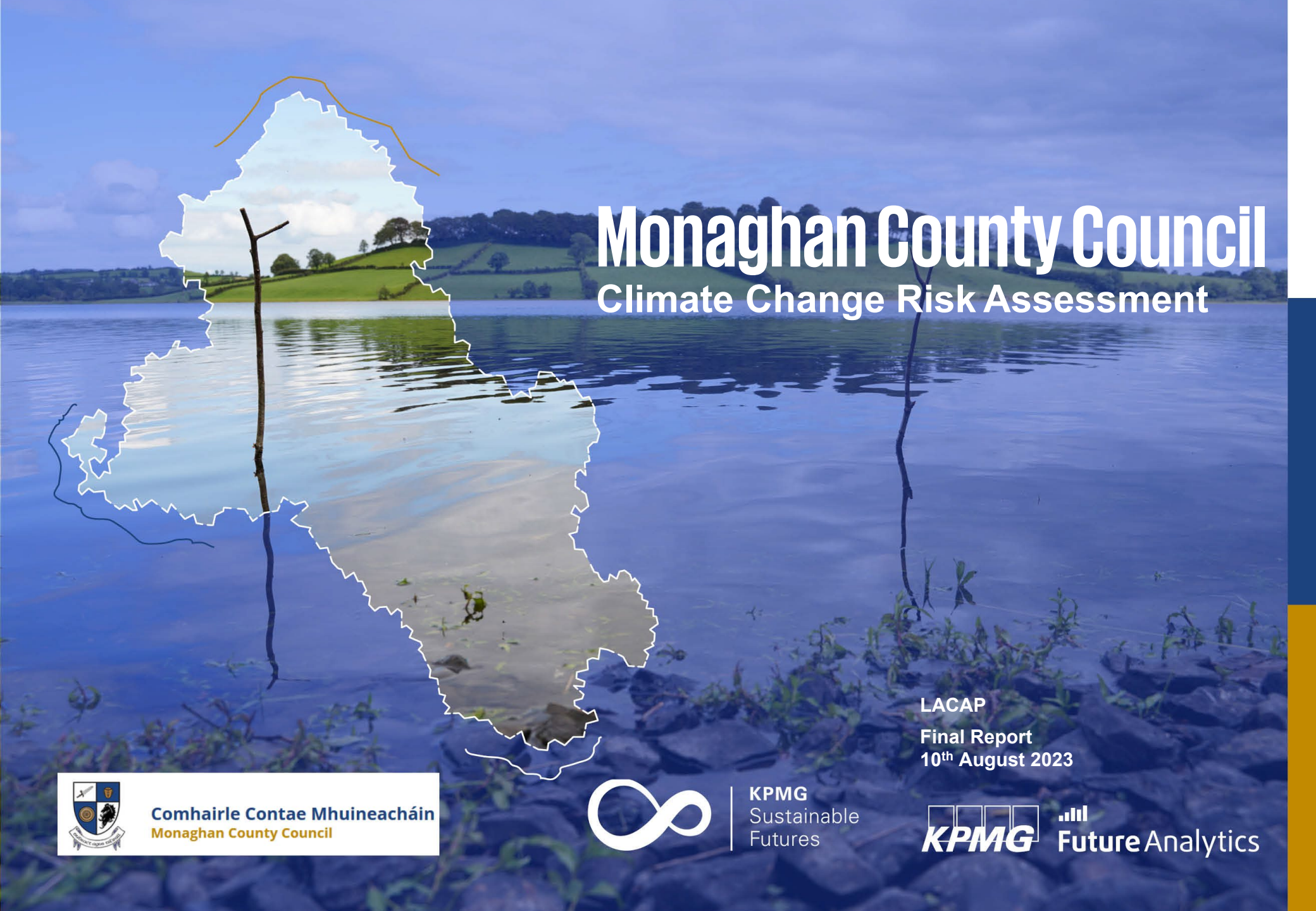

Monaghan County Council

Climate Change Risk Assessment

LACAP

Final Report

10th August 2023

Comhairle Contae Mhuineacháin
Monaghan County Council

KPMG Sustainable Futures

KPMG Future Analytics

Contents

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Executive Summary

Executive Summary

Context and Scope of this Report

Climate change poses a critical challenge for Monaghan County Council. It will result in a wide range of impacts across Monaghan, from damaging infrastructure such as roads and bridges, to uncontrolled fires and limits on water supply. These bring substantial implications for Monaghan County Council.

Internationally, national and local governments are increasingly compelled to take ambitious action to increase resilience to climate change within their organisations and their functional areas through adaptation and mitigation measures.

