will be an increase in average winter precipitation and a decreased 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.

Further details on changes to precipitation, including associated mapping are provided within Appendix A1.

2. Climate Change Profile of Angus

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 a cumulative sum of temperature degrees for mean daily temperature above 5.5°C. In other words, it is the amount of heat crops receive during a given growing season.

- In the uplands, growing degree days are projected to increase by approximately 400 under a 2°C scenario and by 700 under the 4°C scenario.
- In the lowlands, growing degree days are projected to increase by approximately 500 under a 2°C scenario and by 800 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.

Based on the Met Office's UKCP18 factsheets for wind[14] and storms[15]:

- UK Climate Projections show an increase in windstorm number 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.
- For thunderstorms, recent UK observations show a slight decrease in the number of days with thunder. In future climate, UK Climate Projections indicate that lightning is projected to increase in spring and summer, decrease in autumn, and shows little change in winter.

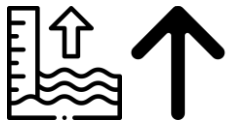
Frequency and intensity of storms are likely to increase.

2. Climate Change Profile of Angus

2.6 Changes to sea level and coastal erosion

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

- Mean sea level is projected to increase by approximately 0.16m under a under a 2°C scenario.
- Mean sea level is projected to increase by approximately 0.41m under a 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 erosion.

Further details on sea level rise and coastal erosion, including associated mapping are provided within Appendix A1.

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.

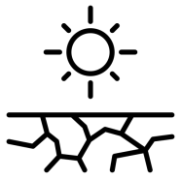
Climate change and sea level rise may make coastal erosion more prominent along the coast of Angus, especially in parts of the coastline which are not protected by hard engineering.

Coastal erosion threatens nature, buildings and infrastructure near the coast.

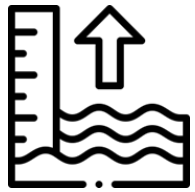
2. Climate Change Profile of Angus

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 Angus; all will increase with climate change apart from extreme cold which will decrease.
- All seven hazards will be considered in the Climate Change Risk and Vulnerability Assessment (CCRVA).

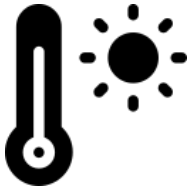


Drought & water scarcity



Coastal flooding and erosion

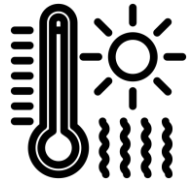
Storms and high winds



Average warming

River and surface water flooding

Frost days



Extreme heat

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2. Climate Change Profile of Angus

2.8 Section Summary

1. **Increasing temperatures.** Both summer and winter temperatures are projected to increase. This will have a knock-on impact on the reduction of frost days in winter and increased likelihood of hot days and heatwaves occurring in summer. **For Monifieth and Carnoustie, daily summer maximum will increase from 18ºC in the baseline to 20.6ºC and 22.3ºC for the 2ºC and 4ºC scenarios respectively.**

2. **Changes in seasonal precipitation patterns.** Winters are projected to become wetter while summer precipitation is projected to reduce, with potential knock-on impacts on drought and water scarcity. **For Forfar and Kirriemuir, average summer precipitation will decrease from 2mm/day in the baseline to 1.85 and 1.56 mm/day for the 2ºC and 4ºC scenarios respectively. Average winter precipitation will increase from 2.2 mm/day to 2.5 and 2.7 mm/day for the 2ºC and 4ºC scenarios respectively.**

3. **Spatial variability.** While the magnitude of change is projected to be similar across the Angus area, there is spatial variability in terms of temperature thresholds being reached in certain areas and not others, e.g. heatwave thresholds reached in coastal areas but not uplands. **For Montrose, the number of hot days is projected to increase from 1 to 12 days/year for the 4ºC scenario compared an increase from 0.1 to 4 days/year for Glen Clova.**

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3. Mapping of socio-economic and socio-demographic vulnerability in Angus

3.1 Introduction

3.2 Vulnerable groups - Age

3.3 Vulnerable groups - Deprivation

3.4 Vulnerability to heat

3.5 Vulnerability to flooding

3.6 Section Summary

3. Mapping Vulnerability in Angus

3.1 Introduction

This section highlights the areas of vulnerability using age and deprivation statistics for Angus. Mapping vulnerability against physical hazards including heat, flooding and coastal flooding, highlights the priority locations for Angus Council and associated stakeholders to focus efforts.

Vulnerability has different multiple intersecting components including gender, ethnicity, age, disability, deprivation and geography (exposure risk to the hazard). As the two more influential factors, the analysis provided here considers risks through the lenses of age and deprivation;

- **Age** – older people are more likely to have chronic health conditions or mobility issues which make them more vulnerable to climate hazards (e.g. unable to evacuate independently in a flood or are more likely to have chronic health conditions which can be exacerbated by a heatwave).
- **Deprivation** – people may lack access to necessary resources to prepare for and be resilient to climate hazards or be more exposed to the risks associated (e.g., a manual labourer in a heatwave or a homeowner may not have home insurance for flood risks or individuals may be more likely to be impacted by climate induced disruption to public transport).

For the vulnerability mapping analysis, data from the following sources has been used:

- Scottish Index of Multiple Deprivation (SIMD) (2020)[16] to map deprivation, see Figure 2;
- 2011 Scottish census* data[17] to map population by age; and
- UKCP18[6] for the heat maps.

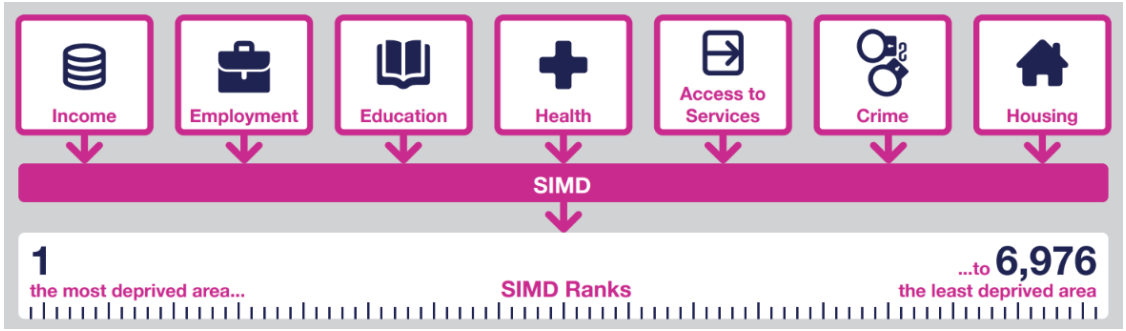

Figure 2: Aspects of deprivation assessed in SIMD. Source: SIMD (2020)[16]

3. Mapping Vulnerability in Angus

3.2 Vulnerable groups - Age

Elderly people are more vulnerable to climate hazards such as heatwaves, flooding and storms. They are more likely to have chronic health conditions which will make them more vulnerable to heat related health risks (for example, through direct health risks such as heat stroke, heat stress or by exacerbating their underlying conditions). Elderly people may be less likely to be able to evacuate if there is a risk of flooding due to their potentially reduced mobility.

By analysing the spatial distribution of individuals over 65 years old, areas which need more support to deal with climate health risks can be more effectively targeted.

The data demonstrates that the older population in Angus is clustered around the **larger towns in land** including Forfar, Kirriemuir, Brechin and with a particularly high concentration in Edzell (located in the dark red data zone to the northeast of the region in Figure 3). There is also a cluster of older people located in the **coastal towns** of Arbroath, Carnoustie and Monifieth.

Overall, according to the statistics from the 2022 Scottish census[18], 25.1% of the population in Angus is over 65. This is the sixth highest % of over 65s in all Scottish council areas. This is a change of 19.9% from the 2011 Scottish census[17].

Although, it should be noted that the age data is a snapshot of the current spatial distribution and can change. While the elderly population is typically concentrated in clustered around settlements both along the coast and inland, the elderly population outside of these population centres will need to be considered when planning.

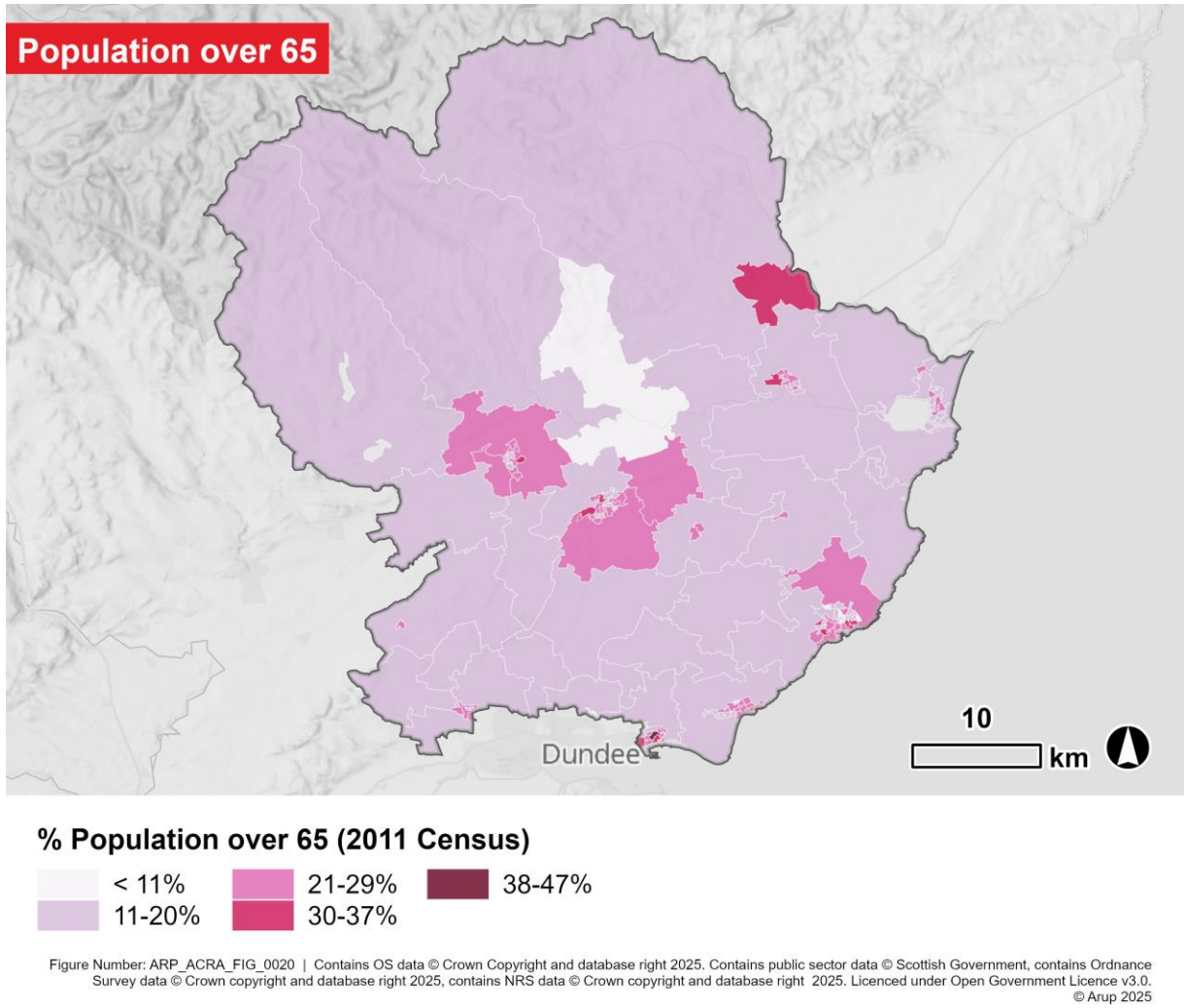

Figure 3: Map showing hotspots of the Angus population over 65. Source: Scottish Census (2011)[17]

3. Mapping Vulnerability in Angus

3.3 Vulnerable groups - Deprivation

The Scottish Index of Multiple Deprivation (SIMD)[16] splits Scotland into 6,976 small areas called data zones and ranks them from most deprived (1) to least deprived (6,976). This allows for relative comparison of multiple deprivation across neighbourhoods. SIMD recognises that deprivation has multiple dimensions beyond just 'low income'. The concept of multiple deprivation therefore includes issues such as access to opportunities and services, health, education and crime (as in Figure 2).

Each data zone contains roughly the same size of population – about 700-800 people per data zone. This is why rural data zones are bigger than urban ones. Problems of transport and distance to employment and services are very important features of rural deprivation. They are part of SIMD but have less influence on the overall SIMD rank compared to other domains such as employment and income. Figure 4 provides a visualisation of the SIMD rankings for each data zone in Angus area. The darker orange areas are those which are more deprived, whereas the lighter areas are less deprived. For Angus, areas within the towns of Arbroath, Montrose, Brechin and Forfar are the most deprived.

It is important to note that SIMD identifies deprived areas, not people. Not all people experiencing deprivation live in deprived areas and not everyone in a deprived area is experiencing deprivation.

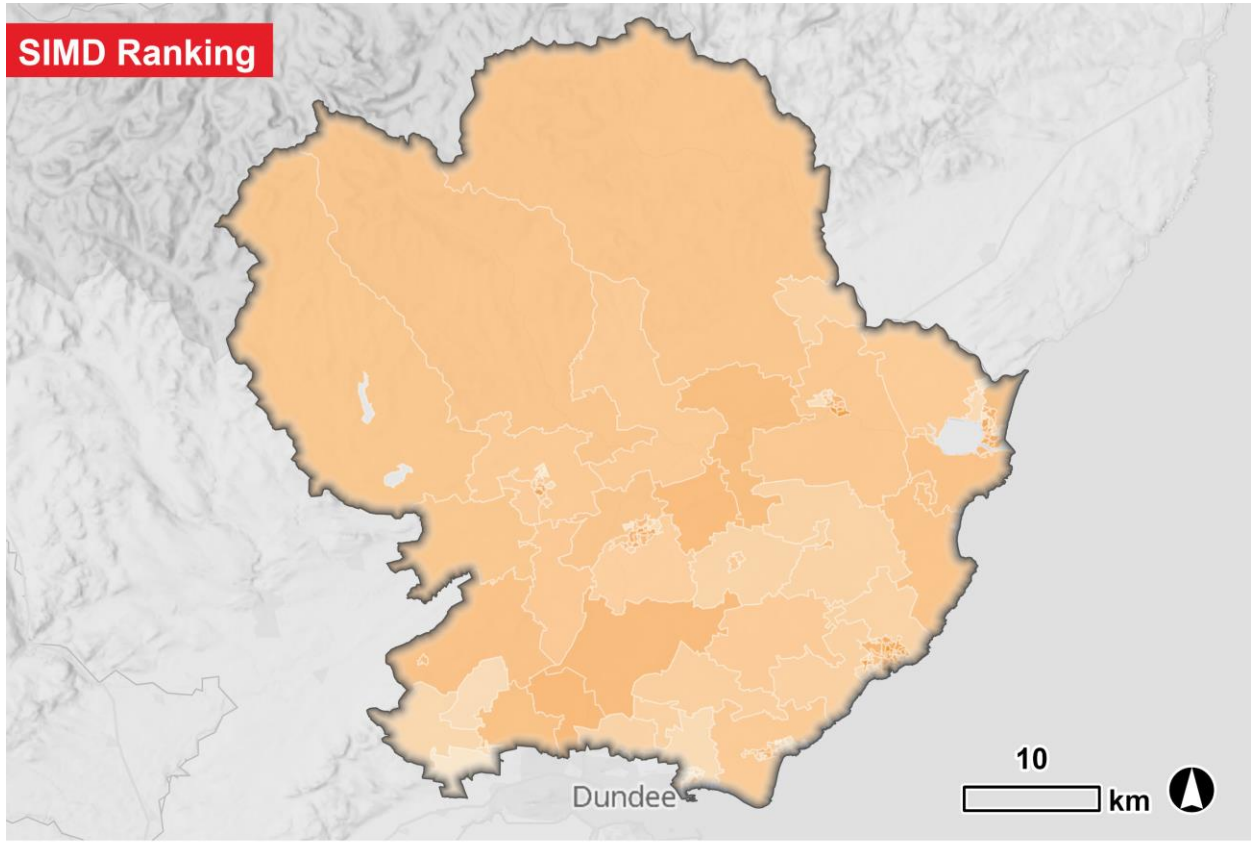

Figure 4: Data zones in Angus ranked from most deprived (239) to least deprived (6773). Source: SIMD (2020)[15]

3. Mapping Vulnerability in Angus

3.3 Vulnerable groups - Deprivation

Deprivation is a key driver of vulnerability towards climate induced weather hazards. People from deprived background can be more exposed to the risks from climate hazards. For example;

- they may work manual labour jobs or work outside and be more exposed to be risks from heatwaves;
- they are more likely to depend on public transport for commuting or travelling and be more likely to be impacted by climate induced disruption to these networks.
- they lack the financial resources to be resilient to these hazards;
  - they may not have home insurance and therefore be more at risk when their home is damaged in a storm or flood;
  - they may be unable to cool or heat their homes effectively;
  - they may not be able to afford a taxi to work or doctor's appointment rather than using public transport.

The data from the SIMD indicates that **rural areas** further inland are generally **more deprived** than the regions along the coast. The highest levels of deprivation in Angus are clustered around **larger settlements** particularly in and around **Arbroath** (Figure 5), Kirriemuir, Forfar, Brechin and Montrose.

The **least deprived regions** of Angus are typically **closer to the coast** and are also **clustered around large settlements** such as Carnoustie, **Monifieth** (Figure 5) and the area around Liff to the north of Dundee, and settlements in-land such as Brechin, Forfar and Kirriemuir. Arbroath appears to be unique amongst settlements in Angus as there are no areas which rank amongst the least deprived, the entire area ranks amongst the higher levels of deprivation. Monifieth appears to be the least deprived larger settlement in Angus.

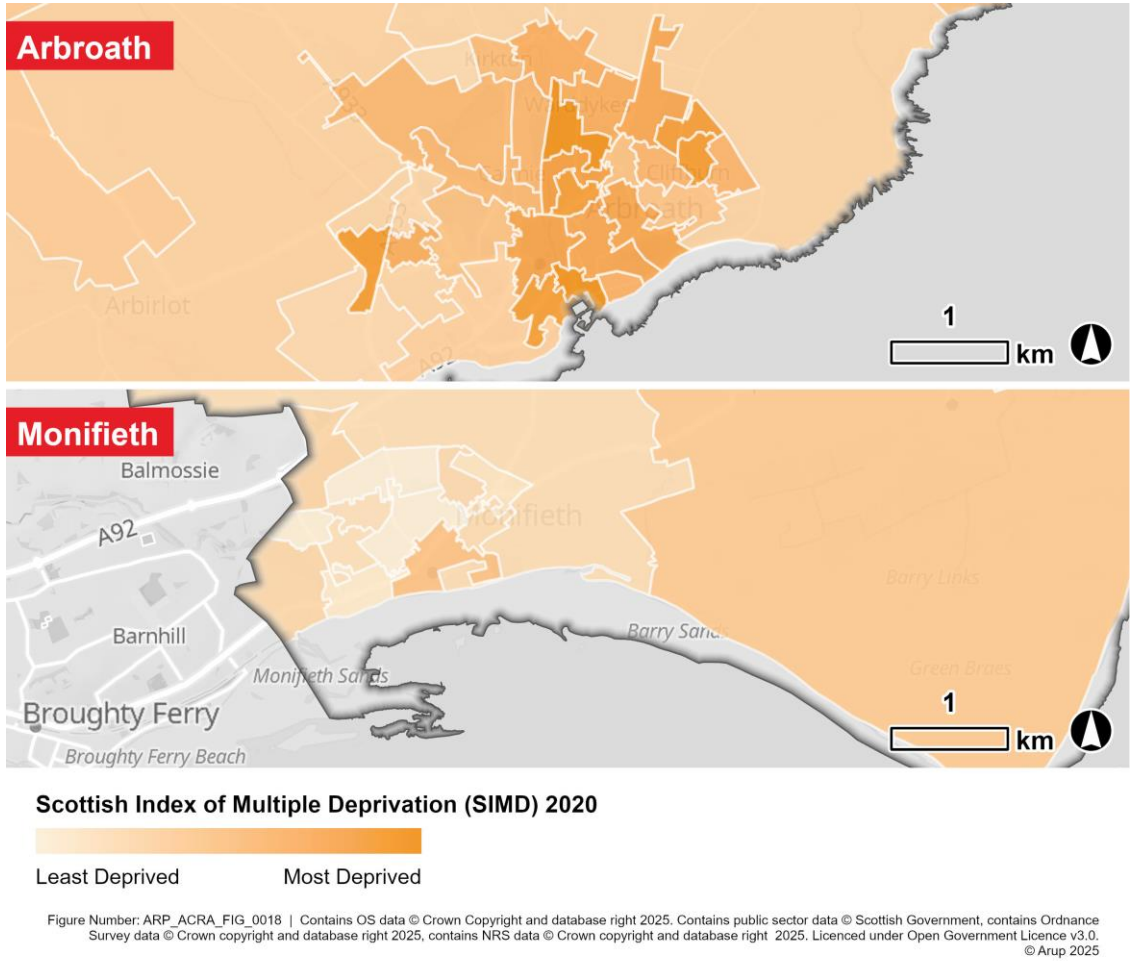

Figure 5: Data zones in Arbroath and Monifieth ranked from most deprived (239) to least deprived (6773). Source: SIMD (2020)[16]

3. Mapping Vulnerability in Angus

3.4 Vulnerability to heat

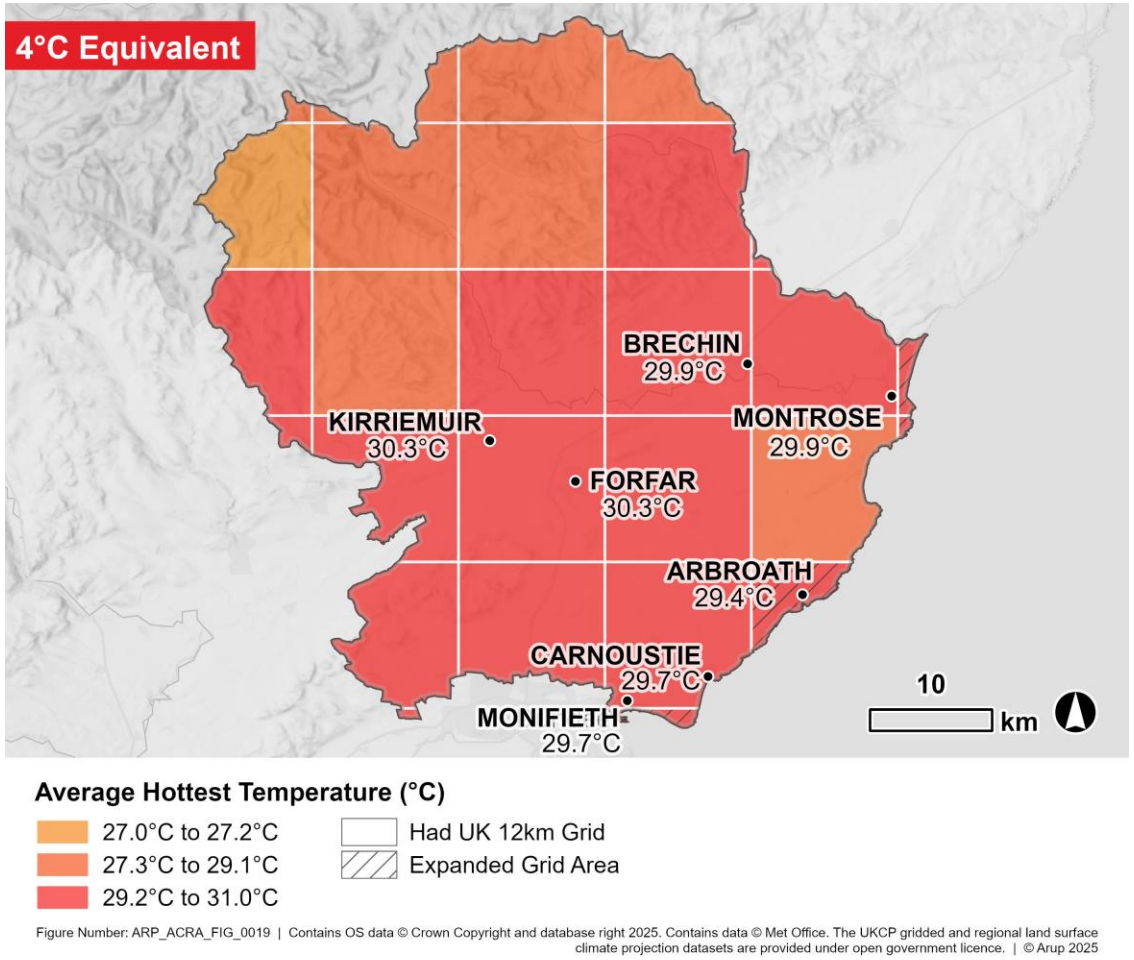

Figure 6: Average hottest temperature in the year for the 4°C scenario. Source: UKCP18 Climate Change Projections (2019)[19]

Figure 6 shows the projected average hottest temperature in the year under a 4ºC of warming scenario – assumed to represent a reasonable worst case future scenario for the purpose of this analysis.

The projected temperature data comes from UKCP18 climate models, which output the projections as a raster (grid) covering the UK. Due to the gridded nature of this dataset, some areas on the coastline (such as Arbroath or parts of Montrose) are not directly covered by any of the grid cells. Despite this limitation in the dataset for these locations, an indication of the projections for these values can be taken as an average of the surrounding grid cells. Further detail around the methodology for extending the grid area is provided in Appendix A1.

The map shows that while there is spatial variability in the projected temperatures between the upland and the coastal areas of Angus, the temperature variability projected for the seven major settlements in Angus is not particularly significant (29.4ºC for Arbroath and 30.3ºC for Forfar and Kirriemuir – a 0.9ºC difference between the lowest and highest projected increase). For this reason, it is difficult to determine hotspots of heat vulnerability, as the small temperature differences between the towns do not provide sufficient basis for prioritising one settlement over another. Instead, it is recommended that vulnerability hotspots are identified based on the other variables presented in this report, such as surface water and coastal and river flooding projections.

3. Mapping Vulnerability in Angus

3.5 Vulnerability to flooding

The Scottish Index of Multiple Deprivation (SIMD)[16] and Scottish Environmental Protection Agency (SEPA) flooding datasets[20] for coasts, rivers and surface water have been used to visualise flood vulnerability. By visualising SIMD and SEPA flooding, this provides insight into the flood disadvantage of a neighbourhood should a flood occur. This can be used as a measure of where **social vulnerability and exposure to flooding coincide**. High levels of risk occur where high numbers of people live in a floodplain in a neighbourhood with high deprivation rates.

Maps have been provided for areas split into low, medium and high likelihoods as follows:

- Low likelihood: the area has a 0.1% chance of flooding each year
- Medium likelihood: the area has a 0.5% chance of flooding each year
- High likelihood: the area has a 10% chance of flooding each year

Figure 7 provides the overview for the full Angus area; however additional visualisations are available for each major settlement in the region. Further details for each settlement are provided within Appendix A2.

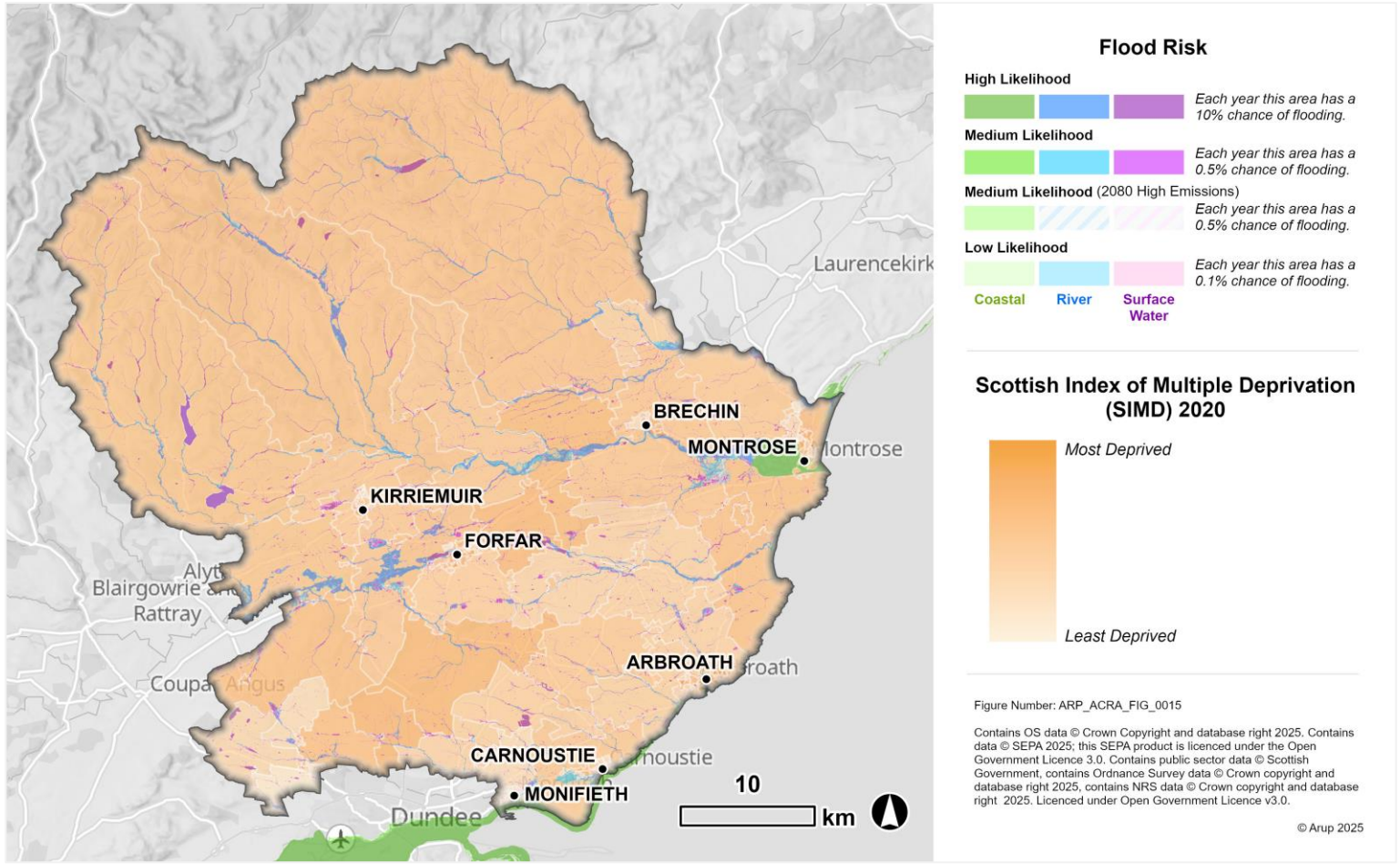

Figure 7: Data zones in Arbroath and Monifieth ranked from most deprived (239) to least deprived (6773). Sources: SIMD (2020)[16], SEPA Flood Maps (2025)[20]

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3. Mapping Vulnerability in Angus

3.6 Section Summary

Age & Climate Impacts:
Elderly people are more vulnerable to climate change hazards due to higher incidence of chronic health conditions and reduced mobility. Neighbourhoods with a large proportion of elderly people (>30% of the population above 65) are concentrated in the centres of the seven main towns within the Angus area, as well as villages such as Edzell. These are areas which are more at risk from climate hazards due to the relative vulnerability of their population.

Deprivation & Climate Impacts:
People experiencing deprivation may lack access to necessary resources to prepare and be resilient to climate hazards or be more exposed to the associated risks. Urban deprivation is most prominent in town centres, particularly Arbroath, Montrose and Forfar, while neighbourhoods in the uplands may be experiencing varying degrees of rural deprivation tied to issues of access to services, opportunities and inclusion.

Climate Impacts on the Angus Area:
Projected temperature increases do not vary among the individual towns so significantly as to justify identification of certain towns as hotspots of heat vulnerability and not others. The spatial distribution of vulnerable groups (age, deprivation) can be considered as a proxy for heat vulnerability.

Flood vulnerability broadly coincides with deprivation in urban areas as identified by SIMD and is projected to increase under a 2ºC and 4ºC scenario. This is for both surface flooding and river and coastal flooding. Generally, the risk of both types of flooding is modelled to increase under the 2ºC and 4ºC scenarios, particularly in towns.

ARUP

4. Climate Change Risk and Vulnerability Assessment

4.1 Introduction

4.2 Approach

4.3 Built Environment

4.4 Health & Wellbeing

4.5 Economy

4.6 Infrastructure

4.7 Land, Nature & Food

4.Climate Change Risk and Vulnerability Assessment

4.1 Introduction

The core task of this work has been to provide a Climate Change Risk and Vulnerability Assessment for the Angus region. This section describes in more detail the approach taken to do this and the key results by sector. The assessment focuses on integrated information and data which has been published, such as the most recent UK Climate Change Risk Assessment[7] and Scotland's national summary[8]. The update also takes a more comprehensive approach to the understanding of the climate hazards (outlined in Section 2) and integrates this information into the risk scoring. Finally, the updated risk assessment integrates lessons learned from recent past extreme events, 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 assessment focuses on, and is arranged into, five key sectors, to align with the next update of the UK Climate Change Risk Assessment, CCRA4 due to be laid in parliament in 2027. The Climate Change Committee are coordinating the Independent Assessment (CCRA4-IA) which is due to be published in 2026, and it is confirmed that these categories will be the basis for the Fourth UK Climate Change Risk Assessment (CCRA4).

The assessment focuses on the following sectors:

- Built Environment
- Health and Wellbeing
- Economy
- Infrastructure
- Land, Nature and Food

4.Climate Change Risk and Vulnerability Assessment

4.2 Approach

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

1. **Background research:** a review of recent information and news articles relevant to climate risk within Angus was conducted to provide 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 the UK National Climate Change Risk Assessment and risk assessments from other local authorities in Scotland an initial long list of risks was created.

3. **Stakeholder workshop:** one workshop with stakeholders from diverse backgrounds working in climate resilience or with deep knowledge of the risks in a local context was conducted. This focused on identifying which risks of the long list were most prominent in Angus, how Angus was vulnerable given local characteristics and if any other relevant risks had not yet been identified.

4. **Focused interviews:** three focused 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 from the workshops.

5. **Refined list and scoring:** the initial risks were 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 likelihood and impact. These two elements combined to give an overall risk score for both scenarios. Further details of the scoring process can be found in Appendix A3.

ARUP

4.3 Built Environment

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

Sector overview

This section specifically focuses on risks to the built environment. It covers the risk for local communities including residential buildings, as well as the impact from climate change on council services and cultural heritage. Climate hazards can impact negatively on buildings during extreme events and are not always designed to function within the projected future climate scenarios.

Connection with the Fourth CCRA Independent Assessment

The risks identified within CCRA4-IA have been included as the basis for this assessment and have been incorporated using Angus-specific information. The following risks identified in CCRA4-IA are considered applicable to Angus and have been taken forward in this assessment:

- BE1: Risks to buildings and communities from heat
- BE2: Risks to buildings and communities from flooding
- BE3: Risks to buildings and communities from coastal change
- BE4: Risks to buildings and communities, excluding from heat, flooding and coastal change
- BE6: Risks to cultural heritage and landscapes
- BE7: Risks to facilities delivering public services, excluding health and social care
- BE8: Risks to local resilience planning and emergency service response capabilities

The above risks have been taken as the basis for the assessment, and the output is summarised in Table 1. Further details of the assessment methodology are provided within Appendix A3. A high-level summary heat map is presented in Appendix A4.2.

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

All risks

Table 1 all climate risks identified for the Built Environment 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 residential homes, council buildings and properties and community buildings from heat	Risk to occupant health in periods of extreme heat, particularly in poorly insulated homes lacking appropriate ventilation. Periods of extreme high temperatures can result in heat stress, heat exhaustion and heat stroke. Potential for increased need for cooling and ventilation during summer months leading to higher operational costs and need for building upgrades to ensure thermal comfort of occupants.		High	Very High
Risks to residential homes from flooding and high rainfall	Risk of property damage due to flooding leading to financial losses, distress and prolonged periods of vacancy as homes need to 'dry out'. Potential for both physical and mental health impacts to residents.		Very High	Very High

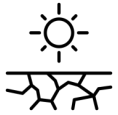
ARUP

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

All risks

Continued Table 1 all climate risks identified for the Built Environment 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 residential homes from coastal change/coastal erosion	Risk of property damage due to coastal erosion and sea level rise. This might lead to higher insurance costs, repair costs and potentially decrease property value of coastal homes. Severe coastal erosion has the potential to lead to displacement. Potential for mental health impacts to residents if housing conditions become insecure.		High	Very High
Risks to residential homes, council buildings and properties and community buildings excluding heat, flooding and high rainfall, and coastal change	Reduction in water supply disrupting households and council operations due to a restricted water provision.		High	High

4.Climate Change Risk and Vulnerability Assessment

ARUP

4.3 Built Environment

All risks

Continued Table 1 all climate risks identified for the Built Environment 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 residential homes, council buildings and properties and community buildings excluding heat, flooding and high rainfall, and coastal change	Risk to residential homes from impact from windblown debris, falling trees and tall infrastructure. This risks include direct impacts from strikes to the home and indirect impacts such as damaged amenities and blocked transport routes that may impair or delay efforts to respond to storm related impacts.		High	Very High
Risks to local businesses from heat	The main risk to business will likely be from reduced employee productivity due to infrastructure disruption and higher temperatures in working environments. There are risks associated with changing extremes, particularly high temperatures, which can have negative impacts on employees' health and wellbeing and their ability to commute to work. These risks are likely to vary depending on the type of work (how physical the job is) and whether the job is indoors (some jobs may be required to work in very hot indoor conditions such as kitchens) or outdoors.		High	High

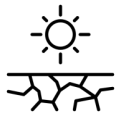
4.Climate Change Risk and Vulnerability Assessment

ARUP

4.3 Built Environment

All risks

Continued Table 1 all climate risks identified for the Built Environment 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 local businesses excluding heat, flooding and high rainfall, and coastal change	Reduction in water supply disrupting operation of local businesses		High	High
Risks to council, private business and community buildings/properties from flooding and high rainfall	Flooding can cause significant damage and disruption to council and community buildings and their operation, both directly and indirectly. Flooding can directly damage assets and stop trading/operation, it can also stop local people from accessing local services or supplies arriving. Frequent damage may lead to increased insurance and repair costs, driving up the costs of provision of services and community spaces to local people. Risks of physical damage from heavy rainfall and flooding leading to financial impact and operational disruption. This might lead to distress and mental health impacts for local communities as community spaces and services become temporarily unavailable.		Very High	Very High

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

All risks

Continued Table 1 all climate risks identified for the Built Environment along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks council, private business and community buildings/properties from coastal change/coastal erosion	Flooding can cause significant damage and disruption to the operation of council assets and community buildings, both directly and indirectly. Flooding can directly damage assets and stop trading/operation, it can also stop local people from accessing local services or supplies arriving. Damages might lead to higher insurance costs and repair costs and drive up the cost of provision of community spaces. Risk of property damage due to coastal erosion and sea level rise. This might lead to higher insurance costs and repair costs and drive up the cost of provision of community spaces. Potential impacts to local communities if access to community buildings becomes limited.		Very High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

All risks

Continued Table 1 all climate risks identified for the Built Environment 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 (museums, statues, cultural landmarks) from heat	The Angus region'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. Historic artifacts often need to be kept within specific temperatures to prevent deterioration. This temperature is often between 16 to 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 artifacts.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

All risks

Continued Table 1 all climate risks identified for the Built Environment along with the associated climate hazard, and scores for both scenarios

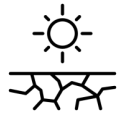
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to cultural heritage (museums, statues, cultural landmarks) from flooding and high rainfall	Flooding can damage cultural heritage assets such as historic buildings. It may also cause temporary closures of attractions to the public for safety reasons, and longer-term closures if more extensive repairs are needed, leading to financial loss.		High	Very High
Risks to cultural heritage (museums, statues, cultural landmarks) from coastal change/coastal erosion	Risk of physical damage due to coastal erosion and sea level rise. Risks are like those identified for buildings but might be harder and more costly to repair in the case of historical buildings and cultural landmarks.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

All risks

Continued Table 1 all climate risks identified for the Built Environment 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 (museums, statues, cultural landmarks) excluding heat, flooding and high rainfall and coastal change	Reduction in water supply might disrupt or limit operation and/or maintenance of cultural heritage sites. This might have implications for water availability for maintenance and landscaping activities in listed the Inventory of Gardens and Designed Landscapes (Historic Environment Scotland).		High	Very High
Risks to cultural heritage (museums, statues, cultural landmarks) excluding heat, flooding and high rainfall and coastal change	Risk to cultural heritage from impact from windblown debris, falling trees and tall infrastructure. This risk includes direct impacts from strikes to property and indirect impacts such as damaged amenities and blocked transport routes that may impair or delay efforts to respond to storm related impacts.		High	High

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.3 Built Environment

Key findings

- In total 14 key climate change risks to the built environment were identified and assessed.

- The highest scoring risks under both the 2°C and 4°C scenarios were "Risks to council buildings and properties from coastal erosion and coastal change", "Risks to council buildings and properties from flooding and high rainfall" and "Risks to residential property from flooding and high rainfall". Coastal erosion has been a significant threat for Angus, as large sections of the shoreline have already been eroded. The recent flooding across Angus, because of Storm Babet in 2023, has also highlighted how serious the risk of flooding is to the region.

- Risks which were comparatively lower but still assessed as 'high' included "Risks to residential homes from drought and water scarcity", "Risks to businesses from drought and water scarcity", "Risks to businesses from high temperatures" and "Risk to cultural heritage from flooding and high rainfall". All these risks were assessed as high under a 2°C to high 4°C scenario.

- Several risks rose from high (in a 2°C scenario) to very high (in a 4°C scenario). This included "Risks to cultural heritage and residential homes from heat", "Risks to residential homes from storms", "Risks to cultural heritage and residential homes from coastal erosion/change" and "Risks to cultural heritage from flooding and high rainfall".

ARUP

4.4 Health and Wellbeing

4.Climate Change Risk and Vulnerability Assessment

4.4 Health and Wellbeing

Sector overview

This section specifically focuses on risks to health and wellbeing risks for the individuals in Angus. It covers the risk for individuals and local communities, as well as the impact from climate change on key public services namely education, and health and social care. Climate hazards can impact negatively on people communities during extreme events and are not always designed to function within the projected future climate scenarios.

Connection with the Fourth CCRA Independent Assessment

The risks identified within CCRA4-IA have been included as the basis for this assessment and have been incorporated using Angus-specific information. The following risks identified in CCRA4-IA are considered applicable to Angus and been taken forward in this assessment:

H1: Risks to people from heat

H2: Risks to people from extreme weather, excluding heat

H6: Risks to health and social care delivery

The above risks have been taken as the basis for the assessment, and the output is summarised in Table 2 on the following pages. In addition, risks to education have been included within this section of the assessment. Further details of the assessment methodology are provided within Appendix A3. A high-level summary heat map is presented in Appendix A4.3.

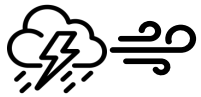
ARUP

4.Climate Change Risk and Vulnerability Assessment

4.4 Health & Wellbeing

All risks

Table 2 all climate risks identified for Health and Wellbeing 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 social care and disruption to hospitals/GPs/community health centres	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
Risks to social care and disruption to hospitals/GPs/community health centres	Risk of direct and indirect impacts due to storms. Direct impacts include physical damage to buildings or facilities. Indirect impacts include wider disruption, such as healthcare staff or deliveries prevented from arriving or being delayed.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.4 Health & Wellbeing

All risks

Continued Table 2 all climate risks identified for Health and Wellbeing 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 social care and disruption to hospitals/GPs/community health centres	Heat poses threats to individual health, social care, as some healthcare buildings might not be 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.		High	Very High
Disruption to schools - flooding/storms closing schools	Possible short-term disruption and closure. Some damage may also cause longer term closure or loss of facilities impacting on the educational experience. Playing fields could be a specific risk. Loss of education has impact on child's development.		High	Very High

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.4 Health & Wellbeing

All risks

Continued Table 2 all climate risks identified for Health and Wellbeing along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Disruption to schools - flooding/storms closing schools	Possible short-term disruption and closure. Some damage may also cause longer term closure or loss of facilities impacting on the educational experience. Playing fields could be a specific risk. Loss of education has impact on child's development. However, since the COVID-19 pandemic, the rise of remote learning may reduce the impact.		High	High
Risks to education from flooding	Possible short-term disruption and closure. Some damage may also cause longer term closure or loss of facilities impacting on the educational experience. Playing fields could be a specific risk. Loss of education has impact on child's development. However, since the COVID-19 pandemic, the rise of remote learning may reduce the impact.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.4 Health & Wellbeing

All risks

Continued Table 2 all climate risks identified for Health and Wellbeing 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 due to high rainfall and flooding	Flooding of homes may have severe short-term consequences during and immediately after the 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.		High	Very High
Risks to health and wellbeing due to storms	Storms pose direct and indirect risks to health and wellbeing. Direct impacts include the risk of injuries, or, in the worst case, death caused by wind-blown debris, falling trees or tall infrastructure in high wind conditions. Indirect impacts include wider disruption such as availability of and ability to access critical services such as healthcare or social care.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.4 Health & Wellbeing

All risks

Continued Table 2 all climate risks identified for Health and Wellbeing 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 due to extreme heat	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 heat stroke, sunburn and dehydration are common heat-induced illnesses. 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	Very High
Risks to health and wellbeing due to coastal change (e.g. homes having to be evacuated)	Risk of property damage due to coastal erosion and sea level rise. This might lead to higher insurance costs, repair costs and potentially decrease in property value of coastal homes. Severe coastal erosion has the potential to lead to displacement. Potential for mental health impacts to residents if housing conditions become insecure.		High	Very High

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.4 Health & Wellbeing

Key findings

- In total 10 key climate change risks to health and wellbeing were identified and assessed.
- Storms and flooding are likely to cause significant disruption to health and wellbeing due to disruption to transport networks and will cause closures of education and health facilities across the Angus region. Buildings such as hospitals, GP centres, schools and colleges are at risks of flooding and storm damage.
- Some risks were assessed as being comparatively lower including “Risks to social care and disruption to healthcare from storms”, “Risks to health and wellbeing due to storms” and “Disruption to schools from storms due to school closures”. While storm events which will necessitate the closure of key facilities will occur less frequently, the risks associated with them are still classified as high.
- The remaining risks scored “High” for the 2°C scenario, however increased to “Very High” under the 4°C scenario. These risks included "Risks to health and wellbeing due to coastal erosion and change"; "Risks to health and wellbeing due to flooding and high rainfall"; "Risks to education from flooding"; "Risks to health and wellbeing due to heat"; "Disruption to schools from flooding and high rainfall through school closures"; "Risks to social care and disruption to healthcare from heat" and "Risks to social care and disruption to healthcare from flooding and high rainfall".

ARUP

4.5 Economy

4.Climate Change Risk and Vulnerability Assessment

4.5 Economy

Sector overview

This section considers how changing climatic conditions will negatively impact on the economy (business and industry) in Angus. This work focuses primarily on domestic risks, 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. Wider regional context is also considered with tourism and other sectors having strong regional links such as visitors to the Cairngorms and areas within neighbouring Local Authorities, such at Perth and Kinross, Dundee City and Aberdeenshire Councils.

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.

Connection with the Fourth CCRA Independent Assessment

The risks identified within CCRA4-IA have been included as the basis for this assessment and have been incorporated using Angus-specific information. The following risks identified in CCRA4-IA are considered applicable to Angus and been taken forward in this assessment:

E2: Risks to domestic and overseas physical assets of UK businesses

E3: Risks to domestic and international supply chains and resource inputs of UK businesses

E4: Risks to Productivity and Availability of Labour in the UK

The above risks have been taken as the basis for the assessment, and the output is summarised in Table 3 on the following pages. Further details of the assessment methodology are provided within Appendix A3. A high-level summary heat map is presented in Appendix A4.4.

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.5 Economy

All risks

Continued Table 3 all climate risks identified for the Economy along with the associated climate hazard, and scores for both scenarios

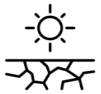
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Disruption to businesses due to loss in trade (storms, flooding)	Storms can impact businesses directly by causing damage to assets and increasing insurance costs. Storms can indirectly impact businesses by preventing staff, customers and supplies from reaching the businesses.		High	High
Disruption to businesses due to loss in trade (storms, 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	Very High
Disruption to tourism levels due to wildfires/storms/flooding	Flooding might prevent staff and visitors from reaching tourist attractions due to traffic disruptions as roads/rail might be flooded and local/regional services might not operate during severe weather alerts.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.5 Economy

All risks

Continued Table 3 all climate risks identified for the Economy along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Disruption to tourism levels due to wildfires/ storms/flooding etc	Storms might prevent staff and visitors from reaching tourist attractions due to traffic disruptions as roads/rail might be blocked and local/regional services might not operate during severe weather alerts.		High	High
Disruption to tourism levels due to wildfires/ storms/flooding etc	Prolonged dry conditions and water unavailability might impact or limit operation of some tourist attractions, leading to reduced footfall and related financial loss.		High	Very High
Damage to local wildlife resulting in a drop in visitors	There are several designated sites in Angus important for wildlife and nature protection that attract visitors to the region. Increasing summer and winter temperatures might lead to knock on impacts on these ecosystems, leading to damages to wildlife and subsequent reduction in tourism due to loss of important species/habitats.		Very High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.5 Economy

All risks

Continued Table 3 all climate risks identified for the Economy 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 golf courses, recreation sites reducing the number of visitors to Angus	Prolonged high temperatures can stress turfgrass, increase irrigation and maintenance costs, and make outdoor recreation uncomfortable, reducing the number of visitors.		High	Very High
Damage to golf courses, recreation sites reducing the number of visitors to Angus	Heavy rainfall and river overflow can waterlog grounds and damage infrastructure, leading to temporary closures and long-term degradation. Indirect impact from travel disruptions preventing visitors from reaching recreation sites.		High	Very High
Damage to golf courses, recreation sites reducing the number of visitors to Angus	High winds can uproot trees, damage buildings and equipment, and create hazardous conditions, reducing the appeal and safety of outdoor recreation, leading to a drop in visitor numbers. Indirect impact from travel disruptions preventing visitors from reaching recreation sites.		High	High

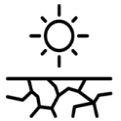
ARUP

4.Climate Change Risk and Vulnerability Assessment

4.5 Economy

All risks

Continued Table 3 all climate risks identified for the Economy 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 golf courses, recreation sites reducing the number of visitors to Angus	Limited water availability can lead to reduced quality and visual appeal of golf courses and recreational sites, leading to a drop in visitor numbers.		High	Very High
Damage to golf courses, recreation sites reducing the number of visitors to Angus	Rising sea levels and increased rates of coastal erosion pose physical risks to coastal golf courses and recreational sites, which might require closures or relocations of facilities.		High	Very High
Risk to local businesses due to coastal change/ coastal erosion	Risks from coastal change (sea level rise and erosion) will occur where industrial and commercial activity occur along the coast		Very High	Very High

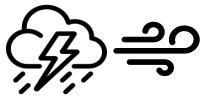
ARUP

4.Climate Change Risk and Vulnerability Assessment

4.5 Economy

All risks

Continued Table 3 all climate risks identified for the Economy along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risk to local businesses due to flooding/ storms	Flooding can cause significant damage and disruption to business both directly and indirectly. Flooding can directly damage assets and stop trading; it can also stop customers accessing business or supplies arriving.		Very High	Very High
Risk to local businesses due to flooding/ storms	Risk to local businesses from impact from windblown debris, falling trees and tall infrastructure. This risks includes direct impacts from strikes to property and indirect impacts such as damaged amenities and blocked transport routes that may impair or delay efforts to respond to storm related impacts. Storms can impact businesses directly by causing damage to assets and increasing insurance costs. Storms can indirectly impact businesses by preventing staff, customers and supplies from reaching the businesses, resulting in loss in trade.		High	Very High

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.5 Economy

Key findings

- In total 14 key climate change risks to economy were identified and classified from “High” to “Very High”.
- On the comparatively lower end of the risk spectrum, risks included "Disruption to tourism levels due to storm disruption"; "Damage to golf courses and recreational sites reducing the number of visitors due to storm disruption" and "Disruption to businesses due to loss in trade from storms". However, these risks were classed as “High” under a 2°C scenario, however increased to “Very High” under the 4°C scenario warming scenario.
- The majority of risks to the economy scored “High” under a 2°C scenario but increased to “Very High” under a 4°C scenario. These risks were "Damage to golf courses and recreation sites reducing the number of visitors to Angus due to coastal erosion and change/ drought and water scarcity/ flooding and high rainfall/ extreme temperatures"; "Risks to local businesses due to storms"; "Disruption to tourism level due to drought and water scarcity"; "Disruption to tourism level due to flooding and high rainfall" and "Disruption to businesses due to loss in trade from flooding and high rainfall".
- Risks assessed as “Very High” under both a 2°C scenario and a 4°C scenario included "Risks to local businesses due to coastal erosion and change"; "Risks to local businesses due to flooding and high rainfall" and "Damage to local wildlife resulting in a drop in visitors due to extreme high temperatures".

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4.6 Infrastructure

ARUP

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

Sector overview

This section summarises the evidence regarding the key risks that climate change brings to infrastructure within Angus. 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 region, 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 such as:

Water – Water infrastructure refers to systems and processes used to manage water within the region 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 Angus this includes the region's public transport (buses and trains), key roads within the region such as the A90 and A92, the regions main train stations and the main ports and harbours along the coast.

Energy – Energy infrastructure is the physical networks and systems that generate, transmit, and distribute energy. For Angus this would include electricity, gas and oil and include such assets as pipelines, electricity lines and substations.

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

Waste – Waste infrastructure 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.

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

Connection with the Fourth CCRA Independent Assessment

The risks identified within CCRA4-IA have been included as the basis for this assessment and have been incorporated using Angus-specific information. The following risks identified in CCRA4-IA are considered applicable to Angus and been taken forward in this assessment:

I1: Risks to the delivery of infrastructure services from interdependencies with other infrastructure systems

I2: Risks to electricity generation assets

I3: Risks to electricity transmission and distribution

I4: Risks to fuel supply systems

I5: Risks to road transport systems

I6: Risks to rail transport systems

I7: Risks to aviation, shipping and other transport systems

I8: Risks to digital and communications systems

The above risks have been taken as the basis for the assessment, and the output is summarised in Table 4 on the following pages. Further details of the assessment methodology are provided within Appendix A3. A high-level summary heat map is presented in Appendix A4.5.