Ireland's Climate Action and Low Carbon Development (Amendment) Act, 2021 highlights the role of the Local Authority in meeting national emission reductions targets and achieving climate resilience. The Act stipulates that local authorities need to prepare a Local Authority Climate Action Plan (LACAP) that will drive local response to the challenges posed by climate change, translating the national climate policy to the local level.

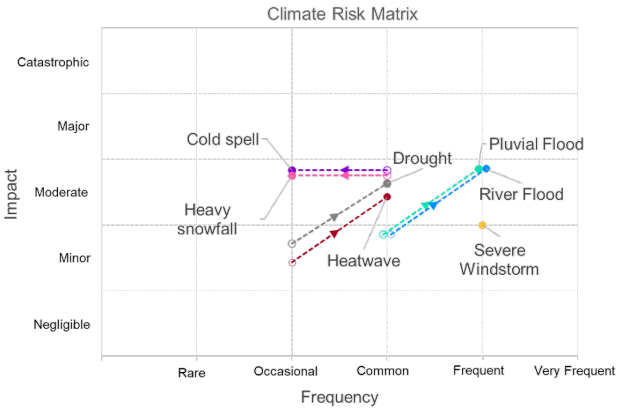
This report provides an assessment of climate change risks for County Monaghan and the consequences of these on the delivery of services by Monaghan County Council. The aim of the report is to provide the evidence base and inform the development of the LACAP for Monaghan's County Council.

Key Results and Findings

As illustrated in the climate risk matrix on the right the level of risk posed by some hazards (e.g., river and pluvial flooding, heatwaves and drought) will increase while others will remain the same, such as severe windstorms. Some hazards are also expected to decrease in frequency, such as cold spells and heavy snowfall.

- Recent **river and pluvial flooding** events in 2021 and 2022 demonstrated the typical type of impacts that Monaghan County Council is faced with, including, inundation of commercial and residential buildings, and transport disruptions (e.g. Monaghan Town). Projected increases in the frequency of extreme precipitation events will result in an increased level of river and pluvial flood risk for Monaghan.
- **Severe windstorms** are currently experienced on a frequent basis in Monaghan with wide ranging impacts, including disruption to energy supply and transport networks across the county (e.g. fallen trees on the N12 and N54 in 2018). Future projections indicate no significant change in this frequency.
- **Heatwaves and droughts** have contributed to uncontrolled fires (e.g. 2018) and have also increased demand on available water resources, resulting in increased pressure on shared resources. Projected increases in the frequency of heatwaves and of drought conditions will mean that events, currently experienced on an infrequent basis, will become more frequent.
- Recent experiences of **cold spells and heavy snowfall** events in 2018 and 2021 had a wide range of impacts across Monaghan, such as closure of roads, disruption of transport networks, and damage to critical infrastructure (e.g., roads and water). Projected increases in average temperature and decreases in the frequency of snowfall indicate a decrease in the frequency of cold spells and heavy snowfall and associated impacts.

To increase resilience, Monaghan County Council will need to proactively plan for and adapt to the **current and projected climate change risks** identified through this report.



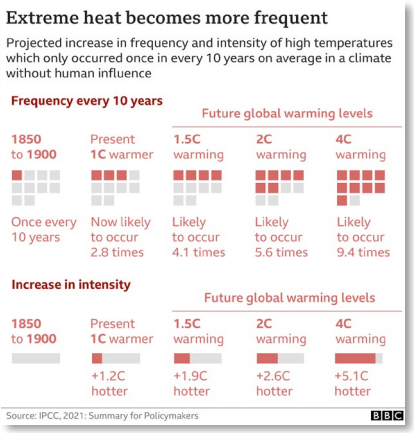
The risk matrix above shows the current and future level of risk associated with climate hazards for Monaghan. *The hollow marker showing the current level of risk and the solid marker the future level of risk. The dotted line shows the change between the current and future risk.*

02

Introduction

Global Response to the Challenge of Climate Change

Global Climate Change Challenge



It is unequivocal that human influence has warmed the atmosphere, land and ocean since pre-industrial times, affecting many weather and climate extremes in every region across the globe. Each of the last four decades has been successively warmer than any decade that preceded it since instrumental records began in 1850.

Since 1990, the Intergovernmental Panel on Climate Change (IPCC) have published a series of assessment reports which provide a synthesis of the most up-to-date science and evidence of climate change. The most recent assessment report shows that the global average temperature has increased by 1.1°C when compared with pre-industrial conditions (1850-1900).

Global trends

Climate relates to average weather over a period of time, which is typically measured over 20 or 30 years.