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Table 4 all climate risks identified for Infrastructure along with the associated climate hazard, and scores for both scenarios

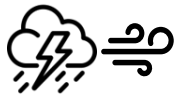
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Disruption to Ports (Port of Montrose) due to storm weather, flooding	Risk to the port from impact of wind blow debris, falling trees and tall infrastructure. This includes direct impacts to the Port itself, along with indirect impacts such as damaged amenities and blocked transport routes that might impair or delay efforts to respond to storm related impacts. The Port is at risk from storm surges and see sea level rise which may disruption to operations.		High	High
Disruption to Ports (Port of Montrose) due to storm weather, flooding	Flooding can damage the physical infrastructure assets. It may also cause temporary closures of main roads to and from the port for safety reasons which could cause disruption for the business. Longer term closures may be possible if more extensive repairs are needed, leading to larger disruption and financial loss.		High	Very High
Risks to Ports (Port of Montrose) due to sea level rise	Sea level rise can disrupt port operations by increasing the frequency and severity of coastal flooding, which threatens port infrastructure such as quays, access roads, and storage facilities. Over time, rising sea levels may require costly upgrades to flood defences and drainage systems.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 all climate risks identified for Infrastructure along with the associated climate hazard, and scores for both scenarios

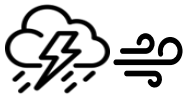
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Damage to public transport systems (bus services etc) and the wider road network from flooding and storms	Risk to the public transport system from impact of wind blow debris, falling trees and tall infrastructure. Includes direct impacts to the infrastructure itself or buses along a particular route, along with indirect impacts such as damaged amenities and blocked transport routes that might impair or delay efforts to respond to storm related impacts. Bus business operations may also be impacted. This can lead to financial loss and increased maintenance costs.		High	High
Damage to road network from flooding and storms	Flooding can damage the physical infrastructure assets. It may also cause temporary closures of main roads for safety reasons which could cause wider disruption in the area and hinder emergency response efforts. Longer term closures may be possible if more extensive repairs are needed, leading to larger disruption and financial loss. In some cases, flooding can disrupt local transport by inundating roads and rail lines, making them impassable and unsafe. This can lead to widespread travel disruption and hinder emergency service response efforts. With drought conditions in summer and heavy rain events in summer and winter, it is possible for this to cause embankment failure (e.g. in Stonehaven) and cause disruption to transportation networks.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 all climate risks identified for Infrastructure along with the associated climate hazard, and scores for both scenarios

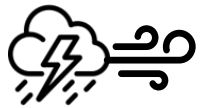
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Damage and disruption to mainline rail services	Flooding can damage the physical infrastructure assets. It may also cause temporary closures of main rail routes for safety reasons which could cause wider disruption in the area. Longer term closures may be possible if more extensive repairs are needed, leading to larger disruption and financial loss.		High	Very High
Damage and disruption to mainline rail services	Risk to the rail infrastructure from impact of wind blow debris, falling trees and tall infrastructure. Includes direct impacts to the rail infrastructure itself, along with indirect impacts such as damaged amenities and blocked transport routes that might impair or delay efforts to respond to storm related impacts.		High	High
Damage and disruption to mainline rail services	Risk to the rail infrastructure from impact of wind blow debris, falling trees and tall infrastructure. Includes direct impacts to the rail infrastructure itself, along with indirect impacts such as damaged amenities and blocked transport routes that might impair or delay efforts to respond to storm related impacts. There are sections of the rail network in Angus that follow the coastline. These are in high-risk areas for sea level rise and the impacts from storm surge, as well as possible sea wall and coastal embankment failure.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 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)
Disruption to public transport systems (bus services etc	Risk to the rail infrastructure from impact of wind blow debris, falling trees and tall infrastructure. Includes direct impacts to the rail infrastructure itself, along with indirect impacts such as damaged amenities and blocked transport routes that might impair or delay efforts to respond to storm related impacts. There are sections of the local road network in Angus that follow the coastline. These are in high-risk areas for sea level rise and the impacts from storm surge, as well as possible sea wall and coastal embankment failure.		High	High
Risks to waste from storms and subsequent flooding	Here waste is defined as 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. Storms cause risks to the waste industry in several ways. High winds can cause rubbish and debris to be blown around causing hygiene problems. High winds could also cause delays to collection services if unsafe for HGV's although this would only be in very extreme circumstances. Flooding due to heavy rain in storm events is also a risk, causing damage, delays and disruption to collection and waste treatment.		Medium	High

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4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 all climate risks identified for Infrastructure along with the associated climate hazard, and scores for both scenarios

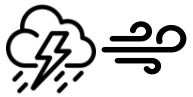
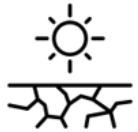
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to waste from storms and subsequent flooding	Waste is defined as activities related to the management (including collection, treatment and disposal) of various forms of waste, such as solid or non-solid industrial or household waste, as well as contaminated sites. Flooding due to heavy rain in storm events is also a risk, causing damage, delays and disruption to collection and waste treatment.		High	High
Risks to waste from high temperatures	High temperatures pose risks to waste management by accelerating the decomposition of organic waste, which can increase odour, attract pests, and raise the risk of fire in landfill sites. Heat can also affect the integrity of waste storage infrastructure and complicate recycling processes, particularly for materials sensitive to temperature like plastics and electronics. High temperatures can also have negative impacts on waste staff, particularly those working outdoors or in physically demanding roles where heat-related health risks may occur.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 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 storms.	High winds can uproot trees, damage buildings and equipment, and create hazardous conditions. High winds can cause debris to be blown and can cause disruption if trees are blown down on treatment works.		Medium	High
Damage to water infrastructure from drought	Prolonged dry conditions and water unavailability may impact or limit operations for residents. There is a risk for Scottish Water to keep operations going and to limit disruption to customers during periods of drought. There may become an over reliance on private abstraction which may create wider issues for the local area; Scottish Water may have to enforce hosepipe bans in the region.		Very High	Very High
Changing demands on energy system due to increased cooling demands or increased heating seasonally	As temperatures increase energy infrastructure will need to be maintained and adapted to cope with the increased demand for cooling in the summer months.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 all climate risks identified for Infrastructure along with the associated climate hazard, and scores for both scenarios

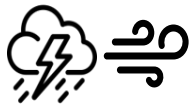
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to coastal infrastructure due to coastal erosion	Coastal erosion may have an adverse impact on the infrastructure of a few of the main towns in Angus that are situated at the coast, namely Arbroath, Montrose, Carnoustie and Monifieth. This could have structural damage to the flood protection assets in the local area, which could lead to increased flooding and making the local area more vulnerable to storm surges.		High	Very High
Risks to energy due to high temperatures	High temperatures pose risks to the energy sector by increasing demand for cooling, which can strain electricity grids and lead to higher operational costs. Heat can also reduce the efficiency of power generation and transmission infrastructure and increase the risk of equipment overheating or failure, potentially causing service disruptions.		Very High	Very High
Risks to energy due to flooding	Flooding can damage the physical energy infrastructure assets. It may also cause temporary power outages for safety reasons which could cause wider disruption in the area. Longer term closures may be possible if more extensive repairs are needed, leading to larger disruption and financial loss.		Very High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 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 due to storms	High winds can uproot trees, damage buildings and equipment, and create hazardous conditions. High winds can cause debris to be blown and can cause power outages if trees are blows down on overhead lines or substations.		High	Very High
Increased risk of contamination/ leachate from flooding / heavy rain	Flooding can increase the risk of contamination and leachate by overwhelming drainage systems and saturating soils, which can mobilize pollutants from agricultural land, landfill sites, and urban surfaces. This runoff can carry harmful substances into watercourses and groundwater, posing risks to ecosystems, drinking water supplies, and public health.		High	Very High
Damage to water infrastructure due to 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.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 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 due to flooding	Flooding can damage the physical water infrastructure assets. Longer term closures may be possible if more extensive repairs are needed, leading to larger disruption and financial loss.		High	High
Damage to water infrastructure due to high temperatures	High temperatures can damage water infrastructure by causing materials—such as pipes, valves, and storage tanks—to expand, warp, or degrade more quickly, especially if they are exposed to direct sunlight or heat over long periods.		High	High
Risks associated with increased private abstractions due to droughts/high temperatures	Over-abstraction can deplete local water sources, especially in rural areas reliant on private supplies, leading to reduced availability for ecosystems, agriculture, and other users. This can also intensify water scarcity and lower groundwater levels.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

All risks

Continued Table 4 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 infrastructure services from, surface water, river and groundwater flooding	Flooding poses a significant risk to infrastructure services by damaging roads, bridges, and utility networks, leading to power outages, disrupted water supply, and impaired emergency response.		Very High	Very High
Risks to bridges and pipelines from flooding and erosion	Coastal erosion may have an adverse impact on the infrastructure of a few of the main towns in Angus that are situated at the coast, namely Arbroath, Montrose, Carnoustie and Monifieth. This could have structural damage leaving pipelines exposed and/or broken. In addition, the Montrose Bridge may be more exposed leading to more frequent maintenance and repair.		High	Very High

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4.Climate Change Risk and Vulnerability Assessment

4.6 Infrastructure

Key findings

- In total 26 key climate change risks to infrastructure were identified and assessed. 2 risks were assessed as being “Medium” risk under a 2°C scenario, which become “High” under a 4°C scenario, these were "Risks to waste from storms and subsequent flooding" and "Damage to water infrastructure from storms".
- Several risks were assessed as being “High” under the 2°C and 4°C scenario, those risks were "Risks to waste from flooding high rainfall/ extreme temperatures"; "Changing demand on energy systems due to increased cooling demand or increased seasonal heating"; "Damage and disruption to the mainline rail networks due to storms"; "Damage to public transport systems and wider road network due to storms"; "Risks to waste from storms/ flooding and high rainfall/ extreme temperatures"; "Disruption to Ports (Port of Montrose) due to coastal erosion, change/ storms"; "Damage to water infrastructure due to drought and water scarcity; flooding and high rainfall/ extreme temperatures" and "Risks to waste from extreme temperatures/ flooding and high rainfall".
- The following risks were assessed as “High” for the 2°C scenario, however increased to “Very High” under the 4°C scenario; "Risk to energy due to storms"; "Increased risk to contamination/leachate from flooding and heavy rain"; "Risks associated with increased private abstraction due to drought and extreme temperatures"; "Risks to bridges and pipelines from coastal erosion, change and sea level rise"; "Risks to coastal infrastructure due to coastal erosion, change and sea level rise"; "Disruption to Ports due to flooding and high rainfall"; "Damage to roads from flooding and high rainfall" and "Damage to the mainline rail network by flooding and high rainfall/ coastal erosion and change".
- 4 of the 26 risks were assessed as “Very High” under 2°C and 4°C scenario, these were "Risks to energy due to flooding and high rainfall", "Risks to energy due to extreme high temperatures"; "Risks to infrastructure services from flooding and high rainfall" and "Damage to water infrastructure from drought and water scarcity".

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4.7 Land, Nature and Food

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

Sector introduction

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 or 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 habitats and species will suffer or benefit will depend on a range of factors including climate change, human disruption, pollution, competition between species, land use pressures and ecological connectivity. Therefore, this assessment describes the general trends and impacts 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.

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

Connection with the Fourth CCRA Independent Assessment

The risks identified within CCRA4-IA have been included as the basis for this assessment and have been incorporated using Angus-specific information. The following risks identified in CCRA4-IA are considered applicable to Angus and been taken forward in this assessment:

N1: Risks to terrestrial and coastal ecosystems

N2: Risks to freshwater ecosystems

N3: Risks to marine ecosystems

N4: Risks to soil ecosystems

N5: Risks to natural carbon stores and sequestration

N6: Risks to agriculture

N7: Risks to fisheries and aquaculture

N8: Risks to forestry

N11: Risks to food security

The above risks have been taken as the basis for the assessment, and the output is summarised in Table 5 on the following pages. Further details of the assessment methodology are provided within Appendix A3. A high-level summary heat map is presented in Appendix A4.6.

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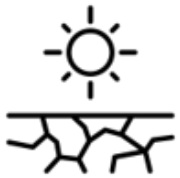
4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions from changing climatic conditions, including temperature change and water scarcity	Rising temperatures pose risks to natural carbon stores and carbon sequestration by altering soil processes, vegetation patterns, and ecosystem stability. Warmer conditions can accelerate organic matter decomposition, reduce soil moisture, and increase the frequency of disturbances like drought and wildfires, all of which can release stored carbon and increase greenhouse gas emissions, undermining the role of natural systems in climate mitigation.		High	Very High
Risks to soils from changing climatic conditions, including seasonal aridity and wetness - which is likely to degrade soils and have knock on impacts on biodiversity	Drought intensifies the risk of soil degradation by reducing moisture levels, weakening soil structure, and increasing vulnerability to erosion and compaction. As soils dry out and organic matter breaks down, their ability to support plant life and biodiversity declines, leading to cascading effects on terrestrial ecosystems and agricultural productivity.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Continued Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risk from new species colonisations in coastal habitats	Climate change is accelerating the colonisation of coastal habitats by invasive and non-native species, driven by rising sea temperatures and changing salinity levels. These species can outcompete native coastal flora and fauna, disrupt food chains, and degrade sensitive ecosystems such as dunes, salt marshes, and estuaries, threatening biodiversity and natural coastal defences.		High	Very High
Risk from new species colonisations in freshwater habitats	Climate change is altering freshwater ecosystems, enabling invasive and non-native species to colonise new areas where they outcompete native aquatic life, disrupt food webs, and degrade habitat quality. Warmer water temperatures and changing flow regimes create favourable conditions for these species, increasing ecological stress and threatening biodiversity in rivers, lakes, and wetlands.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Continued Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risk from new species colonisations in terrestrial habitats	Climate change is enabling the spread of non-native and invasive species into new terrestrial habitats, where they can outcompete native flora and fauna, disrupt ecological balances, and degrade habitat quality. These species often thrive under altered temperature and precipitation patterns, increasing pressure on already vulnerable ecosystems and contributing to biodiversity loss.		High	Very High
Risks to freshwater species associated with agricultural pollution	Agricultural pollution poses significant risks to freshwater species by introducing excess nutrients, pesticides, and sediments into rivers and streams, which can degrade water quality and disrupt aquatic ecosystems. In the River South Esk catchment, for example, pollution from farming activities has led to ecological decline, threatening sensitive species like Atlantic salmon and freshwater pearl mussels.		High	Very High
Risks to freshwater species and habitats from pests, pathogens and invasive species	Climate change increases risks to freshwater species and habitats from pests, pathogens, and invasive species by altering water temperatures and flow patterns, creating conditions that favour non-native and more resilient organisms. These changes can disrupt native aquatic ecosystems, reduce biodiversity, and introduce diseases that threaten fish populations and other freshwater life.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

ARUP

4.7 Land, Nature and Food

All risks

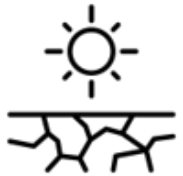
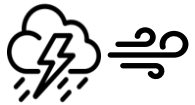
Continued Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to terrestrial species and habitats from pests, pathogens and invasive species	Climate change is increasing the risk to terrestrial species and habitats from pests, pathogens, and invasive species by altering seasonal patterns and creating conditions that favour more robust, non-native organisms. Warmer temperatures and shifting rainfall patterns allow invasive species and pests to expand their range, outcompeting native wildlife and spreading diseases that threaten biodiversity and ecosystem stability.		Very High	Very High
Risks to terrestrial and freshwater 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. Pests, pathogens and invasive species have the potential to disrupt key ecosystem functions and cause significant economic damage.		Very High	Very High
Risks to freshwater species and habitats from droughts, high temperatures (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. The sensitivity varies by species.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

Continued Table 5 all climate risks identified for Land Nature and Food 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 freshwater species and habitats from droughts, high temperatures (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.		High	Very High
Risks to freshwater species and habitats from storms/high rainfall/ flooding	Flooding can disrupt freshwater species and habitats, as during a flood species can be directly killed or harmed. In the aftermath of flooding, species may be indirectly harmed due to habitat loss and damage.		High	High
Risks to freshwater species and habitats from storms/high rainfall/ flooding	Flooding poses direct risks to freshwater species and habitats through physical harm and damage to habitats. Following a flooding event, freshwater species might be further impacted by habitat loss.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Continued Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

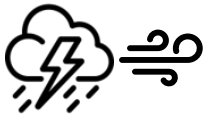
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to coastal species and habitats due to coastal flooding, erosion and climate factors	Coastal species and habitats could be harmed or lost due to coastal flooding and erosion. Permanent loss may occur if erosion is significant		Very High	Very High
Risks to marine species and habitats from high temperatures/ droughts	Marine habitats are particularly vulnerable to extreme high temperatures. These risks could lead to marine 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. In some instances, species may leave the area.		High	High
Risks to marine species and habitats from storms/ high rainfall/flooding	Flooding poses direct risks to marine species and habitats through physical harm. Following a flooding event, terrestrial species might be further impacted by habitat loss.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Continued Table 5 all climate risks identified for Land Nature and Food 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 marine species and habitats from storms/ high rainfall/flooding	Storms can cause direct damage to species through physical harm or storm surge.		Medium	High
Risks to terrestrial species and habitats from wildfires	Extreme heat can have short-term impacts on species which may suffer during a heatwave or wildfire. 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. Additionally, extreme heat increases the risk of wildfires, which can cause widespread destruction of ecosystems, further threatening species survival.		Very High	Very High
Risks to terrestrial species and habitats from high temperatures/ droughts	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. Soil degradation can also occur and further contribute to habitat shifts.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Continued Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

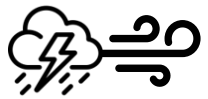
Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Risks to terrestrial species and habitats from high temperatures/ droughts	Extreme heat can have short-term impacts on species which may suffer during a heatwave. Heatwaves may also accelerate the spread of invasive species and pests, outcompeting native flora and fauna. Over time, these pressures could result in shifts in species distributions, declines in biodiversity, and the loss of sensitive ecosystems such as upland woodlands and wetlands.		High	Very High
Risks to terrestrial species and habitats from flooding	Flooding poses direct risks to terrestrial species and habitats through physical harm. Following a flooding event, terrestrial species might be further impacted by habitat loss.		High	Very High
Risks to terrestrial species and habitats from storms/ high rainfall/flooding	Storms can cause direct damage to species and habitats, with trees being particularly vulnerable. High winds can uproot trees, strip vegetation and lead to habitat loss and fragmentation.		High	High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Continued Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Reduced forestry yields due to storms	High wind speeds can uproot trees which will reduce the forestry yields. Fallen trees and debris can also impact forestry operations by preventing maintenance and harvesting.		High	High
Reduced agricultural outputs (food) and forestry yields due to high rainfall and storms	Heavy rainfall can reduce agricultural and timber production output by waterlogging fields, making them inaccessible for machinery and damaging crops through root rot and nutrient leaching.		High	Very High
Reduced agricultural outputs (food) and forestry yields due to drought	Prolonged dry conditions and water unavailability may impact or limit agriculture operations and reduce crop yields. There is a risk for Scottish Water to keep operations going and to limit disruption to customers during periods of drought. There may become an over reliance on private abstraction which may create wider issues for the local area; Scottish Water may have to enforce hosepipe bans in the region which will negatively impact farmers.		High	Very High

4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

All risks

Continued Table 5 all climate risks identified for Land Nature and Food along with the associated climate hazard, and scores for both scenarios

Risk	Description	Hazard(s)	Overall score (2°C)	Overall score (4°C)
Reduced agricultural outputs (food) and forestry yields due to high temperatures	Higher temperatures could lead to decline in crop yields due to heat stress and water scarcity as well as increased pest pressure. This can lead to financial loss and impact the region's food security.		High	Very High

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4.Climate Change Risk and Vulnerability Assessment

4.7 Land, Nature and Food

Key findings

- In total 26 key climate change risks to land, nature and food were identified and assessed. 1 risk was assessed as 'medium' under a 2°C scenario and then as 'high' under a 4°C scenario. This risk was "Risks to marine species and habitats from storms".
- Risks assessed as 'high' under both a 2°C and 4°C scenario include "Risks to terrestrial species and habitats from storms"; "Risks to freshwater species and habitats from storms" and "Risks to marine species and habitats from flooding and high rainfall/ extreme temperatures".
- The majority of risks were scored as 'high' for the 2°C scenario, however increased to 'very high' under the 4°C scenario. These include "Risks to soils from changing climatic conditions including seasonal aridity and wetness due to drought risks and water scarcity"; "Risks to freshwater/ terrestrial/ coastal species colonisation in their habitats due to extreme temperatures"; "Risks to freshwater species associated with agricultural pollutions from flooding and high rainfall"; "Risks to freshwater species and habitats from flooding and high rainfall/ drought and water scarcity/ extreme temperatures"; "Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions from changing climatic conditions due to temperatures increasing"; "Risks to terrestrial species due to flooding and high rainfall/ extreme temperatures/ droughts and water scarcity"; and "Reduced agricultural outputs (food) and forestry yields due to high temperatures/ drought and water scarcity/ flooding and high rainfall".
- Only 4 risks were assessed as 'very high' under both a 2°C and 4°C scenario. These are "Risks to terrestrial species from wildfires"; "Risks to coastal species due to coastal erosion and change" and "Risks to terrestrial and freshwater species and habitats from pests, pathogens and invasive species due to extreme temperatures and flooding/high rainfall".

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5. The Cost of Past Events

5.1 Introduction

5.2 Approach

5.3 Case studies

5.4 Storm impacts on the Economy

5.5 Storm impacts on Infrastructure

5.6 Storm impacts on the Built Environment

5.7 Storm impacts on Health and Wellbeing

5.8 Storm impacts on Nature Land and Food

5.The cost of past events

5.1 Introduction

Understanding the costs of past extreme weather events is a vital tool to 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 Angus.

Storm Arwen in 2021 and Storm Babet in 2023 were chosen as case studies as they both occurred in the last 5 years. Storm Arwen was characterised by high winds, which caused damage across the region and left many without power for several days[21]. Glen Doll, in the southeastern part of the Cairngorms National Park, lost approximately 19% of 191 hectares of forestry[22]. Storm Babet's unprecedently heavy rainfall, resulted in flash flooding across the region, with flooding in Brechin making national news. 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 similar impacts to those experienced during these storms are likely to occur more frequently and even become more devastating in the future.

5.The cost of past events

5.2 Approach

The financial impact of an extreme event is frequently used to understand how disruptive the event was. However, these impacts extended beyond just the financial costs and include the impact on our health and wellbeing as well as cultural heritage. To holistically assess the costs of these past events, we have applied and refined the United Nation's (UN) Framework for Loss and Damage[23]. Figure 10 illustrates the categories of loss that should be considered under this framework. We have adapted this framework to be most relevant for Angus, Table 6 provides mapping of the new categories to the risk assessment sectors.

To understand the holistic losses, damages and disruption, which have occurred due to both storm events, we have;

- reviewed local and national news sources and available Council information; and
- interviewed representatives from the different sectors to understand the impacts the storms had on their sectors.

In this section, firstly background contextual information about the meteorological conditions for each storm is provided and then secondly, the findings on loss and damage by sector are presented.

Figure 10 provides all aspects included within the UN's Loss and Damage framework.

Table 6 Adapted UN Loss and Damage framework and related CCRVA sectors

UN categories	UN sectors	Angus' CCRA Sectors
Direct economic losses	Business	Economy
	Tourism	
	Infrastructure	Infrastructure
	Services and Transport	
	Property	Built Environment
	Leisure facilities	
Indirect economic losses and non-economic losses	Loss of life, mental and physical health	Health and Wellbeing
	Cultural heritage	
	Biodiversity	Land Nature and Food
	Ecosystem services	

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5.The cost of past events

5.3 The case studies: Storm Arwen

Storm Arwen occurred from 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 alongside yellow warnings for snow (Figure 11). The developing storm, tracking south to the north-east of the UK, brought northerly winds gusting widely at over 60Kt (69mph)[24]. 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. There were three reported deaths because of falling trees. The strong winds also brought various reports of structural damage to buildings.

Across the UK, nearly one million homes experienced a loss of power as falling trees brought down power lines, with around 40,000 homes subsequently experiencing more than 3 days without power and 4,000 homes having their supply cut off for over a week[25]. There was widespread disruption to transport systems; trains cancelled due to debris on the rails. Schools were closed for 2 days across Aberdeenshire.

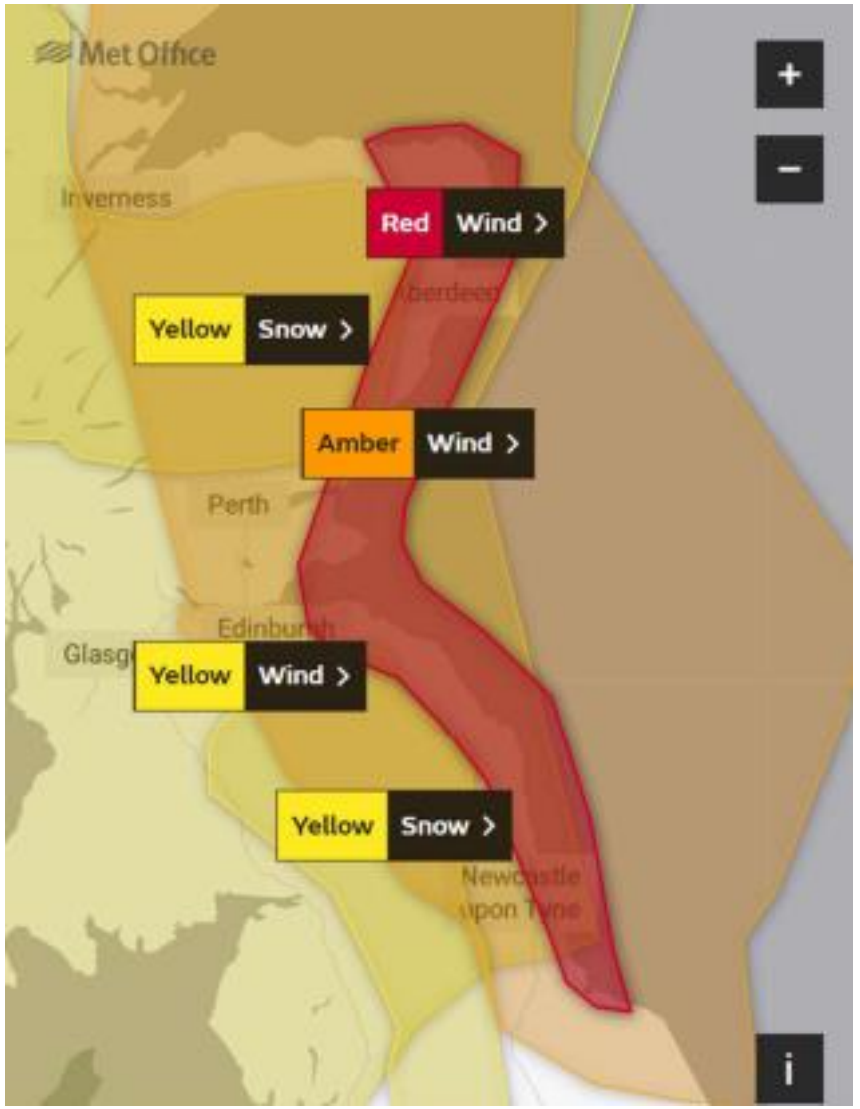

Figure 11 shows the Met Office red warning issued for storm Arwen covering the east coast of eastern Scotland and north-east England. Source: Met Office[21]

5.The cost of past events

5.3 The case studies: Storm Babet

Storm Babet from the 18th of October 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[22] (Figure 12). For Angus, the 19th of October was the wettest day on record since records began in 1891[26]. Parts of eastern Scotland received over 150% of the whole month average rainfall over this period with some receiving over 225% of the average.

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. There were seven recorded deaths associated with Storm Babet. Multiple severe flood warnings were issued by Scottish Environment Protection Agency (SEPA) across the east of Scotland and in Angus. 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 insurance losses around the UK due to the severe weather caused by Storm Babet to be between £450 and £650 million[27]. The Angus Council claim to the Bellwin Scheme (a fund designed to help councils after large-scale emergencies) was £6.9 million[73].

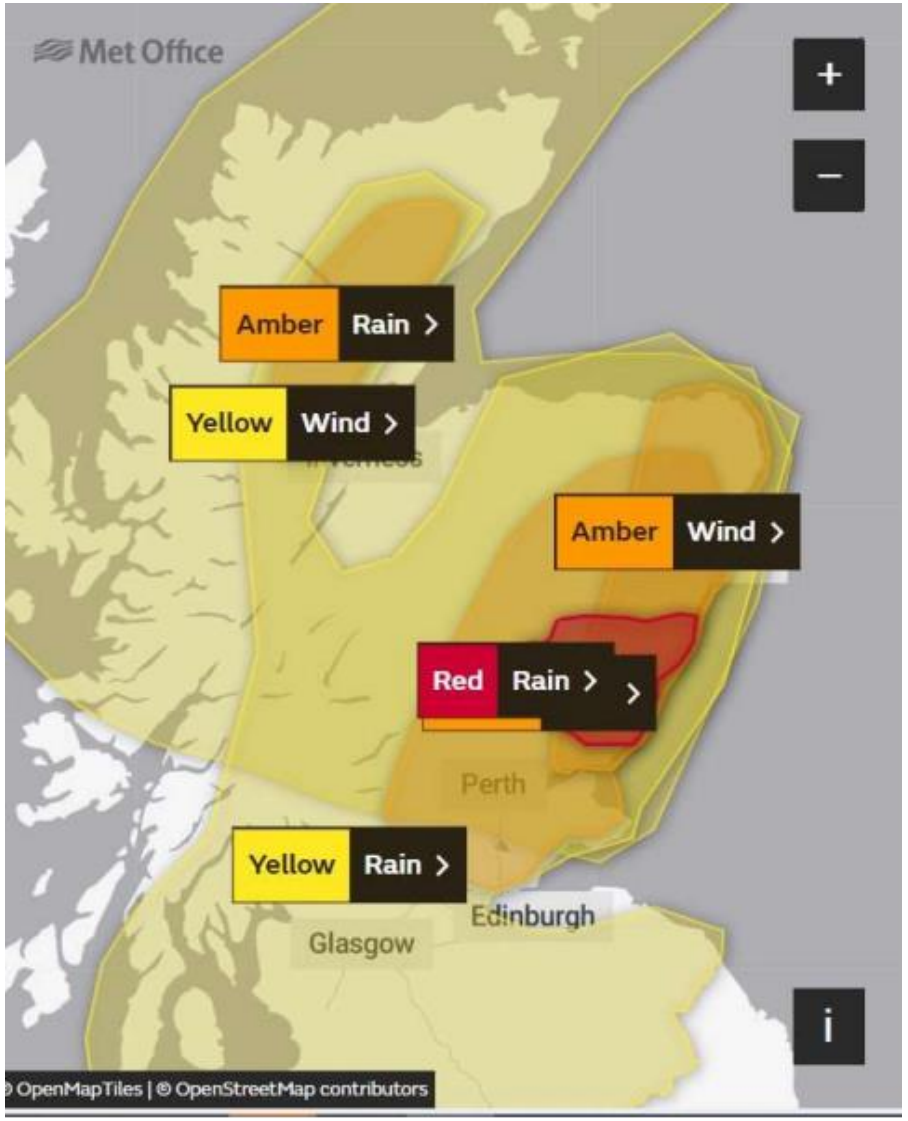

Figure 12 shows the Met Office red warning issued for parts of eastern Scotland from 1800BST Thursday 19 October to 1200BST Friday 20 October 2023. Source: Met Office[22]

5.The cost of past events

5.4 Storm impacts on direct economic losses

Storms cause significant impacts for business and industry, such as loss of income from businesses closing. 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 not be able to commute to work due to wider transport disruption causing further impacts on businesses, if they can remain open. Tourism may also be impacted with visitors cancelling or delaying visits during times of severe weather.

Table 7 Impacts on direct economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damages framework.

Category	Examples of Storm impacts in Angus during Storm Arwen and Babet
Business operational	Storm Arwen had a direct impact on businesses in the run up to Christmas. Falling debris damaged businesses which may or may not have had adequate insurance. There was a drop in tourists and customers to businesses due to disruption to the transport network. Commercial and residential properties across Angus were left without power for an extended period, some without power for over three nights[28]. During Storm Babet, flooding and high winds across the region impacted various areas including all the major settlements in Angus where many businesses are located. Additionally, flooding caused road closures which were likely to have indirect impact on businesses due disrupted supply chains and their staff's inability to commute to work. Flood damage to properties in Brechin resulted in Matrix International, an employer of 120 people, having to move to temporary accommodation. Matrix International is facing closure, which in part is blamed on the inability to recover from the flooding[29]. Many small medium enterprises (SMEs) were impacted by flooding and did not have adequate insurance – particularly around Eastmill in Brechin[30].

5.The cost of past events

5.4 Storm impacts on direct economic losses

Tourism in Angus is worth around £240 million annually to the local economy and supports approximately 4,000 full time jobs[5]. Visitors are drawn in by heritage sites like Glamis Castle or golf courses like the Carnoustie Championship Course, or Angus' unspoiled landscapes and green spaces such as Monikie and Crombie Park and munro bagging in the Angus Glens. Storms disrupt the usual flow of tourists by disrupting transport networks including road and rail routes. Damage or closure of tourist sites can discourage tourists from visiting and reduce tourist spend.

Table 7 Continued Impacts on the direct economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damages framework.

Category	Examples of Storm impacts in Angus during Storm Arwen and Babet
Tourism	During Storm Arwen, disruption to rail and road networks will have prevented tourists from travelling to Angus. Christmas events were cancelled across the region. Furthermore, Angus' parks and green space had many of their trails blocked by falling trees including Monikie, Crombie and Forfar Loch Parks, with fallen trees blocking paths not removed for nearly two years[31]. During Storm Babet, disruption to transport networks will have prevented people travelling to Angus. Damage to caravan parks across sites in and around Angus including Eastmill Caravan Park in Brechin[32]. Reports of tourists having to be rescued in flood water as the River Isla burst its banks near Coupar Angus in Perthshire[33]. Furthermore, due to the closure of businesses and tourist attractions due to the poor weather and transport disruption, there was a reduction in tourist spending. News of flooding and damage to sites in Angus likely dissuaded tourists from visiting for a while after the Storm Babet, as people were advised to 'stay at home'[34].

5.The cost of past events

5.4 Storm impacts on direct economic losses

Approximately 10% of Scotland's prime agricultural land is in Angus and 40% of Scotland's class 1 Agricultural land is in Angus[35]. Angus is famous for its Angus beef and local smoked fish – Arbroath smokies[35]. The impact of the storms on the agricultural sector includes damage to crops and farm buildings and farming machinery, disruption to transport networks preventing normal supply chains and normal farming operations as fences were damaged and roads were blocked.

Table 7 Continued Impacts on direct economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damages framework.

Category	Examples of Storm impacts in Angus during Storm Arwen and Babet
Agriculture	During Storm Arwen, high winds and falling debris damaged buildings and machinery and disrupted farm operations. One member of the National Farming Union (NFU) estimated the damaged to his farm was around £70,000. Another member stated an acre of Sitka Spruce trees had been blown down[35]. The majority of the damage to farms is assumed to be insurable[35]. Storm Babet resulted in significant losses of crops, damage and disruption to flood embankments, flooding of potato stores and damage to machinery[36]. Poultry sheds were flooded causing the loss of chickens and sheep requiring rescue from flood waters[36]. Farming charity RSABI said it had a fund to £100k to provide to impacted families – for around £1,000 per business[36].

5.The cost of past events

5.5 Storm impacts on direct economic losses

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

Table 7 Continued Impacts on the direct economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damages framework.

Category	Examples of Storm impacts in Angus during Storm Arwen and Babet
Infrastructure	During Storm Arwen, power outages occurred in 80,000 homes across Scotland, which included many homes in Angus that were without power due to damage to powerlines[21]. There was widespread disruption to the road network because of fallen trees and other debris on the road. Storm Babet damaged the 240-year-old Bridge of Dun near Montrose, which eventually re-opened in 2025, after a partial collapse[37]. The estimate for repairing the Bridge of Dun is in the region of £1 million. The main A90 trunk road closed between Forfar and Brechin due to storm damage to a bridge[38]. Other road closures included the A92 coastal road between Montrose and St Cyrus. There were widespread power cuts across the network; SSEN had to restore power to 37,000 customers and fix 450 faults across the network[38]. Edzell was temporarily cut off from the wider transport network as roads flooded. An initial estimate for the costs for the damage to infrastructure in Angus is estimated to be around £4 million; with most costs being attributed to the damage to the Brechin Flood Prevention Scheme which will cost £3.9 million[30]. Both storms resulted in significant transport disruption on the road and rail network and damage to the power grid.

5.The cost of past events

5.6 Storm impacts on direct economic losses

Storms can cause direct damage to the built environment by damaging residential and commercial properties through flood waters, falling debris and high winds.

Table 7 Continued Impacts on the direct economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damages framework.

Category	Examples of storm impacts in Angus during Storm Arwen and Babet
Property	During Storm Arwen, properties were damaged by debris carried in high winds, falling trees, and potentially falling stonemasonry. Balhousie Care Home was impacted by power outages; water shortages and phone and internet lines were also disrupted[39]. Local businesses across Angus including Val Di Vara chip shop in Brechin and Bel's Butchers in Edzell stepped in to help supply to residents of Balhousie The Glens with food. In Arbroath, two other Balhousie care homes were impacted by outages, and a local McDonalds had to supply hot drinks. Around 1,600 homes in Angus were left without power, some for over three nights[40]. During Storm Babet, flood waters caused significant damage to properties in Brechin after the River South Esk burst its banks. In particular, properties along River Street were affected by rising floodwater, with households having to be evacuated due to the flood risk. Some homeowners did not have insurance to cover the damage due to the high cost of flood insurance. Families had to be relocated to temporary accommodation and lost their possessions. Over 50 council houses in Brechin have lain empty since Storm Babet. There are up to 80 vacant properties in Brechin. In Monifieth, houses also had to be evacuated as Dighty Burn burst its banks[41]. Approximately 400 households were impacted by flooding due to Babet.

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5.The cost of past events

5.7 Storm impacts on indirect and non-economic losses

Storms have wide-ranging impacts on non-economic losses. Recent storms in the UK have caused fatalities and injuries which have impact 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 regularly cause damage to homes and other buildings, ranging from damage to roofs due to high winds or through fallen trees and debris or through homes being flooded in flash flood events. Loss of 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 disputation can cause delays in ambulances, staff getting to work and direct damage to facilities can also occur.

There is a direct risk to the safety of individuals 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 are 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.

5.The cost of past events

5.7 Storm impacts on indirect and non-economic losses

Table 8 Impacts on the indirect and non-economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damage Framework

Category	Examples of Storm impacts in Angus during Storm Arwen and Babet
Life & Health	Nobody died in Angus during Storm Arwen, however, there was one death recorded nearby in Aberdeenshire, as a man was killed by a falling tree[42]. Local schools were closed due to power outages and school transport issues[43]. Furthermore, parks in Angus were closed for an extended period due to fallen trees and debris making them dangerous to visitors, which may have an adverse impact on local mental and physical health[31]. Furthermore, power cuts will have had an adverse impact on health and wellbeing as homes had no heating during winter, some for over three nights. During Storm Babet, there were two deaths recorded in Angus; A woman was swept away by a river during Storm Babet, and a man was killed by a falling tree which landed on his vehicle near Forfar[44]. Schools were also closed due to disruption. This transport disruption also led to some shortages in supermarkets[37] and undoubtedly disruption to social care. Furthermore, the flooding of homes in Brechin had a significantly adverse impact on the mental health and wellbeing of residents as they had to evacuate their homes and had their possessions lost or damaged due to storm water[37].

5.The cost of past events

5.7 Storm impacts on indirect and non-economic losses

Table 8 Continued Impacts on the indirect and non-economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damage Framework

Category	Examples of Storm impacts in Angus during Storm Arwen and Babet
Cultural heritage	Across Scotland, various cultural events had to be cancelled due to Storm Arwen including Edinburgh Christmas Market[45]. There was also a delay in the Christmas Light switch on in Carnoustie due to power outages[46]. In Forfar, Christmas at the Cross had to be cancelled due to Arwen[47]. Storm Babet damaged a hall on River Street in Brechin which was used by the City of Brechin Pipe Band to practice, with some of their instruments were damaged due to the flood water[32]. There are also concerns around the loss of community as many evacuated homes have stayed empty since the flooding[48]. Both storms occurred during the run up to the festive period and will have had an impact on the plans for festive celebrations. 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.

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5. The cost of past events

5.7 Storm impacts on indirect and non-economic losses

Storms can cause significant damage to habitats through flooding and strong winds. Trees are particularly vulnerable in high winds and can be damaged or blown over completely, which can result in financial loss to the timber and forestry industry. 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. Flooding can damage crops and agricultural land, through washing away topsoils and flooding crop stores.

Table 8 Continued Impacts on the indirect and non-economic losses from Storms Arwen and Babet, presented using the adapted UN Loss and Damage Framework

Category	Examples of Storm impacts in Angus during Storm Arwen and Babet
Biodiversity & Ecosystem Services	The strong winds during Storm Arwen caused hundreds of trees to be uprooted across the region, fallen tress 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 would have negative impacts to species, especially those reliant on trees due to damage to their habitats. The loss of trees during Storm Arwen has had significant cascading impacts on local biodiversity and loss of ecosystems services through the loss of habitats, loss of food sources and pollinators affected. Strong wind and heavy rainfall caused surface water flooding and path erosion; it is likely that soil would have also been eroded and or exposed in these areas. The erosion of soil along with the loss of vegetation also has a subsequent impact on carbon sequestration. Carbon locked in veteran trees and within the soils will have been released during these processes. There are three Country Parks at Forfar Loch, Crombie and Monikie in Angus were closed temporarily due to fallen trees with the fallen debris still to be cleared two years later[31]. During Storm Babet, the River South Esk burst its banks and flooded and inundated agricultural lands. This flooding will likely have changed the aquatic ecosystems through changing the sediment load of the river and damaged existing habitats. Soil erosion and the loss of nutrient rich soils in agricultural land will reduce agricultural output. Damage to trees will have destroyed habitats.

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6. Adaptation Options

6.1 Introduction

6.2 Becoming resilient to flooding

6.3 Becoming resilient to storms and high winds

6.4 Becoming resilient to extreme heat and drought

6. Adaptation options

6.1 Introduction

This section provides six adaptation options that could be implemented by stakeholders within Angus to address the climate risks identified in the Climate Risk and Vulnerability Assessment (CRVA). The adaptation options would contribute towards strengthening the region's resilience to future climate change impacts and better protect communities, organisations and infrastructure against climate induced hazards. Furthermore, these adaptation options can be delivered by adopting a multi-stakeholder approach working closely with local stakeholders to implement effectively.

For each of the six options presented, we have included a description of the option and a high-level assessment of cost, time and the wider co-benefits. This work is designed to complement the CRVA, offer specific actions for tackling climate risks and outline possible next steps for the Angus region. This is not a comprehensive action plan covering all options, nor is it an in-depth analysis on how to implement options. Instead, it is a high-level assessment of adaptation options and how stakeholders within Angus can come together to deliver them.

In addition to the six area-wide adaptation options detailed in this report, we would recommend two additional adaptation options for Angus Council which would provide a broad cohesive approach to increase the region's resilience to climate change and to all future climate hazards which have been identified.

- The first option is to develop a joined-up community resilience plan for Angus.
- The second option focuses on ensuring Angus Council takes action to become resilient as an organisation, by reviewing and updating its own business continuity, and coordinate risk and emergency response plans.

These overarching adaptation options for Angus Council are not detailed in this report. Instead, the six adaptation options covered in this report are targeted actions aimed at reducing the threat from specific climate hazards.

6. Adaptation options

6.1 Introduction

Six 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 region in the future as identified from the CRVA. Storms and flooding were chosen due to currently being a significant threat to the region. Heat and drought are both developing hazards, which are likely to worsen throughout the coming century, therefore advanced adaptation planning for these hazards is recommended.

Changes to precipitation and future flooding

AO1: Angus Council supporting community groups in taking a proactive role in flood resilience.

AO2: Review of flood risk within all buildings and business assets leading to the creation of an action plan to mitigate this risk.

Changes to the frequency of storms

AO3: Review the emergency planning and response to vulnerable communities and businesses on the coast and create an action plan strengthening flood and storm resilience.

AO4: Educating business and residents on preparing for storms.

Future extreme heat & drought

AO5: Cross sectoral approach to set up and run a heat health working group and review of overheating risk within Council-owned buildings and business assets, resulting in the development of a heatwave action plan.

AO6: Cross sectoral approach for stakeholders and landowners to review and refine their own water management plans.

All six 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.

6. Adaptation options

6.2 Becoming resilient to flooding

AO1: Angus Council supporting community groups in taking a proactive role in flood resilience

Changing precipitation patterns project the Angus region 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 region. Flooding has already occurred in Angus and is one of the most prominent and tangible climate hazards across the region; flooding from Storm Babet in 2023 resulted in evacuations and damage to homes and businesses in Brechin. Due to its prominence, flooding has already received significant attention within the region with numerous schemes (such as the Brechin Flood Protection Scheme and the Arbroath (Brothock Water) Flood Protection Scheme) currently ongoing to reduce flood risks.

Therefore, this adaptation option focuses on Angus Council's role in helping residents take very localised actions to prevent flooding and cope with the aftermath of flood events. This adaptation option proposes that Angus Council assists in the development of community groups across the region focusing on flood resilience, including those already established in areas such as Brechin (e.g. Brechin Community Resilience Group).

This work could use the flood vulnerability index, alongside the flood mapping and story mapping produced, to help prioritise areas within the region that are exposed to flooding and the community groups in these areas that would benefit from support (e.g., small grants for community-led projects, training and capacity building on property flood resilience and public awareness campaigns on flood preparedness). The type of support may differ between community groups to ensure the groups meet the specific needs of the local community. This adaptation option builds on Angus's active civic community scene, as the region already has multiple existing sustainability and climate community groups.

6. Adaptation options

6.2 Becoming resilient to flooding

AO1: Angus Council supporting community groups in taking a proactive role in flood resilience

The remit of each group should, at a minimum, incorporate the following services:

1) Advice and support with building local physical resilience to flooding – building on current support provided (such as the Angus Council website[49]), educating residents in the role and importance of permeable surfaces within private gardens to slow water flow into drainage rather than paving over driveways or use of water butts to store water and re-use water within gardens.

2) 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 getting the appropriate insurance coverage for flood events. Safety advice on what to do during a flood event; moving furniture upstairs, unplugging electronics, packing a 'grab bag' in the event of an evacuation with clothing, medication, money and other essentials. Generic advice is available via the British Red Cross[50] including a full list for an emergency grab bag and a community resilience toolkit to develop community-based emergency plans.

3) Support during a flood event – identification and checking in on those most vulnerable in the community e.g. elderly, chronically ill or those with disabilities. Identification and running of a local safe space, which is warm and provides basic needs for those whose homes are flooded including a place to sleep with food and other essential supplies. Help relocating vulnerable people to a safe space.

4) Post flood support – support with clearing of homes, repairing damage, help gaining financial support where needed and advice on insurance claims, sharing best practice across the community. Documenting experiences of the flood is important and feeding back on what did and did not work in the planning procedure.

It is understood that there are communities around Angus who already take an active role in flood resilience. It is vital that Angus Council provides support to allow those groups to actively learn from each other and lean on each other in times of trouble.

Table 9- AO1: Angus Council supporting community groups taking a proactive role in flood resilience.				
Intervention Type:	Community / action based			
Hazard Categories:	Flooding			
Stakeholders:	Angus Council internal stakeholders: Infrastructure & Environment Directorate, Policy, Strategy & Engagement Directorate External stakeholders: Angus Climate Hub, Community groups, local charities, established flood groups around Angus			
Implementation Timeframe:	This option 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 < 5years	Medium 5-10yrs	Long >10 years
Cost Indication (Initial Cost/Set-Up Cost):	One of the first steps is defining Angus Council's role in supporting community groups. It is unlikely that this will involve direct financial support and will instead focus help on identifying other funding support mechanisms. Therefore, it is anticipated that financial cost to set up this measures would be low.	£	££	£££
Cost Indication (Ongoing/ Maintenance)	This will be dictated by Angus Council's role and if any financial aid is included. It is more likely Angus Council's main role will be coordination and resource support and sharing best practice.	£	££	£££
Staff Resource Intensity:	This option will vary depending on how involved Angus Council is with established community groups, initial set up of Angus 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 further groups are established.	Low	Medium	High
Co-Benefits:	**Health benefits:** safer practices and more support in the response during floods are likely to improve physical and mental health outcomes, for example, by identifying vulnerable residents. **Biodiversity benefits:** Some measures to enhance flood resilience through nature are likely to improve local biodiversity (by encouraging green space). **Community morale/sense of place:** Groups such as these can play a role in bringing people together and creating more pride for the local neighbourhood and a sense of belonging.			
Implementation Feasibility:	This is measures is medium to high complexity; the measure 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 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 should 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:	(1) Define clearly Angus Council's role in this work, identify funding possibilities. (2) Collate a list of existing community groups in Angus working in this space and their work on flooding. (3) Review and identify the most at-risk areas of the region. (4) Collate publicly available guidance on community flood resilience, such as through the British Red Cross and ReadyScot.			

6. Adaptation options

6.2 Becoming resilient to flooding

AO2: Review of flood risk for all buildings and business assets, leading to the creation of an action plan to mitigate the risk.

Angus has already experienced significant flooding due to Storm Babet in 2023. Properties in Brechin were flooded as the River South Esk overflows[51]. Households had to be evacuated and there was extensive damage to properties. As of summer 2025, approximately 85 council properties in the Brechin River Street Area (BRSA) have lain empty since Storm Babet [52].

As a result, measures local stakeholders should take to understand and prepare for flood risk in the area include:

1. **Focusing an action plan on the most vulnerable areas in Angus.** Use the Strategic Flood Risk Assessment (SFRA) findings to identify which areas are most at risk and tailor the response to these areas, such as Forfar, Arbroath and Monifieth as the extreme priority areas (as in Figure 5.47 of the SFRA).
2. **Develop contingency plans for at risk assets.** E.g., a community building at risk of flooding cannot be an evacuation hub during a flood event, even if it is nearby to a high-risk flood zone. Targeted advice for Angus Council tenants living in high-risk homes.

In addition, it is important for Angus Council to understand which of their properties and assets are at highest risk of flooding across different projected scenarios and to consider the increased risk from climate change (e.g., key transport infrastructure was damaged in Storm Babet such as Bridge of Dun in Montrose. The repairs are expensive and ongoing and will need to consider future risk and how to enhance the resilience of the bridge in the future). This is essential to protect individuals, communities and Angus Council's own finances.

An additional measure which Angus Council should undertake to understand their own risk is to:

- **Update the mapping of Angus Council-owned properties and business assets across Angus** (including community/ leisure centres and social housing and other sensitive assets such as schools and care homes).

Table 10- AO2: Review of flood risk for all buildings and business assets, leading to the creation of an action plan to mitigate the risk.				
Intervention Type:	Internal research/ outreach and education			
Hazard Categories:	Flooding			
Stakeholders:	Angus Council internal stakeholders: Infrastructure & Environment Directorate, Policy, Strategy & Engagement Directorate External stakeholders: Angus Climate Hub, Scottish Flood Forum, Planning teams in neighbouring local authorities, local communities			
Implementation Timeframe:	Due to the internal and short-term nature of the adaptation option, 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 < 5years	Medium 5-10yrs	Long >10 years
Cost Indication (Initial Cost/Set-Up Cost):	The initial exercise would involve internal conversations, possibly workshops, to better understand the topic and is anticipated to have low to no cost associated.	£	££	£££
Cost Indication (Ongoing/ Maintenance)	No large long-term financial costs anticipated for ongoing maintenance, just costs associated with maintaining and updating the data.	£	££	£££
Staff Resource Intensity:	Initial staff time would be of medium intensity, as all Angus Council assets will be reviewed and mapping updated; however, efficiencies may be gained in subsequent actions if a prioritisation exercise occurred for different housing categories, e.g. high risk, medium risk and low risk, and resilience measures put in place.	Low	Medium	High
Co-Benefits:	No immediate co-benefits from the research work however a number of co-benefits may arise from subsequent actions. **Economic:** Cost savings to the region from reduced flood damage and uninsured assets. **Community and Social:** Benefits for those living in social housing or Angus Council-owned properties, as flood disruption is minimised through intervention and vulnerable households are supported.			
Implementation Feasibility:	Initial project is highly feasible and not complex, however subsequent actions and possible integration of resilience measures into properties may be more complex given budget or logistical concerns.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	Once conducted and actions integrated, minor reviews should take place yearly in line with the storm seasonality. More in-depth reviews should take place after majority flood events to highlight benefits of the work, to then be replicated in other locations, and to identify areas for improvement.	Minor review – every year Additional review after major flood events		
Immediate Next Steps:	1) Initial discussion between relevant stakeholders and research to understand benefits and challenges where this have been included within other Local Authorities.			

6. Adaptation options

6.3 Becoming resilient to storms and high winds

Storms and high winds are already causing negative impacts across the Angus region. Strong winds can cause serious damage to properties, greenspaces, they can block roads and damage power and telecommunications lines. Storm Arwen in 2021 demonstrated the impact that high winds and storms can bring. There was widespread disruption to power supplies and transport routes in the area. In addition to the high winds, major flooding was felt on the coast, with damage to major coastal resilience infrastructure along the Angus coastline. High winds brought by severe storms hitting the region cannot be altered or reduced, but measures can be taken to ensure that the region is more resilient to them.

Two adaptation options are recommended which local Angus stakeholders should consider:

AO3: Review the emergency planning and response to vulnerable communities and businesses on the coast and create an action plan strengthening flood and storm resilience.

AO4: Educating business and residents on preparing for storms.

6. Adaptation options

6.3 Becoming resilient to storms and high winds

AO3: Review the emergency planning and response to vulnerable communities and businesses on the coast as part of the development of an action plan strengthening coastal resilience.

The Angus coastline has faced significant coastal erosion. The Dynamic Coasts report[53] found that based on the current rates of erosion, 120 metres of coastline will be lost in the next 40 years, which would result in ~3 metres of coastline lost per year[53].

During Storm Babet in 2023, the beach promenade in Montrose collapsed in high tides and around 2-3 metres of coastline was lost[54]. Montrose Golf Course has already had to adapt and adjust its operations to remove the tees from areas at risk of erosion near the shoreline. Along the coastline of Montrose, dunes have started to erode and therefore no longer function as a natural flood barrier. Sandbags have been used to support the eroding dunes by reinforcing their low points as emergency temporary measures. Similarly, Storm Babet resulted in coastal damage to the coastline at Carnoustie golf course[55]. Despite attempts to slow the rate of erosion by using beach replenishment, dune restoration and hard engineering methods, it is likely that coastal erosion will remain a prominent and expensive risk for Angus Council to manage.

By understanding who is at risk along the coastline – from private households to businesses, Angus Council can develop an emergency response plan for further coastal erosion.

The proposed work should research the following:

- Review and update the current emergency planning for the communities (including private households, businesses and landowners) along the coast who are at risk and vulnerable to coastal erosion, flooding and storm surges
- Create an action plan to strengthen the response to flood and storm resilience

6. Adaptation options

6.3 Becoming resilient to storms and high winds

AO3: Review the emergency planning and response to vulnerable communities and businesses on the coast as part of the development of an action plan strengthening flood and storm resilience.

Angus Council should monitor communities and businesses who are at risk along the coastline. This includes stakeholders such as Montrose and Arbroath Golf Clubs and the Montrose Port Authority, farmers and landowners, and private households along the coast. Angus Council could also work alongside the Scottish Environmental Protection Agency (SEPA) and utilise existing partnerships and links with the Dynamic Coasts research project to ensure that the information is as relevant and up to date as possible.

After identifying those communities in areas most at risk from coastal erosion, Angus Council should create an action plan for coastal flooding, erosion and storms. This involves identifying vulnerable residents along the coastline (for example, elderly residents or those with chronic health conditions or live alone) and tailoring communications during storms and post disaster recovery support for those most vulnerable. In addition, this should involve identifying vulnerable assets along the coastline (e.g., the beach promenade at Montrose) and taking proactive steps to secure assets against further damage. It involve outreach and collaboration with specific stakeholders that are at risk - such as Montrose Golf Club - to understand how Angus Council and other local stakeholders can support businesses along the shoreline. This can include how to take proactive measures before a storm or flood to reduce the damage.

This plan should be updated as findings from the Dynamic Coasts[53] research project develops, and as various hard and soft engineering techniques are installed such as groynes and beach replenishment.

This action plan should be circulated amongst the communities most at risk and updated as the shoreline management changes and as research develops.

Table 10- AO3: Review the emergency planning and response to vulnerable communities and businesses on the coast as part of the development of an action plan strengthening flood and storm resilience.				
Intervention Type:	Research and Emergency Planning			
Hazard Categories:	Coastal Erosion, Storms, Flooding			
Stakeholders:	Angus Council internal stakeholders: Infrastructure & Environment Directorate, Housing & Social Work Directorate External stakeholders: Angus Climate Hub, Dynamic Coasts, SEPA, Communities along the coastline including private households and businesses, Montrose Port Authority			
Implementation Timeframe:	A review of the current response plan would be achievable in the short-term. The creation of a new action plan including liaising the relevant stakeholders should be achievable in the short to medium term depending on staff resourcing and ability to co-ordinate an emergency plan across departments within Angus Council.	Short term < 5years	Medium 5-10yrs	Long >10 years
Cost Indication (Initial Cost/Set-Up Cost):	The review of existing planning and response would low cost, the creation of a new plan to strengthen flood and storm resilience would be more costly as it would involve the coordination of various stakeholders, possibly through workshops or interviews.	£	££	£££
Cost Indication (Ongoing/Maintenance)	Once the plan has been created, the resource and cost to maintain and update the plan would be relatively low.	£	££	£££
Staff Resource Intensity:	Reviewing the current planning and response would be low intensity. However, the creation of a new action plan would require more staff, across various teams, and require Angus Council to reach out to the communities at risk along the coastline.	Low	Medium	High
Co-Benefits:	**Economic:** An action plan will reduce the economic damage from flooding and storms to assets along the coast. Potentially a reduction in insurance costs, encourages investment along the seafront, encourages and supports tourism to the region. **Social**: Improved mental health and wellbeing for the communities living along the coast, community empowerment.			
Implementation Feasibility:	Initial project is highly feasible. The creation of a new action plan will be more complex due to the involvement of multiple stakeholders. However, existing research projects such as Dynamic Coasts will enable Angus Council to utilise existing research and expertise in this space reducing the complexity.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	The action plan should be updated as research into coastal erosion develops. It would also be beneficial to review the action plan after a storm or flood event to assess the effectiveness of the plan.			
Immediate Next Steps:	(1) Review the existing emergency planning and response for the communities along the coast.			

6. Adaptation options

6.3 Becoming resilient to storms and high winds

AO4: Educating business and residents on preparing for storms.

This adaptation option would strengthen the capacity for Angus residents and businesses to prepare for a storm event. The option would involve Angus Council building on their current guidance on best practice to prepare individuals and properties for storms and severe wind[56]. Angus Council should produce simple guidance for residents on key actions they could 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. Figure 13 is an example of some guidance from the American Red Cross; this could be adapted and made applicable to Scotland.

There are already plenty of UK specific resources available including;

- The British Red Cross[50]
- UK Government Guidance[57]
- ReadyScot run by the Scottish Government[58]
- Examples include American Government advice on grab bags[60]


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 13 example of hurricane safety guidance from the USA. Source: American Red Cross[60]

6. Adaptation options

6.3 Becoming resilient to storms and high winds

AO4: Educating business and residents on preparing for storms.

Angus residents will be safer by following advice such as staying indoors, having plans in place for loss of power or communications, and having access to emergency supplies of food or medication. They can also keep their properties safer and more secure by ensuring trees and other vegetation is kept well maintained, bringing indoors or securing items such as bins and outdoor furniture to prevent them becoming wind-blown debris and causing damage to their property or neighbouring properties and vehicles. This could be particularly important for residents near railway lines, as overhead lines can be damaged by loose debris. Typically, guidelines and advice are provided by the Met Office during extreme conditions. Such guidelines can also be altered and made applicable to local businesses. For example, moving waste bins so they do not become storm debris, using window shutters for shop fronts and ensuring emergency supplies are kept on site. Taking such steps will reduce safety risks during the storm event but also help to reduce damage and promote a faster recovery for the region. Angus Council and residents will be able to draw on their recent experience of Storm Arwen in 2021 to better inform how best to prepare for storms in the future.

It is anticipated that there will be some overlap between the flood resilience guidance (AO1) and storm resilience guidance (AO4).

Table 11-AO4: Educating business and residents on preparing for storms.				
Intervention Type:	Educational / guidance			
Hazard Categories:	Storms and high winds			
Stakeholders:	Angus Council internal stakeholders: Infrastructure & Environment Directorate, Policy, Strategy & Engagement Directorate External stakeholders: Angus Climate Hub, Climate Ready Tayside, Scottish Flood Forum, Scottish Enterprise, resident groups			
Implementation Timeframe:	As storms and damage from high winds are such current issues it is suggested that if chosen to be implemented, work begins as soon as possible ready for the next storm season.	Short term < 5years	Medium 5-10yrs	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 guidance has been produced, the costs will be very low, with some costs associated with production of physical leaflets and disruption and costs of using other channels such as social media to ensure the guidance regularly reaches residents especially just prior to and during storm season on a yearly basis.	£	££	£££
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 focused with the communications team and ensuring the information is visible to Angus residents.	Low	Medium	High
Co-Benefits:	**Economic benefits:** Reduction in damage to residential properties and business will have subsequent positive economic effects for the region. Reduced insurance claims. **Health benefits:** Residents understanding better how to stay safe during storms will provide positive impacts on health outcomes during storms. **Biodiversity benefits:** Education on the importance of trees on private property and guidance on correct maintenance will help protect the trees in the region.			
Implementation Feasibility:	This measure is 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 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:	(1) Identify the best team or individuals for this to sit with and appropriate timeframes for the initial research phase.			

6. Adaptation options

6.4 Becoming resilient to extreme heat and drought conditions

As stated previously, extreme heat and drought risk are likely to become more intense and frequent over time. Future extreme heat and drought are therefore likely to have a greater impact on Angus. Heat risks occur across each sector, impacting communities, organisations, infrastructure and nature.

There are various proven solutions that increase resilience to extreme heat, including; using green and blue infrastructure to cool outdoor spaces; 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 and avoid heatstroke.

In 2025, Backwater Reservoir in Angus was half full, after an unusually dry summer, with Scottish Water requesting households reduce their water use[61]. Angus Council already provides drought advice for private abstractors[62].

To adapt to the risk of drought (due to changes in seasonal precipitation levels), proven solutions include reducing household water usage, using water butts to water greenspace in individual households and community gardens and reducing abstraction of water sources.

Due to the increasing risk of wildfires, education around fire safety in rural areas is useful; for example, disposing of BBQs and cigarettes properly, especially in dry grassy areas, providing guidance in leisure hotspots such as along the beach and at campsites. The local fire service could also visit schools, youth groups and other civil society groups to help spread awareness about reducing the risk of wildfires.

Though there are many ways in which Angus Council and local stakeholders can play a key role in building a more heat resilient region, two specific adaptation options have been identified here and will be discussed further. These are:

- **AO5: Cross sectoral approach to set up and run a heat health working group and review of overheating risk within Council-owned buildings and business assets, resulting in the development of a heatwave action plan.**
- **AO6: Cross sectoral approach for stakeholders and landowners to review and refine their own water management plans.**

6. Adaptation options

6.4 Becoming resilient to extreme heat and drought conditions

AO5:Cross sectoral approach to set up and run a heat health working group and review of overheating risk within Council-owned buildings and business assets, resulting in the development of a heatwave action plan.

Provisional Met Office statistics state summer 2025 was the warmest on record[63]. The UK experienced four heatwaves over the Summer of 2025[64]. Heatwaves pose a growing risk for Scotland.

By establishing a heat health working group, Angus Council can work with other stakeholders such as care homes, the local NHS, schools and community groups to increase knowledge sharing and reduce the risk associated with extreme heat. This can include disseminating good health advice such as drinking fluids, not engaging in physical activity, wearing loose flowing garments and following the 'Slip Slap Slop' advice[65]. A heat health working group can also target interventions for the most vulnerable groups including elderly people, people who may have chronic health conditions, and young children, in school and youth groups. Advice could include what to do in the event of heat exhaustion, heatstroke or dehydration.

Though there are formal definitions and specific overheating criteria, overheating generally describes the interior of homes reaching temperatures that are uncomfortable for residents. This is likely to become a wider problem as extreme heat worsens in the future. Overheated homes not only cause discomfort for residents but also cause a lack of sleep and can lead to wider health problems. The fourth National Planning Framework (NPF4) states in Policy 19 the importance of decarbonised solutions for both heating and cooling demand and ensuring adaptation to more extreme temperatures[66].

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 Angus Council's current housing stock can help identify homes most in need of retrofit and specific retrofit measures to maximise effectiveness. In addition, ensuring any new homes and facilitates are designed to minimise overheating and be resilient to increased temperatures and heatwaves.

Some homes are more prone to overheating than others, factors such as age, insulation levels, roof type, orientation and type of home (e.g. flat or terrace) can alter the risk of overheating. This adaptation option involves Angus Council undertaking analysis of its own housing stock and identifying how severe overheating risk is likely to be within the stock in the future and which homes are most at risk due to their characteristics. This can then be taken as lessons learned for other building types, such as hotels and care homes.

6. Adaptation options

6.4 Becoming resilient to extreme heat and drought conditions

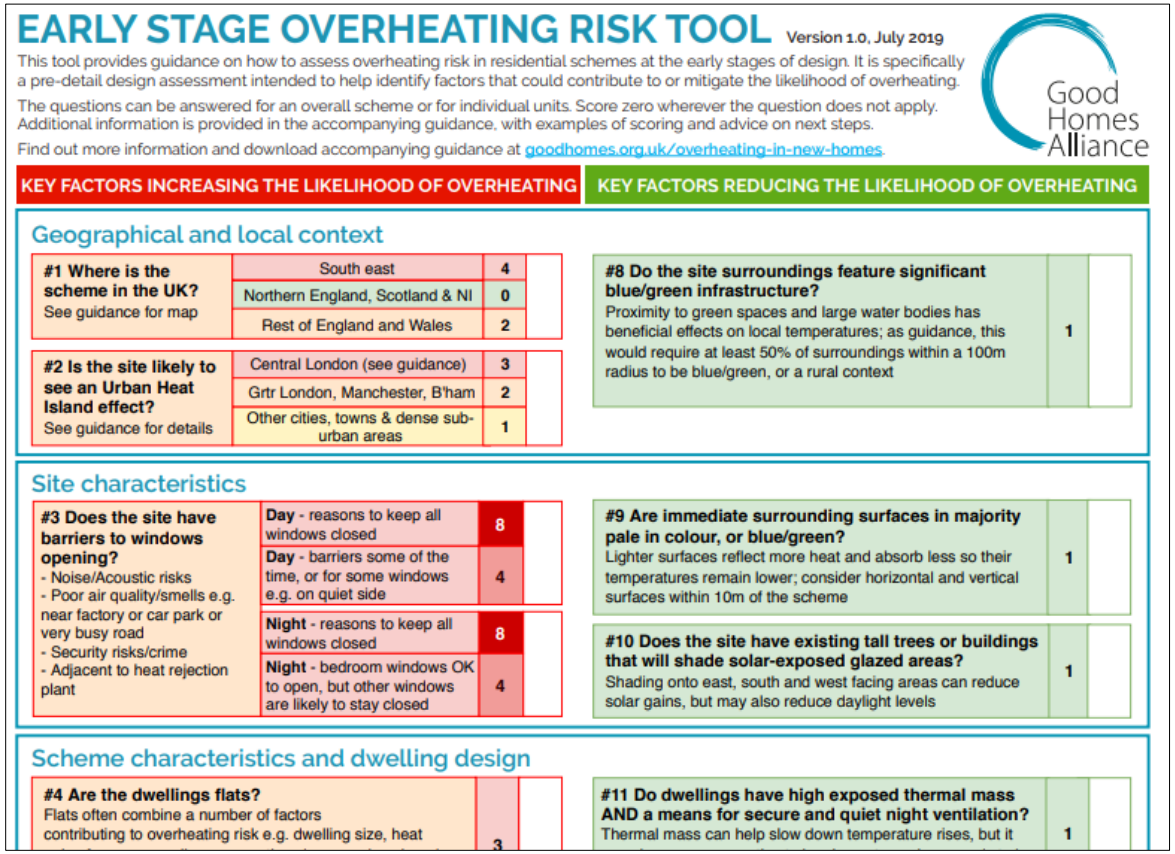
AO5: Cross sectoral approach to set up and run a heat health working group and review of overheating risk within Council-owned buildings and business assets, resulting in the development of a heatwave action plan.

The research could consist of in-depth modelling to understand likely indoor temperatures during future heatwaves, or it can consist of a simpler identification of risk based on risk characteristics present. One example could be using the Good Homes Alliance *Early-stage overheating risk tool*[67] (Figure 14).

From 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 privately owned businesses such as care homes and hotels.



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
	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

#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

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
	Day - barriers some of the time, or for some windows e.g. on quiet side	4
	Night - reasons to keep all windows closed	8
	Night - bedroom windows OK to open, but other windows are likely to stay closed	4

#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

#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

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 14 image of Good Homes Alliance, high level overheating risk tool for houses, Source: Good Homes Alliance[67]

6. Adaptation options

6.4 Becoming resilient to extreme heat and drought conditions

AO5: Cross sectoral approach to set up and run a heat health working group and review of overheating risk within buildings and business assets, resulting in the development of a heatwave action plan

Extreme heat can cause heat related illness, and in some extreme cases cause excess deaths. Increases 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, cooling outdoor and indoor spaces to reduce exposure. However, this adaptation option focuses on more direct interventions. Interventions include examples such as educating people on heat risks and staying safe, protecting vulnerable people 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 with. Therefore, one of the first actions suggested to improve resilience to heat health risks is the formation of a heat health working group in the region.

This working group should help to coordinate an approach to reduce heat health risks in the future across Angus. The group should bring together organisations and individuals across the region that can help increase the resilience of people to heat and foster conversations on the topic and eventually enable action. The group should offer a space where both experts and individuals on the front line can combine knowledge to both enhance understanding of the problem and devise effective Angus-specific action.

There are examples of other Councils working in this space, who Angus Council could work with to share lessons learned and best practice with. Leeds City Council published a 'Heat in the City' report in July 2025[68] and concluded that they need to collaborate with healthcare and third sector partners to implement and disseminate heat health advice, improve access to cool spaces across Leeds and improve community engagement with heat health risks through the creation of an action plan. Other recommendations in the report included ensuring that heat health was included within the planning framework and mapping heat health inequalities in Leeds.

6. Adaptation options

6.4 Becoming resilient to extreme heat and drought conditions

AO5: Cross sectoral approach to set up and run a heat health working group and review of overheating risk within Council-owned buildings and business assets, resulting in the development of a heatwave action plan.

The cross sectoral 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 public on heat health risks and how to manage them, e.g. through heat health guidance in Figure 15.
- Protection of vulnerable people (those with chronic illness, elderly especially living alone and young children) during times of extreme heat.

Working closely with NHS Tayside and other stakeholders such as Ready Scotland[69] will help inform advice material for the region.

Figure 15 shows an example of simple heat health guidance that could be produced and distributed from the UK Health Security Agency[70]

Table 12- AO5: Cross sectoral approach to set up and run a heat health working group and review of overheating risk within Council-owned buildings and business assets, resulting in the development of a heatwave action plan.				
Intervention Type:	Research /Planning and Procedural/Outreach			
Hazard Categories:	Heatwaves and extreme heat			
Stakeholders:	Angus Council internal stakeholders: Infrastructure & Environment Directorate, Policy, Strategy & Engagement Directorate External stakeholders: Angus Climate Hub, Housing associations, NHS Tayside, Care Homes, Police Scotland, Scottish Fire & Rescue, education providers, local charities, academic representatives, Angus Health & Social Care Partnership			
Implementation Timeframe:	Developing a heat health working group can be achieved in the short term within the next 5 years. Extreme heat and overheating of home may not become a significant risk until later in the century, however this should be proactively considered within the medium term.	Short term < 5years	Medium 5-10yrs	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. However, external expertise may be needed to conduct specialist surveys, which may come at a medium cost to assess the housing stock.	£	££	£££
Cost Indication (Ongoing/Maintenance)	**Heat health group:** 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 involve physical changes or additional resources. **Council owned housing:** No ongoing cost after initial research and report. However, this output is likely to recommend next steps which may include retrofitting of houses and so would be a medium to high cost to Angus Council. Other recommendations, such as education of residents, may be lower cost.	£	££	£££
Staff Resource Intensity:	**Heat health group:** Initial establishment would be medium to high intensity to organise stakeholders. This would reduce to low intensity over time. **Council owned housing:** If external expertise were commissioned, intensity for Angus Council staff would be low. If Angus Council staff were to complete the assessments, intensity would be medium for a short period.	Low	Medium	High
Co-Benefits:	**Health:** Significant improvement in health outcomes during heatwaves for the most vulnerable groups. **Decarbonisation:** Recommendations for retrofit are likely to both reduce overheating and reduce energy use within homes.			
Implementation Feasibility:	The initial research into overheating risk is likely to be low complexity, especially if outsourced. However, implementing subsequent recommendations are likely to be more complex. Managing multiple stakeholders in a heat health group is likely to be more complex.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	Lessons learnt and action plan updates after each major heatwave experienced. Formal review of the action plan should take place every 5 years.	Initial research – one off project Action plan – updated every 5 years		
Immediate Next Steps:	**Heat health group:** (1) Identification of internal stakeholders and Council roles within the running of the group. (2) Identification of external stakeholders and initial introduction workshop to gather interest and discuss format/goals of the working group. **Council owned housing:** (1) Identify funding and/or internal expertise and key research questions.			

6. Adaptation options

6.4 Becoming resilient to extreme heat and drought conditions

AO6: Cross sectoral approach for stakeholders and landowners to review and refine their own water management plans.

Climate change projections have 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 more frequent and intense in the region; reducing water consumption will help increase resilience. In 2025, the Angus region experienced water levels reach a critical level after the driest spring since 1964 and a summer heatwave[61]. Backwater Reservoir in Angus was seven metres lower than its expected level for the time of year[61]. In Kirriemuir, the water tank holding the town's water supplies had to be topped up by a water tanker from Scottish Water[61].

This adaptation option proposes that local stakeholders develop water management plans to prepare for periods of drought and water scarcity.

This adaptation option would look at how best to address a period of water scarcity and proactively manage a period of water shortages with Scottish Water and SEPA. This option recommends that stakeholders work together with private abstractors and farmers in Angus to understand their water needs and usage and how to influence businesses in Angus to use less water in times of water scarcity through community engagement.

This advice to organisations and private households in the region will focus on how to reduce their usage of water by using water butts rather than hosepipes to water their garden, take short showers rather than baths and only using household appliances such as washing machines and dishwashers when they are completely full[71]. Other general advice on saving water can be found on Scottish Water's Water is Always Worth Saving page[71]. Scottish Water has a ready-made campaign toolkit on how to encourage water saving habits which Angus business and residents can use to enable behaviour change during a drought or period of water scarcity[71].

Table 13- AO6: Cross sectoral approach for stakeholders and landowners to review and refine their own water management plans.				
Intervention Type:	Governance/policy/ physical actions			
Hazard Categories:	Drought, extreme heat, water scarcity			
Stakeholders:	Angus Council internal stakeholders: Infrastructure & Environment Directorate, Policy, Strategy & Engagement Directorate External stakeholders: Angus Climate Hub, Scottish Water, SEPA, the agricultural sector (e.g., NFU) and private abstractors.			
Implementation Timeframe:	A review of water scarcity should happen in the short term with Scottish Water and SEPA to establish the risks and understand how best to plan for periods of water scarcity. Understanding water usage from the agriculture sector and private abstractors may take longer to complete due to the need to involve multiple stakeholders. Once both actions have been completed, local stakeholders can create a water scarcity adaptation plan in the medium term.	Short term - < 5years	Medium - 5-10yrs	Long - >10 years
Cost Indication (Initial Cost/Set-Up Cost):	Reviewing water scarcity will not be as expensive as the development of a water scarcity plan. The development of the plan will involve collaboration within the agricultural sector and private water abstractors through targeted workshops which will require time and funding.	£	££	£££
Cost Indication (Ongoing/Maintenance)	After the initial cost, maintenance costs are likely to be minimal and involve continuing to proactively liaise with the agriculture and private abstractors to monitor water usage. Updates to the action plan as and when necessary.	£	££	£££
Staff Resource Intensity:	Resource will be anticipated to be medium to high intensity, as multiple stakeholders will be engaged. The creation of an action plan will also need to include a wide range of stakeholders adding to the resource intensity.	Low	Medium	High
Co-Benefits:	**Economic:** Supports the continued growth and development of the agricultural sector within Angus, enabling them to adapt to changes in precipitation levels. **Social:** Behavioural change reduces the amount of water used, which in turn has carbon savings and positive environmental impacts.			
Implementation Feasibility:	Coordinating and organising workshops for the agricultural sector and private abstractors will likely be more complex due to the number of stakeholders. Developing an action plan will also involve working across multiple local stakeholders.	Low Complexity	Medium Complexity	High Complexity
Monitoring and Evaluation – Timeframe for Review:	A good timeframe for review would be once every 5 years post creation of an action plan. The plan could also be reviewed after every drought/ period of water scarcity.	In depth review: every 5 years		
Immediate Next Steps:	Review existing guidance on water scarcity in the Council and begin liaising with SEPA and Scottish Water to understand the water scarcity risk in the Angus region			

6. Adaptation Options

Summary

As per the scope of works, 6 adaptation options have been provided for Angus Council and wider stakeholder consideration. These are:

Changes to precipitation and future flooding

AO1: Angus Council supporting community groups in taking a proactive role in flood resilience.

AO2: Review of flood risk for all buildings and business assets, leading to the creation of an action plan to mitigate the risk.

Changes to the frequency of storms

AO3: Review the emergency planning and response to vulnerable communities and businesses on the coast and create an action plan strengthening flood and storm resilience.

AO4: Educating business and residents on preparing for storms.

Future extreme heat & drought

AO5: Cross sectoral approach to set up and run a heat health working group and review of overheating risk within Council-owned buildings and business assets, resulting in the development of a heatwave action plan.

AO6: Cross sectoral approach for stakeholders and landowners to review and refine their own water management plans.

All six adaptation options have been described with summary tables to highlight the benefits, costs and possible governance choices for each adaptation option for future consideration by stakeholders within Angus.

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7. Conclusions and Next Steps

7.1 Conclusions

7.2 Next steps

7.Conclusions and next steps

7.1 Conclusions

Analysis of the UK's latest climate change projections for Angus has highlighted several 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 region, through both flooding and wind damage. These costs are wide-ranging and include financial costs, disruption to services, life in the region, and nature, as well as impacts on physical and mental wellbeing.

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

Changes to precipitation patterns are likely to increase flood risk within the region. Flooding can have devastating impacts with sometimes irreversible damage and threatens communities, education, health care, cultural heritage and nature. Angus has already experienced the devastation and disruption from flooding and heavy rainfall that was caused by Storm Babet in 2023.

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 and agriculture within the 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 buildings in the region 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 nature, due to the region'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 region which may be detrimental to native or existing nature, or to the agriculture and forestry industries.

7.Conclusions and next steps

7.1 Conclusions (continued)

Further findings from the CCRVA include:

- Storms are also likely to increase in intensity and frequency, though this is less predictable. This can result in flash flood events and damage to assets from both wind and lightning. Storm Arwen in 2021 highlights how storm events can bring widespread disruption to the region.
- Sea level is rising, this is likely to have knock on impacts to the communities situated on the coast, possibly increasing both coastal erosion and coastal flood risk. This is a particular problem for settlements, nature and assets located along the coast. Focus should be on the towns of Carnoustie, Monifieth, Arbroath and Montrose, as well as smaller community hubs.
- 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, which would reduce fuel poverty levels, with 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, a number of diverse adaptation options have been identified which will help the region to 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 Angus Council can work collaboratively with external stakeholders to develop. These adaptation measures are not a complete adaptation action plan and neither address all risks or explore all possible adaptation measures, but rather, can be used as a starting point to identifying and developing further action.

7.Conclusions and next steps

7.2 Next steps

It is intended that this CCRVA commission is the first step in a much wider plan for climate change adaptation in the region. Immediate next steps for this work are recommended as follows:

- Review adaptation options and their suggested next steps in terms of developing adaptation plans for the Angus region.
- Conduct further work on the regional partnerships (e.g. the Tayside Local Resilience Partnership) and use the risk assessment to help further identify regional synergies and priorities. The Adaptation Options also identify several relevant stakeholders to engage with including local flood resilience groups, local businesses and the local health services.
- Use the work on past events such as Storm Arwen in 2021 and Storm Babet in 2023 to help build a robust business case for future action.
- Assess the costing of the next steps recommended in the adaptation options and begin planning for the next steps for the short- and medium-term including costing and resource allocation.

At its heart, the recommendations for future work emphasise the importance of stakeholder collaboration in the region.

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APPENDICES

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A1 – Climate Change Profile Mapping

A1.1 Terminology

A1.2 Climate change profile of Angus – Scenarios and Timescales

A1.3 Methodology

A1.4 Average Winter Daily Minimum Temperature

A1.5 Average Summer Daily Minimum Temperature

A1.6 Average Hottest Temperature

A1.7 Drought Severity Index and Wildfire / Muirburn Extents

A1.8 Days per year with maximum temperature over 25°C

A1.9 Average Daily Precipitation in Summer

A1.10 Average Daily Precipitation in Winter

A1.11 Number of days per year with daily precipitation at or above 20mm/day

A1.12 Sea Level Rise

A1 – Climate Change Profile Mapping

A1.1 Terminology

- **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 A1.1: UKCP18 logo, Source Met Office.

For the scenarios, the following definitions have been used:

- Baseline – baseline data is a historical average between 1980-2010
- 2°C – 2° Celsius warming by the end of 2100 compared to pre-industrial baseline scenario
- 4°C – a 4° Celsius warming by the end of 2100 compared to pre-industrial baseline scenario

Further details are provided overleaf.

A1 – Climate Change Profile Mapping

A1.2 Scenarios and Timescales

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	–

Figure A1.2: Table from Future changes to high impact weather in the UK. Source: Hanlon et al. (2021)[72]

A recent academic paper from Hanlon et al. (2021) suggests that use of the **2°C warming** scenario can be modelled using the **RCP 8.5 emissions** scenario by using the timeframe from **2031-2059. The 4°C-warming scenario** can be modelled by using the **2060-2081.** Further details provided in Figure A1.2.

A1 – Climate Change Profile Mapping

A1.3 Methodology

UK Climate Projections (UKCP18) data is based on the Had UK 12km Grid Area. To provide full coverage of Angus Council's region in coastal areas, the 12km grid has been expanded (Grid IDs 5001-5004) and associated scenario projections calculated using the average values of adjacent cells, as shown in Figure A1.3. Table A1.1 provides further details on the adjacent cells used to expand the analysis. These projected values are used for illustration purposes only and do not represent official forecasts produced by the Met Office Hadley Centre. The following pages provide the map visualisations of the climate data for the climate variables used to identify key hazards relevant to Angus.

Table A1.1: Details of HadUK cells used to expand the projections

Expand Grid ID	Coverage Area	Had UK Cells used to Calculate Projections
5001	Montrose Bay	1870, 1887, 1888
5002	Arbroath	1832, 1850, 1851
5003	Firth of Tay	1816, 1831, 1832
5004	Lunan Bay	1851, 1870

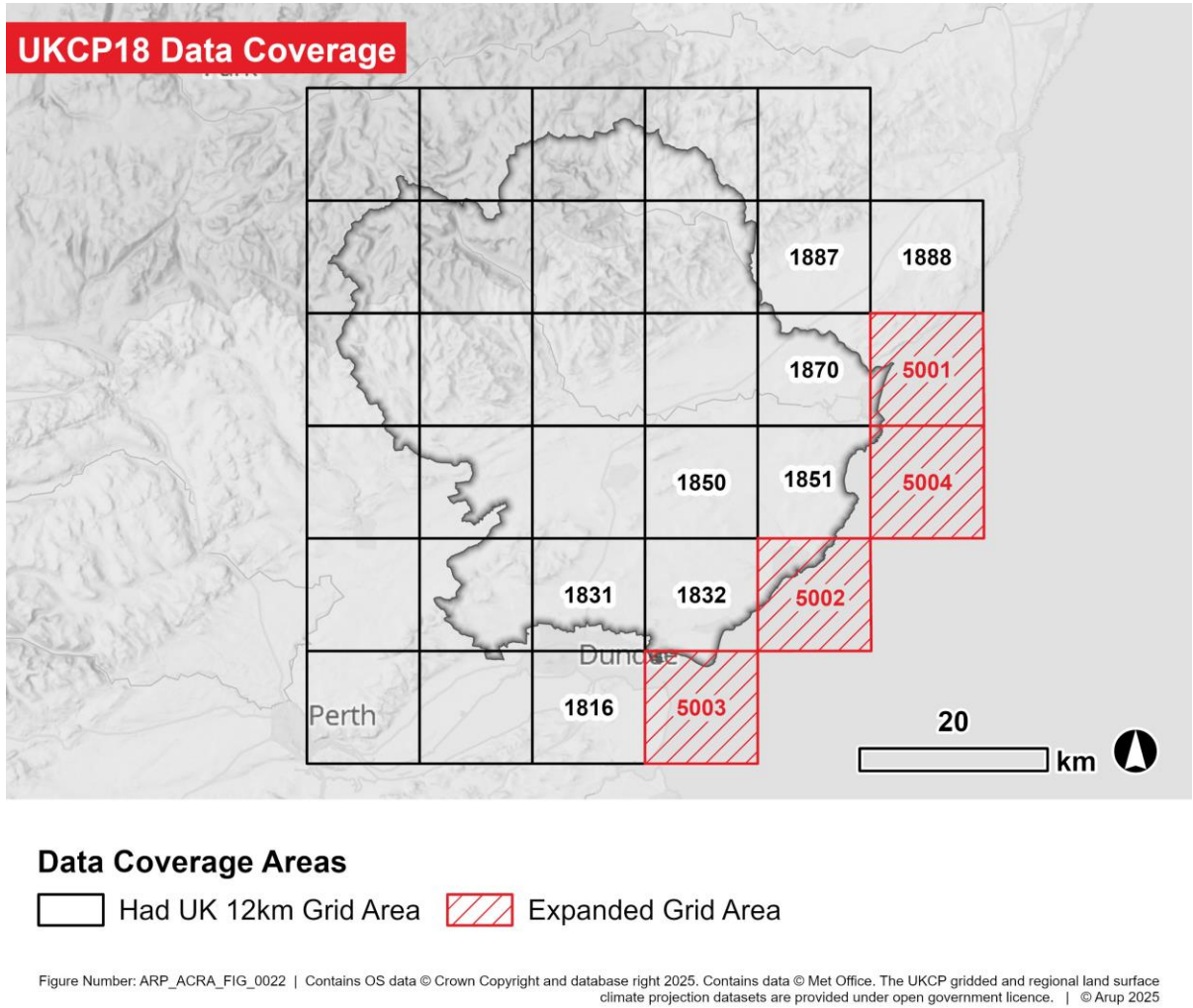
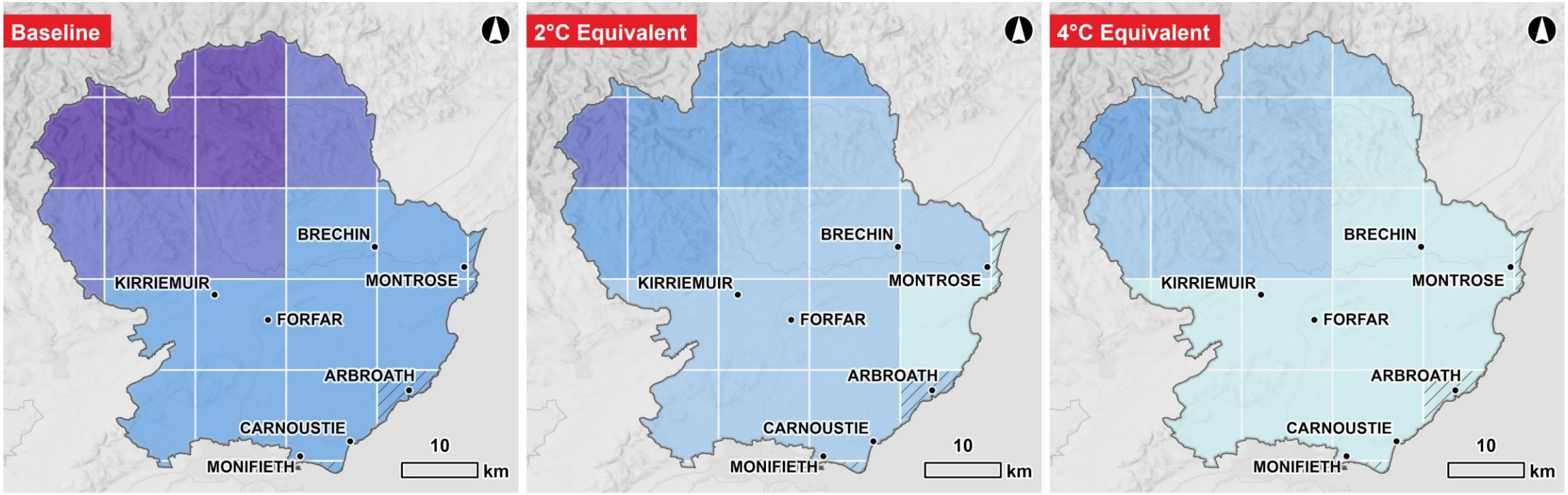


Figure A1.3: The red highlighted areas are the grid cells that have been expanded and data calculated from the adjacent cells to over the full Angus Council boundary.

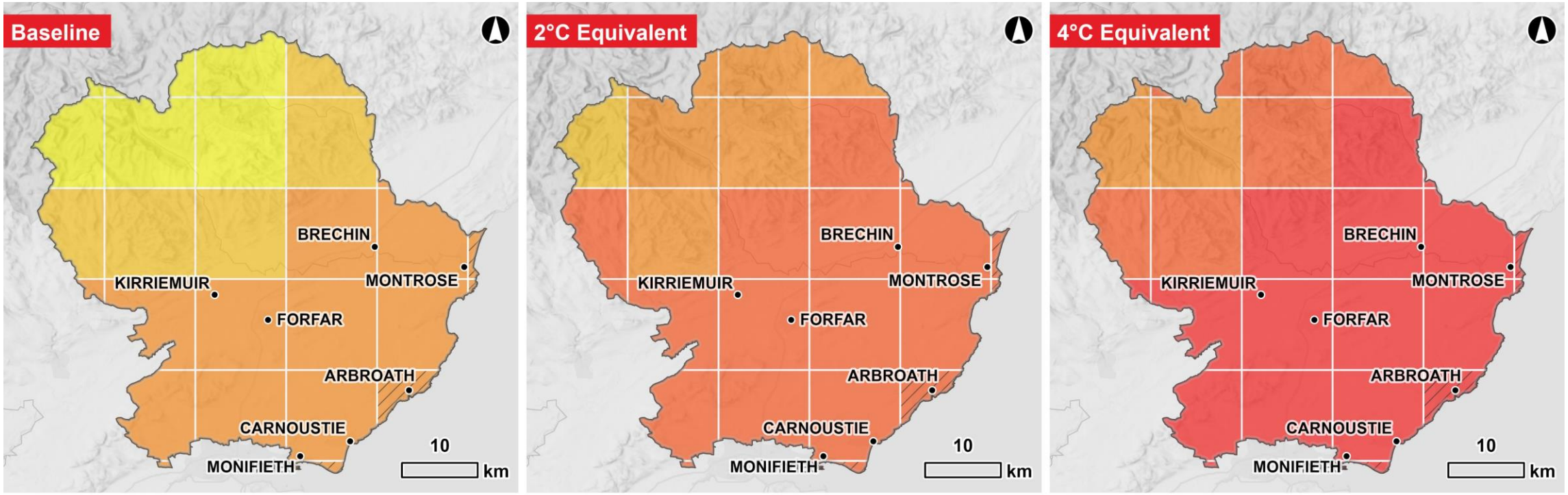
A1 – Climate Change Profile Mapping

A1.4 Average Winter Daily Minimum Temperature



A1 – Climate Change Profile Mapping

A1.5 Average Summer Daily Minimum Temperature

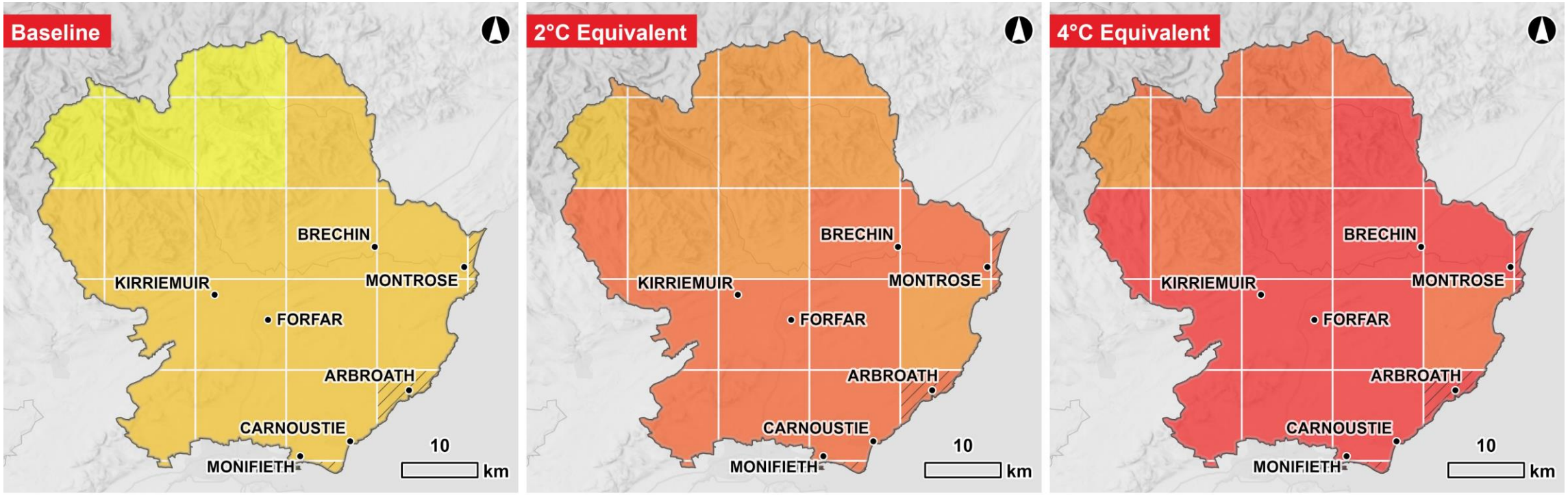


Average Summer Daily Maximum Temperature (°C)

- 13.33°C to 15.31°C
- 15.32°C to 17.29°C
- 17.30°C to 19.26°C
- 19.27°C to 21.24°C
- 21.25°C to 23.21°C
- Had UK 12km Grid
- Expanded Grid Area

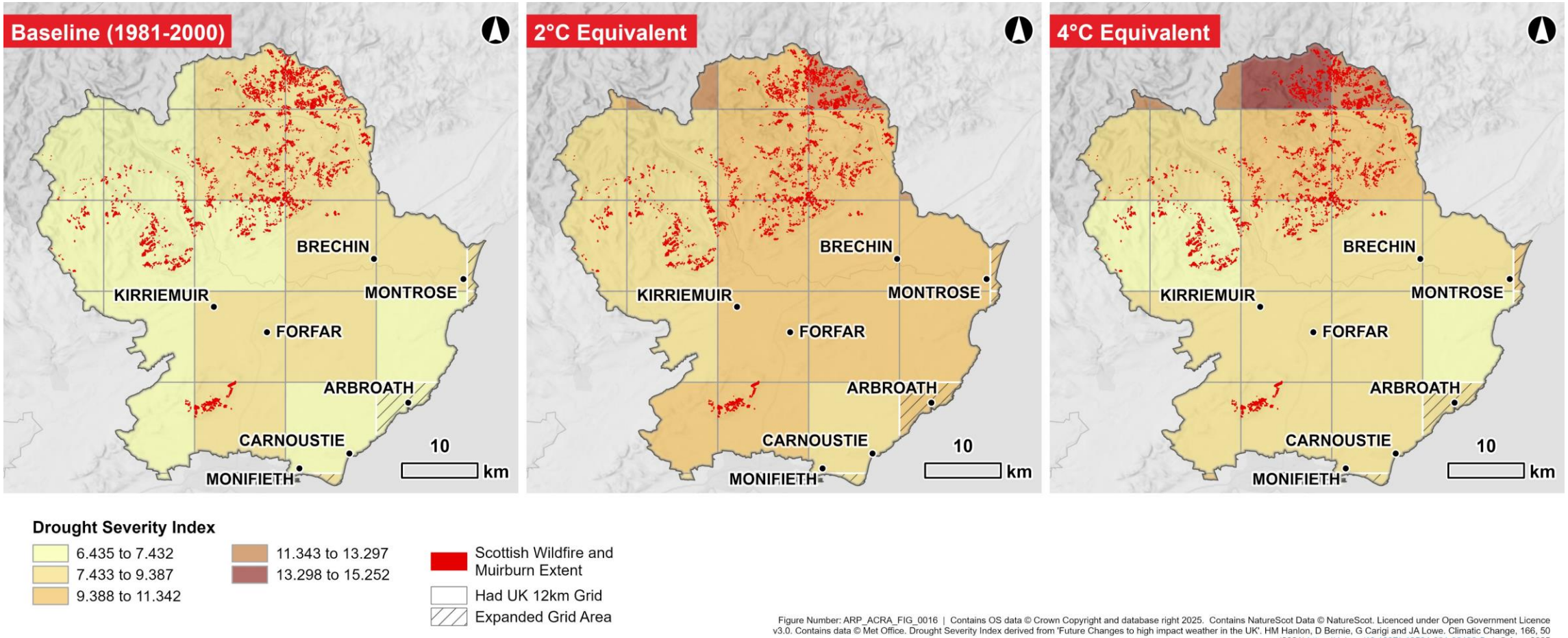
A1 – Climate Change Profile Mapping

A1.6 Average Hottest Temperature in degrees Celsius (°C)



A1 – Climate Change Profile Mapping

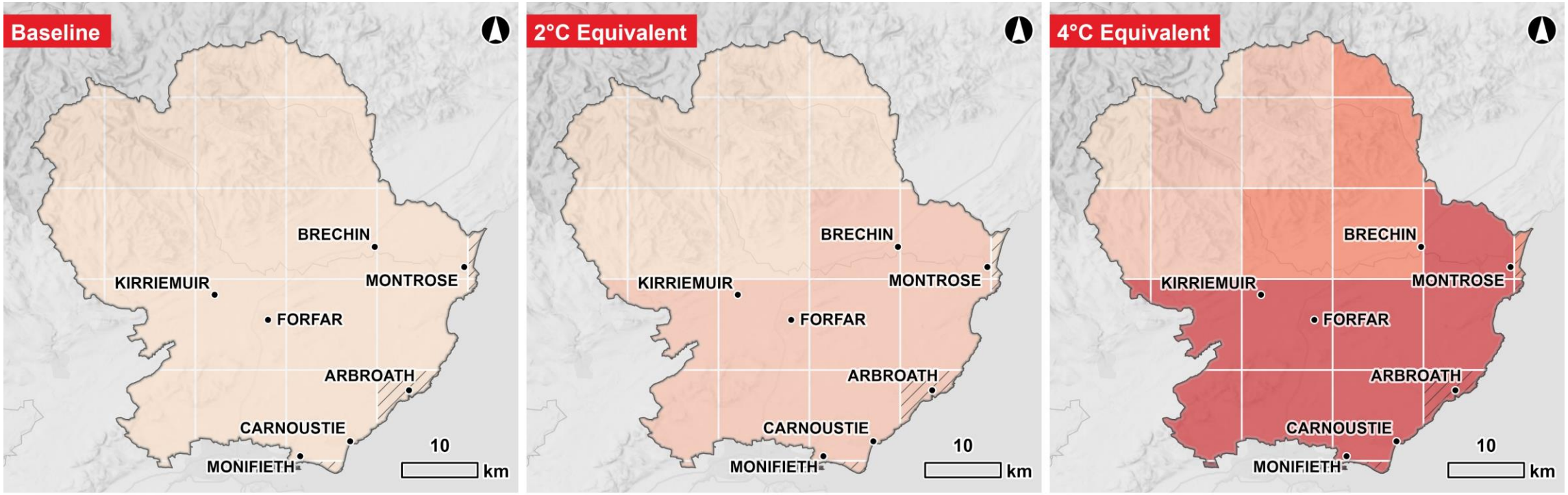
A1.7 Drought Severity Index and Wildfire / Muirburn Extents



Drought Severity Index, 12-Month Accumulations (Projections)

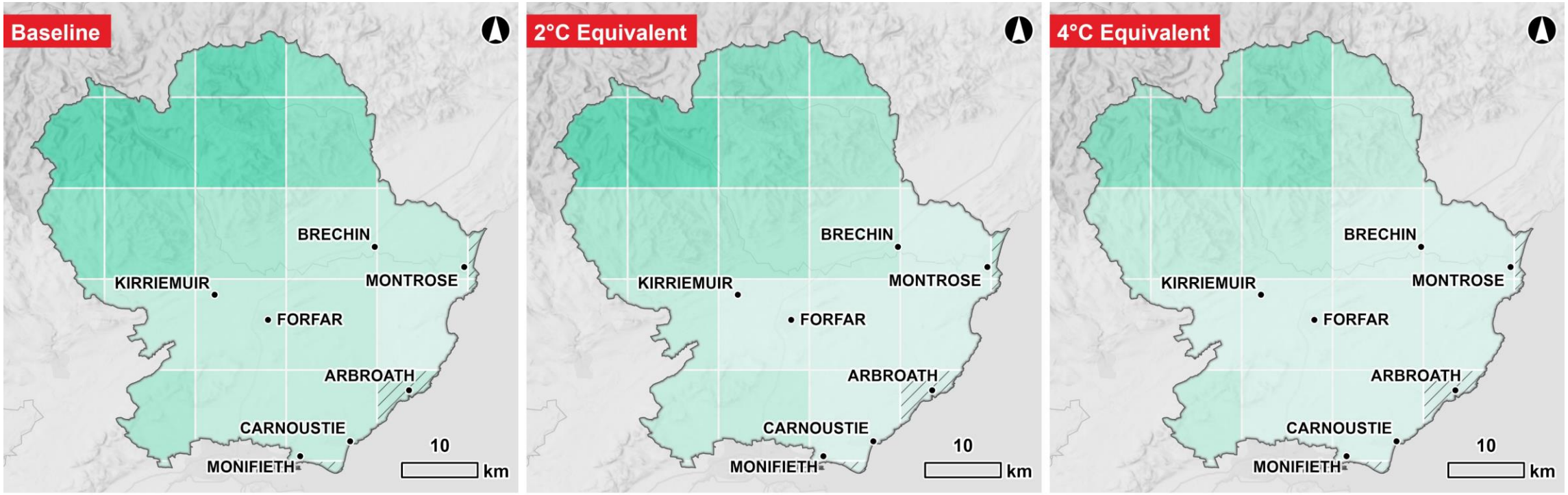
A1 – Climate Change Profile Mapping

A1.8 Days per year with maximum temperature over 25°C



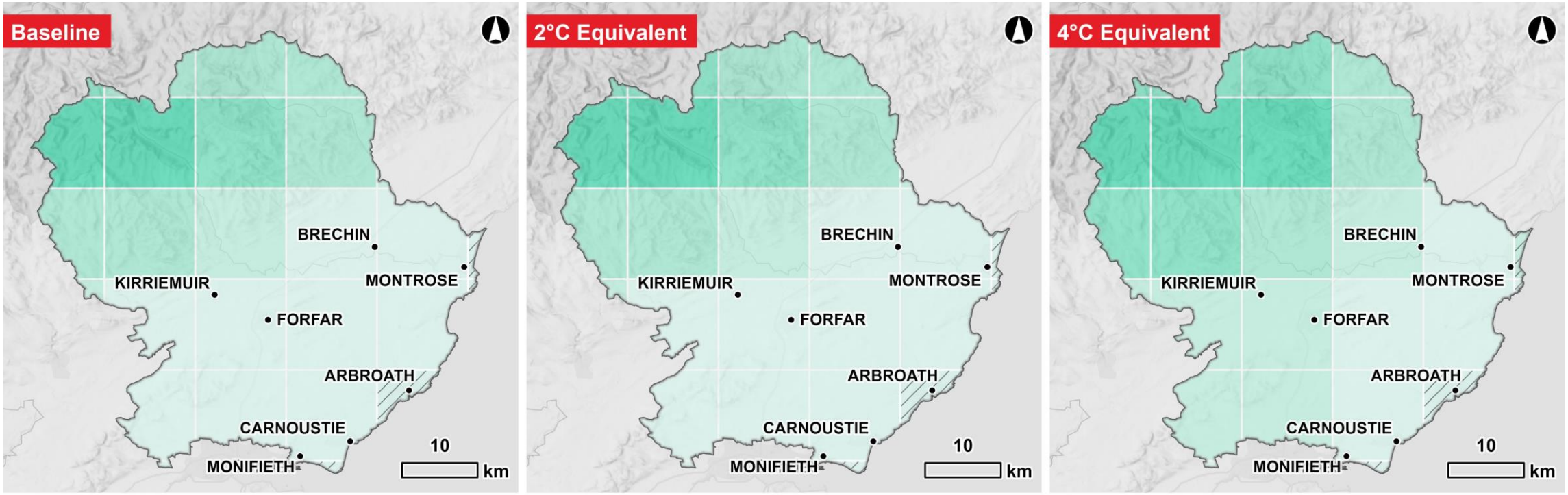
A1 – Climate Change Profile Mapping

A1.9 Average Daily Precipitation in Summer



A1 – Climate Change Profile Mapping

A1.10 Average Daily Precipitation in Winter

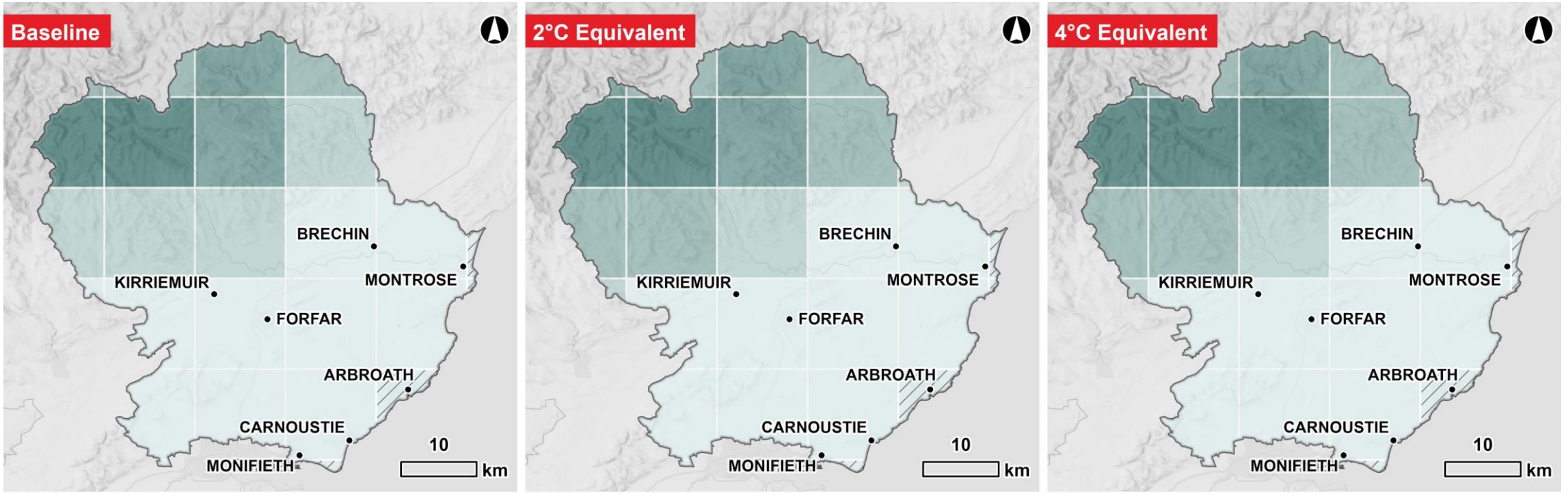


Average Daily Precipitation in Winter (excluding days without precipitation)

- 1.87 to 2.69 mm
- 2.70 to 3.50 mm
- 3.51 to 4.32 mm
- 4.33 to 5.13 mm
- 5.14 to 5.95 mm
- Had UK 12km Grid
- Expanded Grid Area

A1 – Climate Change Profile Mapping

A1.11 Number of days per year with daily precipitation at or above 20mm/day



A1 – Climate Change Profile Mapping

A1.12 Sea Level Rise along the Angus Coast

Table A1.2: Details of coastal grid cells applicable to the Angus coast

Grid cell	**2043** (2°C eq) m above sea level	**2081** (4°C eq) m above sea level
Cell A	0.158	0.412
Cell B	0.157	0.411
Cell C	0.155	0.407
Cell D	0.157	0.411
Average	0.157	0.410

Figures in Table A1.2 are presented as meters above sea level. Grid cells as provided in Table A1.2 are visualised in Figure A1.12. Sea level is taken to be the mean sea level for a baseline period of 1981-2000.

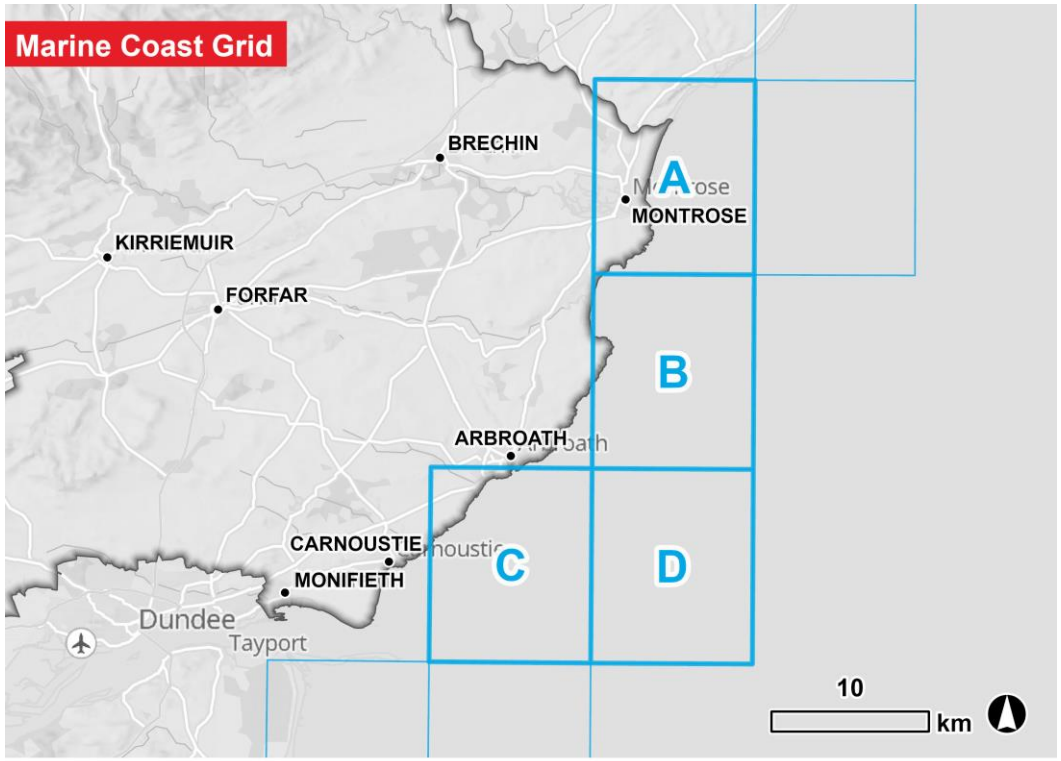


Figure A1.12: The blue highlighted areas are the grid cells that have been used to calculate the sea level rise projected along the Angus coastal boundary.

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A2 – Mapping Vulnerability within Angus

A2.1 Introduction

A2.2 Social Vulnerability to Flooding – Monifeith

A2.3 Social Vulnerability to Flooding – Carnoustie

A2.4 Social Vulnerability to Flooding – Kirriemuir

A2.5 Social Vulnerability to Flooding – Forfar

A2.6 Social Vulnerability to Flooding – Brechin

A2.7 Social Vulnerability to Flooding – Arbroath

A2.8 Social Vulnerability to Flooding – Montrose

A2 – Social Vulnerability to Flooding

A2.1 Introduction

While most of Angus is below the national average risk of surface water flooding, small pockets of Angus are at an increased risk of flooding; For example, Edzell and larger settlements such as Forfar, Brechin, Montrose and Kirriemuir (Figure A2.1 for an overview of the whole Angus region). This is only exacerbated under the 2ºC and 4ºC warming scenarios.

Most of Angus is below the UK average risk for river and coastal flooding. Smaller sections of Angus are at a low to high risk of river and coastal flooding. This risk is primarily concentrated around larger settlements.

The following pages contain more detailed maps demonstrating the risk of surface water, river and coastal flooding to larger settlements in Angus, against the Scottish Index of Multiple Deprivation to highlight where the areas of highest deprivation overlap with the areas of flooding risk.

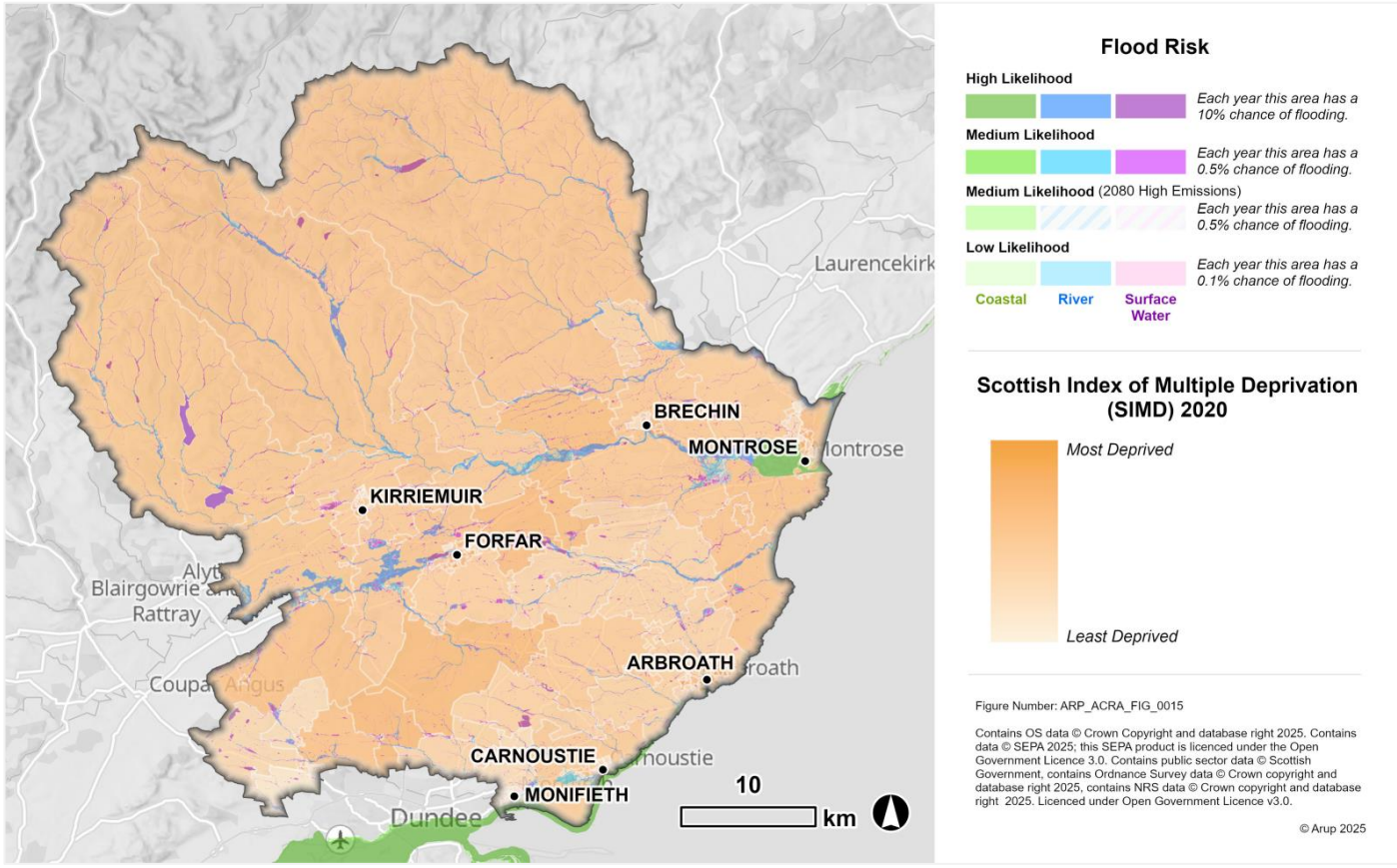

Figure A2.1: Angus flooding vulnerability for the full local authority boundary.

ARUP

A2 – Social Vulnerability to Flooding

A2.2 Monifeith

Social Vulnerability has been mapped for Monifeith by overlaying SEPA flooding data for surface water, river and coastal flooding with the SIMD data in the town. As a result, the most vulnerable areas are those around the train station, Tayview Caravan Park and the golf club.

For each type of flood risk:

- Surface water flooding risks are highest to the North East of the town
- River flooding risks are highest along the Buddon Burn to the East of the town, near the Monifieth Golf Links
- Coastal flooding risks are highest along the coast and likely to impact the Tayview and Riverview Caravan Parks

It is important to note that Monifieth currently lacks a formal flood protection scheme, which may exacerbate vulnerability under future climate change scenarios. Further details are visualized in Figure A2.2 overleaf.

A2 – Social Vulnerability to Flooding

Figure A2.2 Monifieth

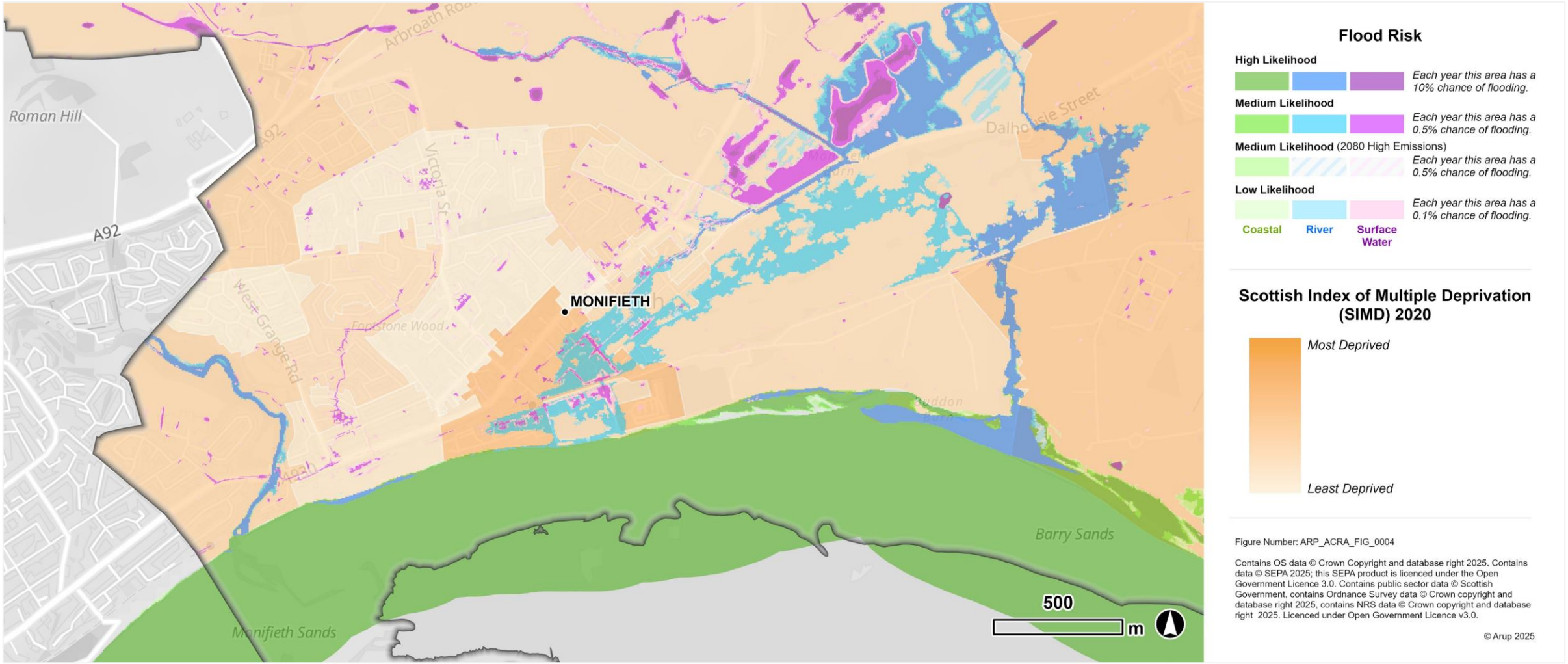

Figure Number: ARP_ACRA_FIG_0004

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A2 – Social Vulnerability to Flooding

A2.3 Carnoustie

Social Vulnerability has been mapped for Carnoustie by overlaying SEPA flooding data for surface water, river and coastal flooding with the SIMD data in the town. As a result, the most vulnerable areas are those in the west of the town, around the Golf Street train station, Carnoustie Golf Hotel and Spa and areas on the banks of the Barry Burn.

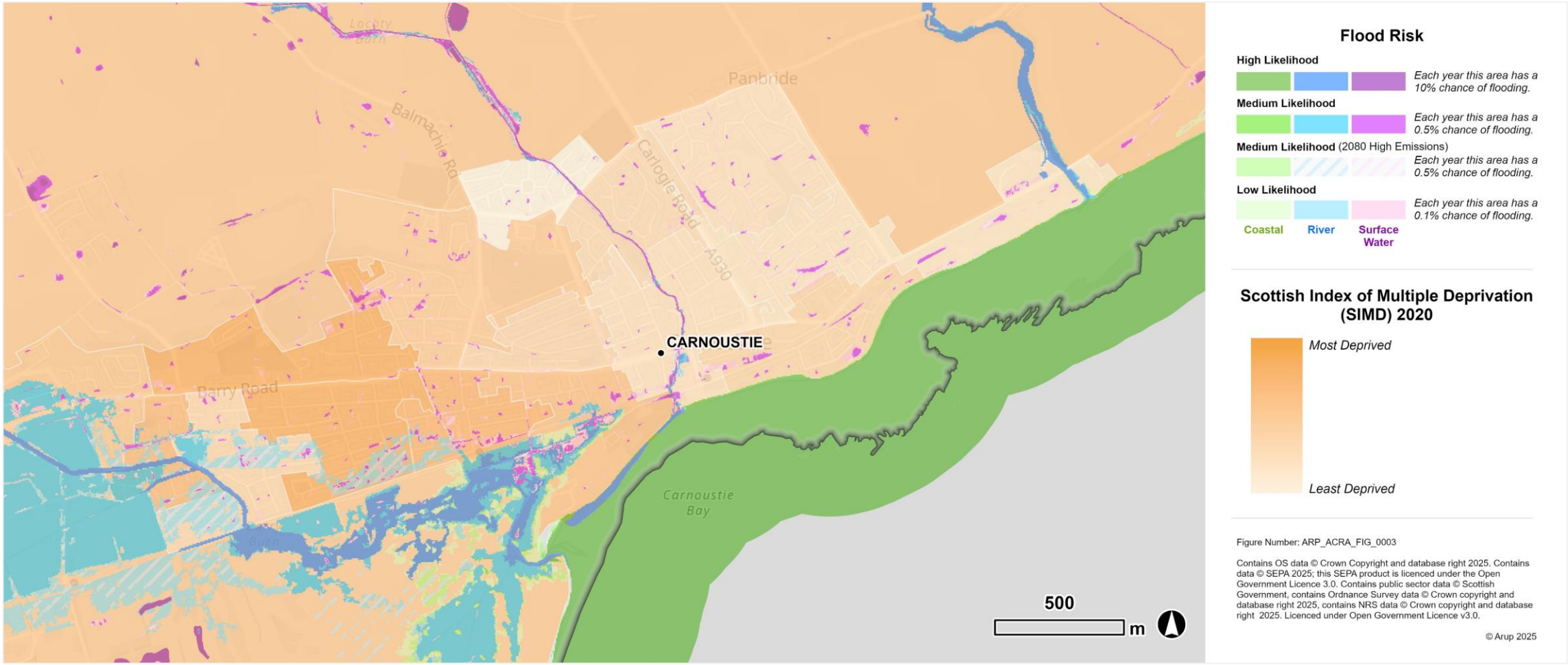
For each type of flood risk:

- Surface water flooding risks are highest to the east of the town, along the banks of the Lochty Burn
- River flooding risks are highest along Taymouth Street, west of the town, near the Carnoustie Golf Links
- Coastal flooding risks are highest in Carnoustie Bay and likely to impact Carnoustie train station, Carnoustie Leisure Centre and other businesses along the Links Parade.

It is important to note that Carnoustie has a formal flood protection scheme, however it is important to review this in future years for any exacerbation of vulnerability under future climate change scenarios. Further details are visualized in Figure A2.3 overleaf.

A2 – Social Vulnerability to Flooding

Figure A2.3 Carnoustie



ARUP

A2 – Social Vulnerability to Flooding

A2.4 Kirriemuir

Social Vulnerability has been mapped for Kirriemuir by overlaying SEPA flooding data for surface water, river and coastal flooding with the SIMD data in the town. As a result, the most vulnerable areas are those in the centre of the town, around Webster's Sport Centre, along Bellies Brae and areas on the banks of the Gairie Burn.

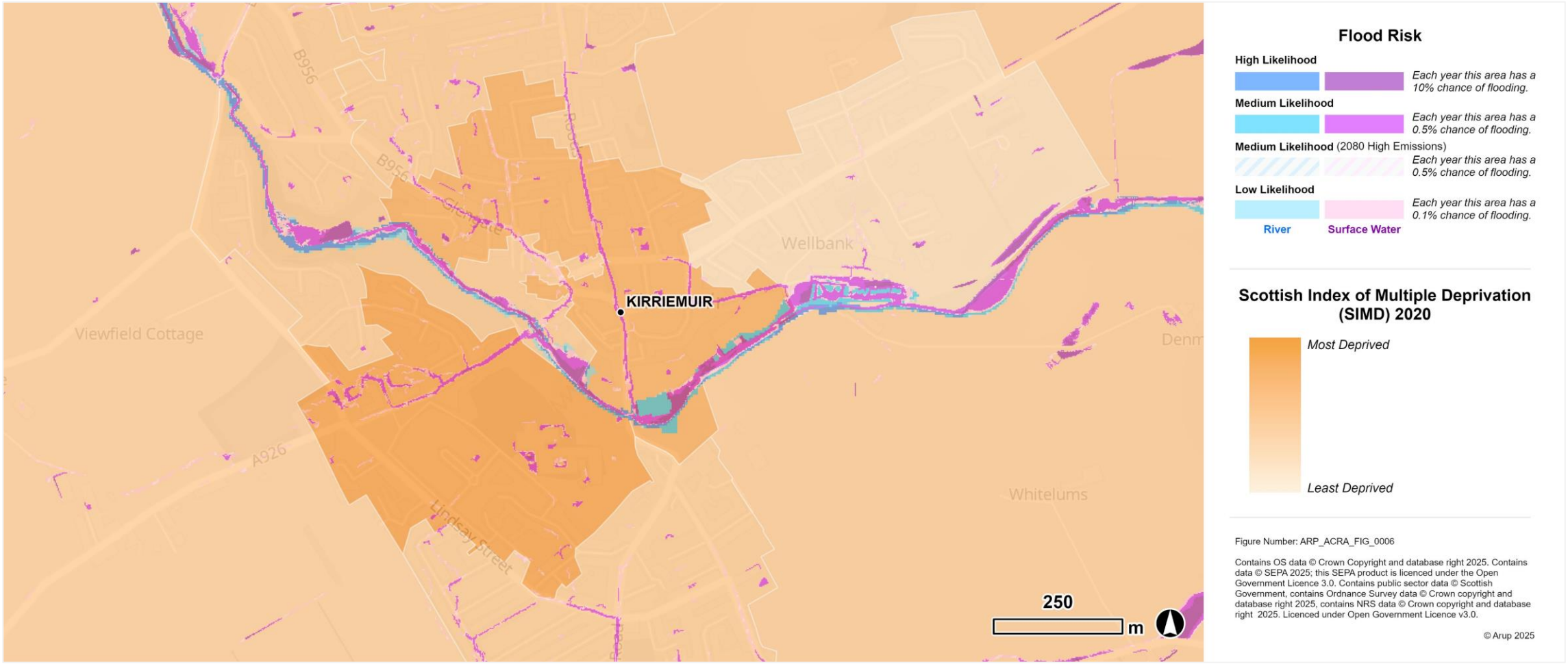
For each type of flood risk:

- Surface water flooding risks are highest along the banks of the Gairie Burn and are likely to impact areas around the Kirriemuire Health Centre and Gairie Factory buildings
- River flooding risks are highest to the south and east of the town, impacting the Gairie Factory buildings, and the residential area along Whitelums Road and Marywell Gardens.
- Due to Kirriemuir's location, coastal flooding is not applicable to the town.

Further details are visualized in Figure A2.4 overleaf.

A2 – Social Vulnerability to Flooding

Figure A2.4 Kirriemuir



ARUP

A2 – Social Vulnerability to Flooding

A2.5 Forfar

Social Vulnerability has been mapped for Forfar by overlaying SEPA flooding data for surface water, river and coastal flooding with the SIMD data in the town. As a result, the most vulnerable areas are those in the centre of the town, around Forfar Town and County Hall, Forfar Community Fire Station and the residential areas around Lilybank Resource Centre.

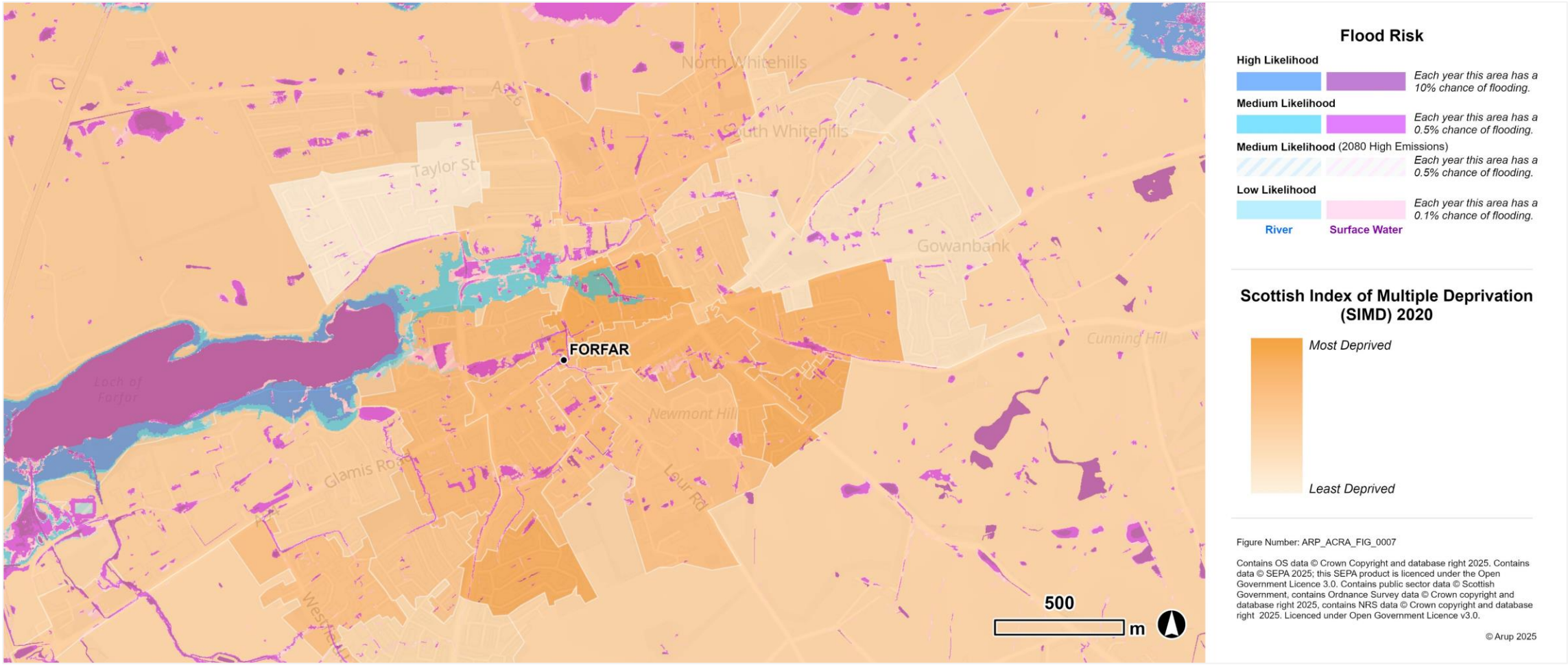
For each type of flood risk:

- Surface water flooding risks are highest to the west of the town, around the service station that links onto the A90. In addition, other pockets of surface water flooding can be found throughout the town such as around the Forfar Lochside Caravan and Motorhome Club Campsite, Myre Road and Myre Car Park, and along Arbroath Road.
- River flooding risks are highest around Forfar Loch and are likely to impact the Scottish Water treatment plant off Orchard Loan and other organisations such as the Strathmore Cricket and Rugby Football Clubs.
- Due to Forfar's location, coastal flooding is not applicable to the town.

Further details are visualized in Figure A2.5 overleaf.

A2 – Social Vulnerability to Flooding

Figure A2.5 Forfar



A2 – Social Vulnerability to Flooding

A2.6 Brechin

Social Vulnerability has been mapped for Brechin by overlaying SEPA flooding data for surface water, river and coastal flooding with the SIMD data in the town. As a result, the most vulnerable areas are those in the south of the town, around River Street and the East Mill Road Caravan Site.

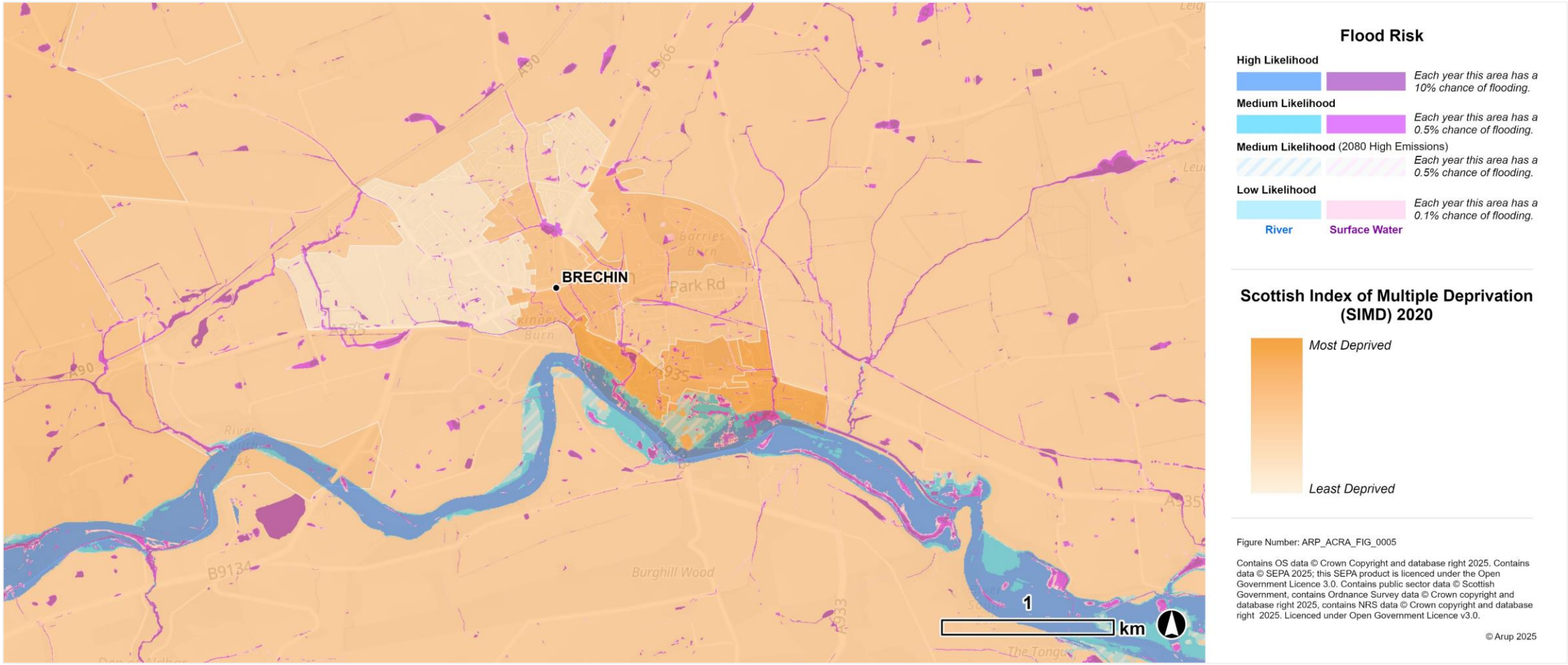
For each type of flood risk:

- There are pockets of surface water flooding risks throughout the town, specifically near Trinity Road and Brechin City Football Club. In addition, surface water risk exists along Witchden Road, and East Mill Road impacting areas of the Inch Park and warehouses of AJ Allan (Potato Merchants) Limited.
- River flooding risks are concentrated around the River South Esk. Landmarks such as the Brechin Walled Garden and Tearoom, Brechin Castle and Brechin Cathedral are likely to be affected.
- As in Forfar, a Scottish Water treatment works will likely be impacted by both surface water and river flooding due to it's location to the River South Est and the A935.
- Due to Brechin's location, coastal flooding is not applicable to the town.

It is important to note that Brechin has a formal flood protection scheme, however due to the impact that Storm Babet had on the town, it is important to review this in future years for any exacerbation of vulnerability under future climate change scenarios. Further details are visualized in Figure A2.6 overleaf.

A2 – Social Vulnerability to Flooding

Figure A2.6 Brechin



ARUP

A2 – Social Vulnerability to Flooding

A2.7 Arbroath

Social Vulnerability has been mapped for Arbroath by overlaying SEPA flooding data for surface water, river and coastal flooding with the SIMD data in the town. As a result, the most vulnerable areas are those in the centre of the town, following Ladyloan and Burnside Drive.

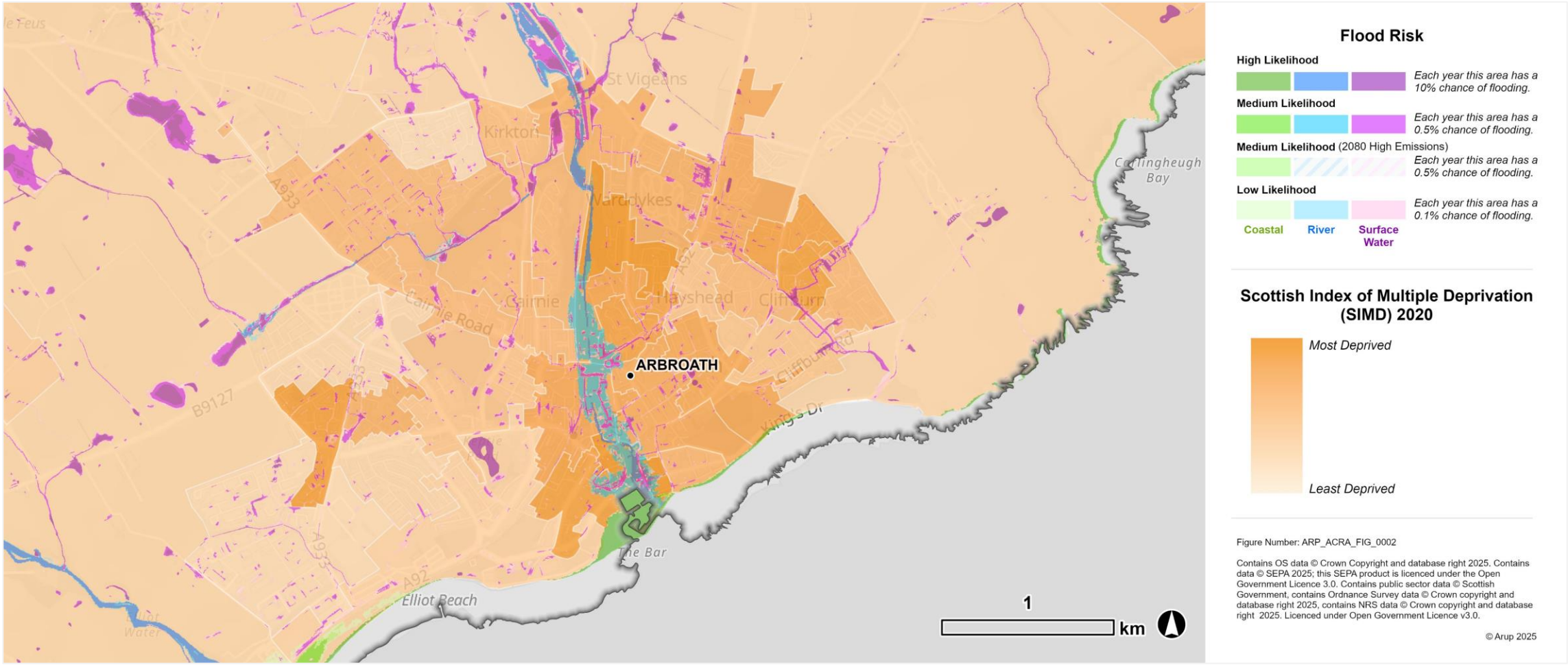
For each type of flood risk:

- Surface water flooding risks are highest to the north of the town, along the banks of the Brothock Water and St Vigeans Brae. It is possible the St Vigeans Stones and Museum, run by Historic Environment Scotland, may be impacted by this. In addition, the railway line is also shown to be impacted.
- River flooding risks are highest along Burnside Drive. Important transport links such as Arbroath bus and train station are likely to be affected. Businesses in the Abbeygate Centre and the Police Station may be impacted by both surface water and river flooding.
- Coastal flooding risks are highest in Arbroath Peir and King's Drive. It is likely that the Signal Tower Museum will be affected by coastal flooding.

It is important to note that Arbroath has a formal flood protection scheme, however it is important to review this in future years for any exacerbation of vulnerability under future climate change scenarios. Further details are visualized in Figure A2.7 overleaf.

A2 – Social Vulnerability to Flooding

Figure A2.7 Arbroath



A2 – Social Vulnerability to Flooding

A2.8 Montrose

Social Vulnerability has been mapped for Montrose by overlaying SEPA flooding data for surface water, river and coastal flooding with the SIMD data in the town. As a result, the most vulnerable areas are those in the south of the town, around the harbour.

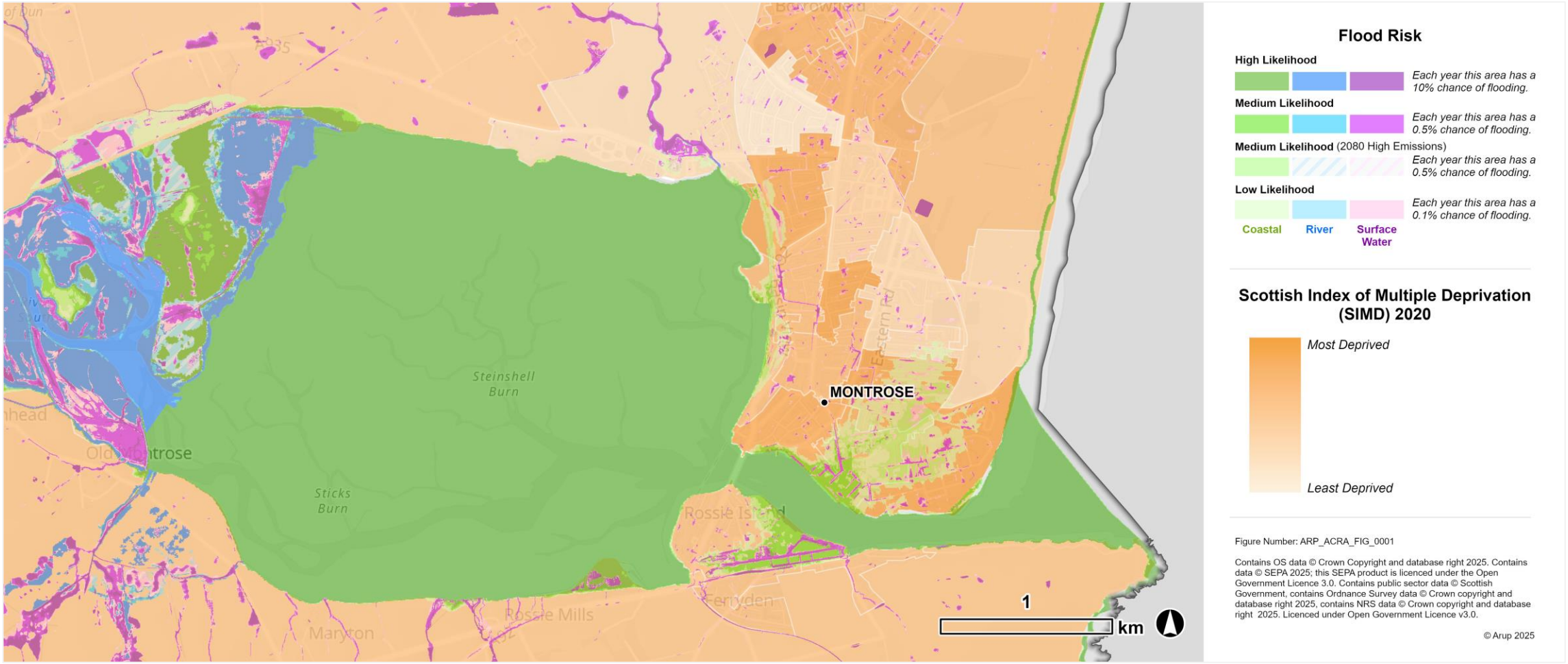
For each type of flood risk:

- Surface water flooding risks are highest to the north of the town, along Brechin Road. Also, there is surface water flooding risk south of the town on Inchbraoch, Braoch Road and Ferry Street.
- River flooding risks are highest to the west of the town, in the area of Old Montrose to the west of Montrose Bay. There aren't many river flooding risks in the town.
- Coastal flooding risks are highest in Montrose Port. Other areas impacted include the area around the train station, and River Street. In addition, coastal flooding risks may be felt as far in land as Montrose Sports Centre, Melville Gardens and the Links Health Centre.

It is important to note that Montrose does not have a formal flood protection scheme. It is important to review this in future years for any vulnerability of the town under future climate change scenarios. Further details are visualized in Figure A2.8 overleaf.

A2 – Social Vulnerability to Flooding

Figure A2.8 Montrose



ARUP

A3 – Climate Change Risk Assessment Methodology

A3.1 Introduction

A3.2 Likelihood criteria

A3.3 Impact criteria

A3.4 Risk Matrix

ARUP

A3 – Climate Change Risk Assessment Methodology

A3.1 Introduction

This section of the appendices provides details and definitions used within the scoring of the assessment.

ARUP

A3 – Climate Change Risk Assessment Methodology

A3.2 Likelihood Criteria

The likelihood of a risk occurring is rated almost impossible to almost certain. The likelihood criteria used within the assessment is provided in Table A3.1.

Table A3.1: Details of likelihood definitions

Level of Likelihood	Definition of Likelihood
Almost impossible	Difficult to see how this could occur. Has happened very rarely before or never. Is a highly unlikely climate scenario, even at the extremes of climate projections.
Unlikely	Do not expect occurrence but it is possible. Less than 10% chance of occurrence May have happened in the past; unlikely to happen in the next three years
Possible	May occur occasionally. Only likely to happen once in 3 or more years Has happened in the past; reasonable possibility it will happen as part of climate change scenarios
Likely	Will occur persistently but is not an everyday occurrence. Likely to happen at some point within the next 1-2 years Circumstances occasionally encountered within likely climate change scenarios
Almost certain	High probability of situation occurring Regular occurrence, Circumstances frequently encountered, daily/weekly/monthly/seasonally

ARUP

A3 – Climate Change Risk Assessment Methodology

A3.3 Consequence Criteria

The consequence of a risk occurring is rated Insignificant to Catastrophic. The impact criteria used within the assessment is provided in Table A3.1.

Table A3.1: Details of likelihood definitions

Impact Rating	Health	Impact on life in the region	Service delivery	Economic	Environment	Reputation
Insignificant	minor injury, basic first aid required, 1 person affected, no days absence, no delay	insignificant disruption to community services, including transport services and infrastructure	no service disruption, unlikely to cause complaint or instigate litigation	none/minimal financial burden (less than £100, can be resolved at local service / department level), minor interruption to income generation, no permanent loss	insignificant impact on environment	organisation(s) reputati on remains intact
Minor	non-permanent harm, short-term injury, resulting in absence of up to 3 days. 1 – 2 persons affected	minor localised disruption to community services or infrastructure less than 24 hours	minor service disruption, complaint possible, litigation unlikely	minimal financial burden or disruption to income generation (less than £1,000 but greater than £100). Can be resolved at line manager/ service manager level through usual budgetary measures	minor impact on environment with no lasting effects	minimal impact on organisation(s) reputation
Moderate	causing semi-permanent disability, injury, disease or harm which could interrupt attendance at work for 3-28 days AND/OR affects 3 - 50 people	damage that is confined to a specific location, or to a number of locations, but requires additional resources. Localised disruption to infrastructure and community services	moderate service disruption. High potential for complaints, litigation possible, but not certain	moderate financial burden (less than £100,000 but greater than £1,000). Interruption to income generation lasting less than 14 days, majority of income recoverable but at additional cost	limited impact on environment with short-term or long-term effects	moderate impact on organisation(s) reputation
Major	causing death, permanent disability, serious injury or harm, e.g. loss of function or body part(s), serious disability, single death of any person. 51-200 people affected. And/ Or Long term absence from work (28-84 days), extended medical attention required, e.g. up to a month in hospital	significant damage that impacts on and possible breakdown of some local community services. Requires support for local responders with external resources	service closure for 1-7 days, complaints expected, litigation expected	major financial burden (less than £500,000 but greater than £100,000). Can include significant extra clean up and recovery costs.	significant impact on environment with medium to long term effects	major impact on organisation (s) reputation / National adverse publicity
Catastrophic	multiple deaths involving any persons, greater than 200 people affected, And/ Or more than 84 days absence, more than 30 days extended	extensive damage to properties and built environment in affected areas. General & widespread displacement of more than 500 people for prolonged duration. Community unable to function without significant support	service closure for more than 7 days or closure of multiple services, complaints certain, litigation certain	catastrophic financial burden (greater than £500,000). Extensive clean up and recovery costs	serious long-term impact on environment and/or permanent change.	catastrophic impact on organisation(s) reputation. International adverse publicity

ARUP

A3 – Climate Change Risk Assessment Methodology

A3.4 Risk Matrix

The likelihood of a risk occurring is rated almost impossible to almost certain. The likelihood criteria used within the assessment is provided in Table A3.1.

Table A3.3: Details of the risk matrix

	Impact				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost impossible	Low	Low	Medium	Medium	Medium
Unlikely	Low	Medium	Medium	High	High
Possible	Low	Medium	High	High	Very High
Likely	Medium	High	High	Very High	Very High
Almost certain	Medium	High	Very High	Very High	Very High

ARUP

A4 – Climate Change Risk and Vulnerability Assessment Summaries

A4.1 Introduction

A4.2 Built Environment

A4.3 Health & Wellbeing

A4.4 Economy

A4.5 Infrastructure

A4.6 Land, Nature & Food

ARUP

A4 – Climate Change Risk and Vulnerability Assessment Summaries

A4.1 Introduction

This section of the appendices provides the summary of the rapid risk heat maps for each sectors as per the CCRA4 categories.

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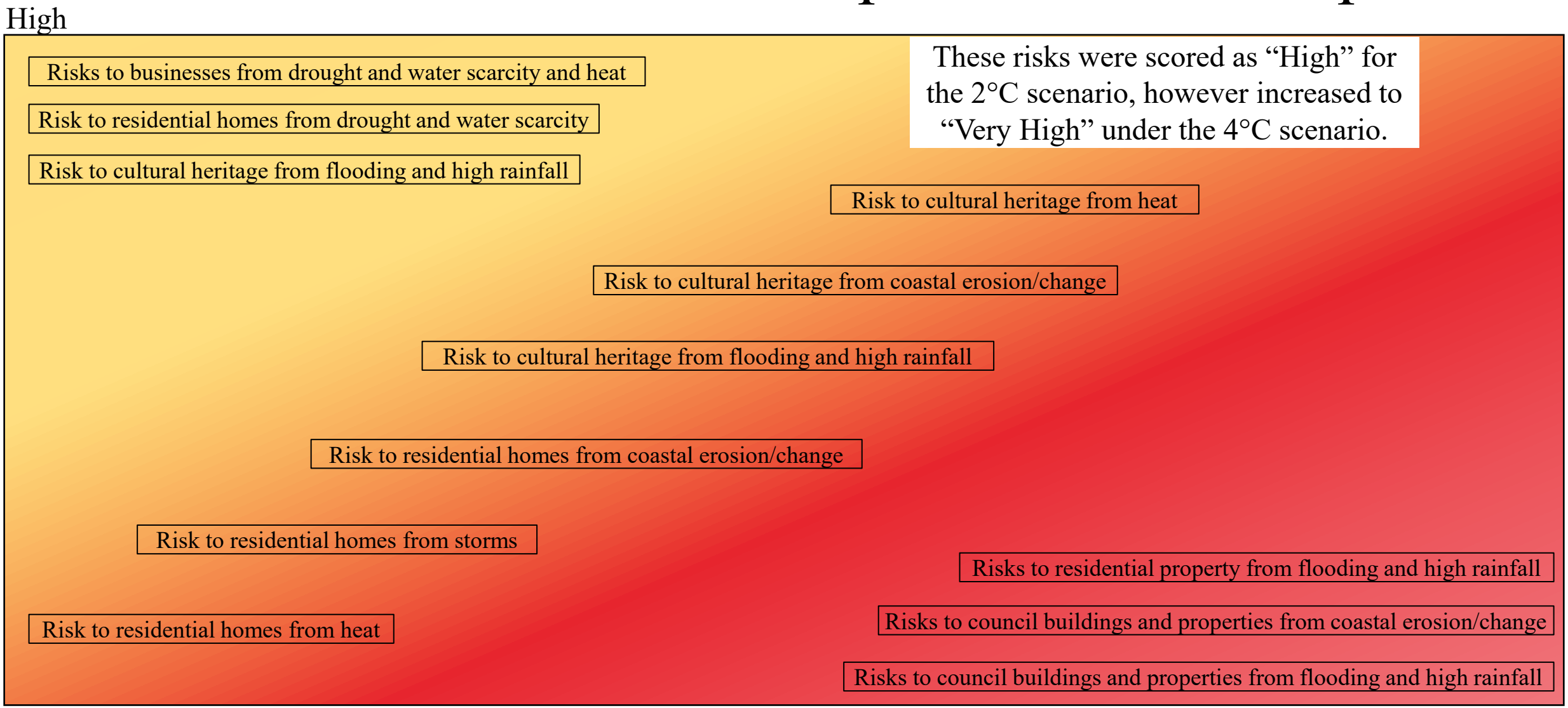
A4.2 Built Environment – Rapid Heat Risk Map

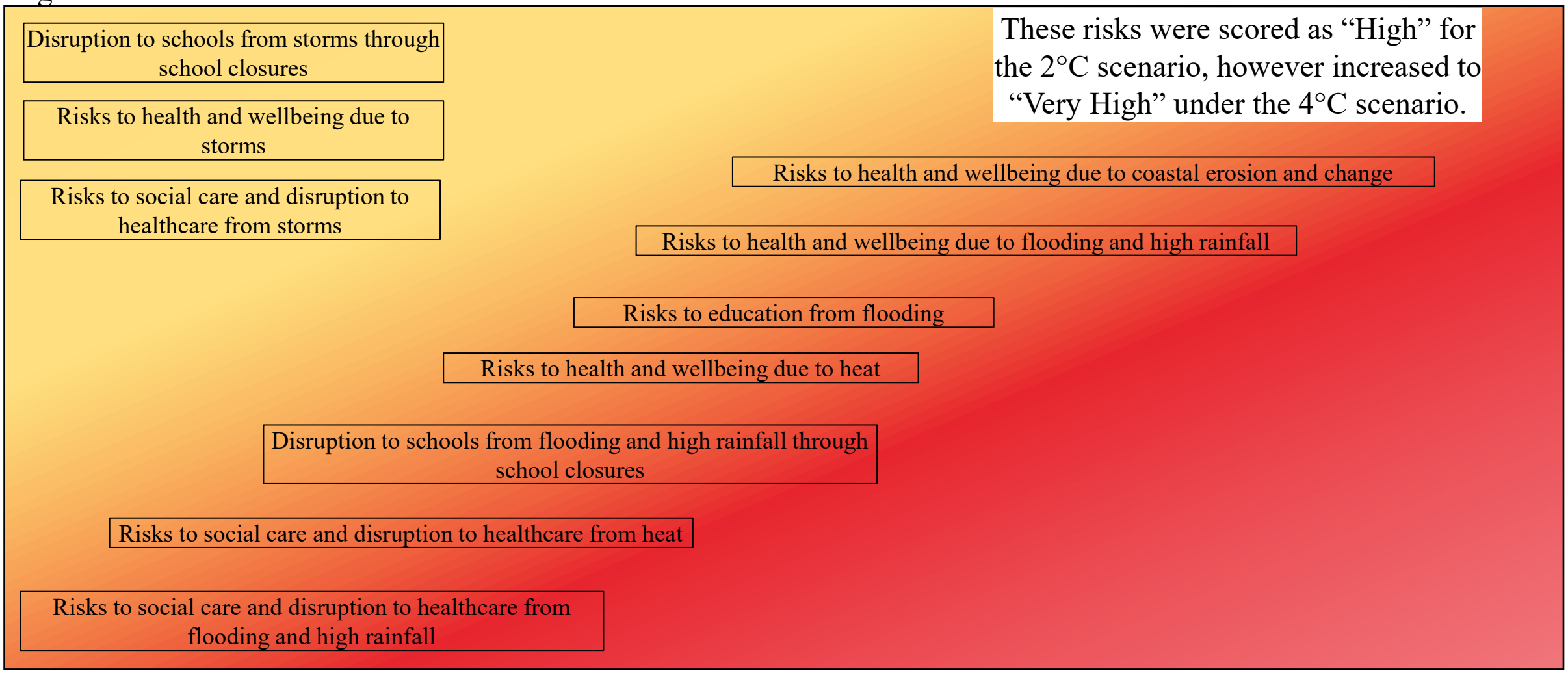


*Risks in each scoring (High/Very High) are grouped only in scoring rather than risk priority.

Very High

ARUP

A4.3 Health & Wellbeing - Rapid Heat Risk Map



A4.4 Economy- Rapid Heat Risk Map

ARUP

High

These risks were scored as “High” for the 2°C scenario, however increased to “Very High” under the 4°C scenario.

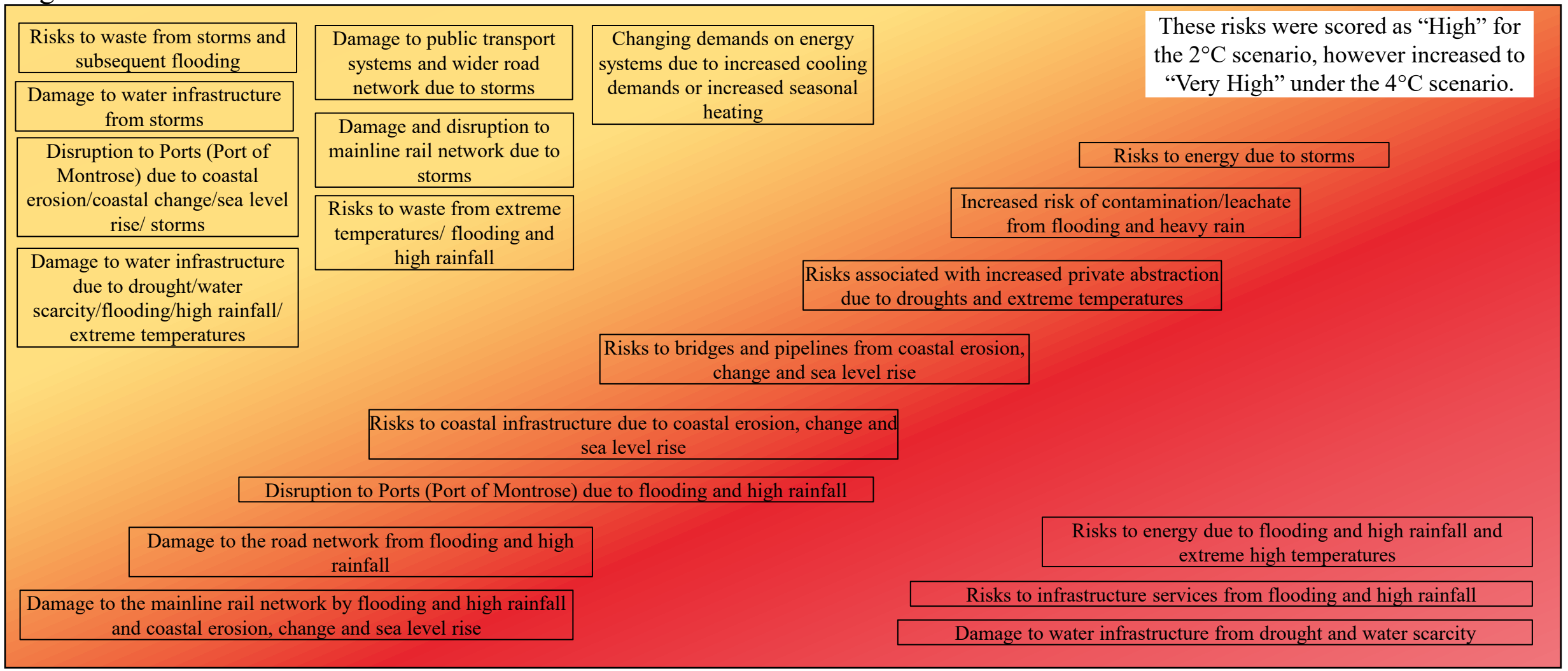
- Disruption to tourism levels due to storms
- Damage to golf courses, recreation sites reducing the number of visitors to Angus due to storms
- Disruption to businesses due to loss in trade from storms
- Damage to golf courses, recreation sites reducing the number of visitors to Angus due to coastal erosion and change
- Damage to golf courses, recreation sites reducing the number of visitors to Angus due to drought and water scarcity
- Damage to golf courses, recreation sites reducing the number of visitors to Angus due to flooding and high rainfall
- Damage to golf courses, recreation sites reducing the number of visitors to Angus due to extreme temperatures
- Risk to local businesses due to storms
- Disruption to tourism levels due to drought and water scarcity
- Disruption to tourism levels due to flooding and high rainfall
- Disruption to businesses due to loss in trade from flooding and high rainfall
- Damage to local wildlife resulting in a drop in visitors due to extreme high temperatures
- Risks to local business due to flooding and high rainfall
- Risks to local business due to coastal erosion and change

*Risks in each scoring (High/Very High) are grouped only in scoring rather than risk priority.

Very High

ARUP

A4.5 Infrastructure - Rapid Heat Risk Map



*Risks in each scoring (High/Very High) are grouped only in scoring rather than risk priority.

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A4.6 Land, Nature & Food- Rapid Heat Risk Map

High

Risks to marine species and habitats from storms

Risks to terrestrial species and habitats from storms

Risk to freshwater species and habitats from storms

Risks to marine species and habitats from flooding/high rainfall/ extreme temperatures

These risks were scored as “High” for the 2°C scenario, however increased to “Very High” under the 4°C scenario.

Risks to soils from changing climatic conditions, including seasonal aridity and wetness due to drought risk and water scarcity

Risks to freshwater/ terrestrial/ coastal species colonization in their habitats due to extreme temperatures

Risks to freshwater species associated with agricultural pollution from flooding and high rainfall

Risk to freshwater species and habitats from flooding and high rainfall/ drought and water scarcity/ extreme temperatures

Risks and opportunity for natural carbon stores, carbon sequestration and GHG emissions from changing climatic conditions due to temperatures increasing

Risk to terrestrial species due flooding and high rainfall/ extreme temperatures/ droughts and water scarcity

Reduced agricultural outputs (food) and forestry yields due to high temperatures / droughts & water scarcity/ rainfall and flooding

Risks to terrestrial and freshwater species and habitats from pests, pathogens and invasive species due to extreme temperatures and flooding/high rainfall

Risks to terrestrial species from wildfires

Risks to coastal species due coastal erosion/change and sea level rise

*Risks in each scoring (High/Very High) are grouped only in scoring rather than risk priority.

Very High

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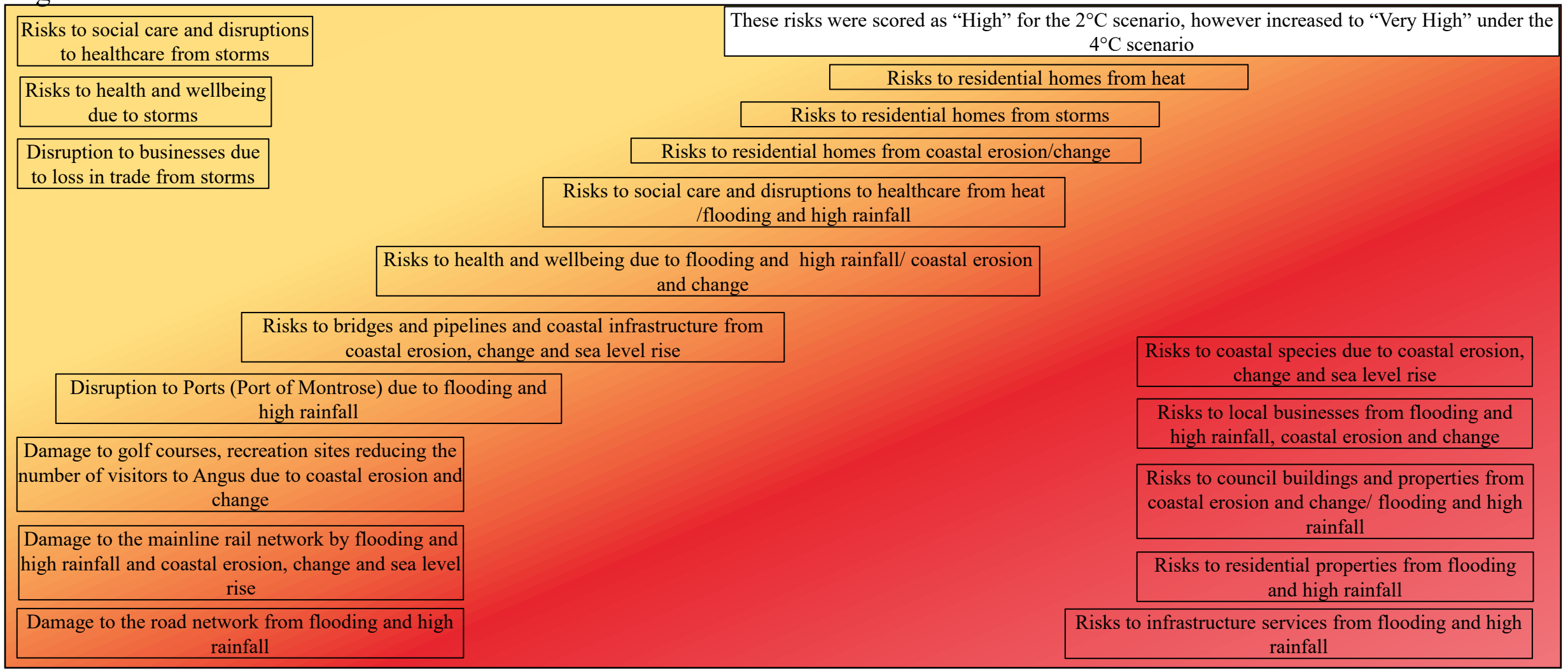
A4.7 Adaptation Option Risks- Rapid Heat Risk Map



*Risks in each scoring (High/Very High) are grouped only in scoring rather than risk priority.

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