Local impacts

Weather relates to short term changes in atmospheric conditions and can change from minute-to-minute, day-to-day and season-to-season.

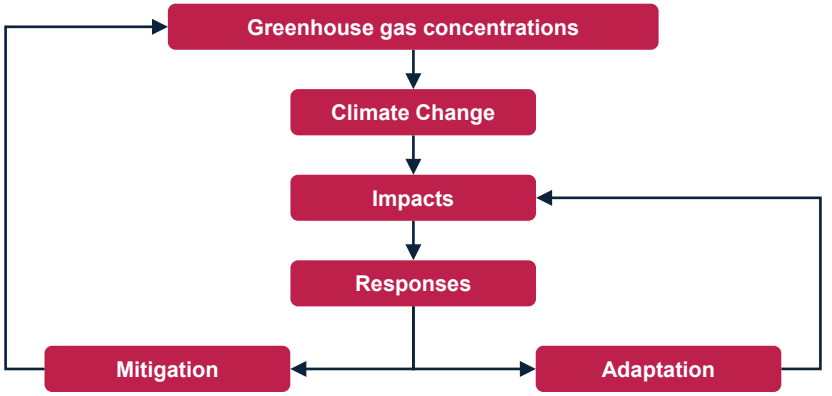
It is becoming apparent that **changes in global climate are being reflected in changes in the frequency and intensity of extreme weather events such as heatwaves, droughts and flooding.**

Global Climate Change Response Framework

In response to the challenges posed by climate change, two complementary approaches are being adopted.

Mitigation: Making the impacts of climate change less severe by preventing or reducing the emission of greenhouse gases (GHGs) into the atmosphere. Mitigation is achieved either by reducing the sources of these gases (e.g. by increasing the share of renewable energies, or establishing a cleaner mobility system) or by enhancing the storage of these gases (e.g. by increasing levels of afforestation). In short, mitigation is a human intervention that reduces the sources of GHG emissions and/or enhances GHG sinks.

Adaptation: Anticipating the adverse impacts of climate change and taking appropriate action to prevent or minimise the damage they can cause, or taking advantage of opportunities that may arise. Examples of adaptation measures include large-scale infrastructure changes, such as building defences to protect against sea-level rise, as well as behavioural shifts, such as individuals reducing their food waste. In essence, adaptation can be understood as the process of adjusting to the current and future effects of climate change.



Ireland's Challenge of Climate Change

Observed Impacts of Climate Change on Ireland

The mean annual observed temperature for Ireland (1900-2019) (Source: Cámaro García and Dwyer, 2021)**

According to the Environmental Protection Agency (EPA)* Ireland's climate is changing in line with global trends, with an increase in annual average temperature of 0.9 °C between 1900 and 2018. Ireland has seen an increase in annual average rainfall of approx. 6% for the period 1989-2018 when compared to 1961-1990. Global sea level is rising at an increasing rate with the average global rate of sea level rise for the period 2006-2015 being about 2.5 times the rate for the period 1901-1990.

- Surface air temperature has increased, on average, by 0.9 °C during the past 120 years.

- Yearly precipitation was, on average, 6% higher in the 30 years from 1989-2018 as compared to 1961-1990.
- The period 2006 to 2015 was shown to be the wettest in Ireland since records began.

- Due to limited analysis, no long-term change in windiness have been observed.

- For the seas around Ireland, there has been a rise in sea level of approximately 2-3 mm per annum since 1990.
- Sea surface temperature at Malin Head has been, on average, 0.47 °C higher over the period 2009 to 2018 when compared to the average for the period 1981 to 2010.

Projected Impacts of Climate Change on Ireland

Climate projections indicate that observed changes in Ireland's climate will continue and likely intensify into the future. It is expected that Ireland's climate will become warmer and drier, sea levels will continue to increase at a faster rate and that extreme weather events will occur more frequently. Even if mitigation actions are taken over the next 30 years, a level of projected changes are locked in for the foreseeable future as a result of historical GHG emissions. As a result, temperatures will continue to increase globally until at least 2050, even under low emissions scenarios.

- By 2050, average annual temperatures are expected to increase by up to 1.6°C under a high emissions scenario.
- The frequency and intensity of heatwave events are projected to increase.

- By 2050, levels of summer precipitation are expected to decrease by up to 17% under a high emissions scenario.
- During winter and autumn months, there is expected to be an increase of up to 19% in the occurrence of heavy precipitation events.

- By 2050, projections indicate a small reduction in overall wind speed (10m) by up to -3.3% under a high emissions scenario.
- Projections of severe windstorms show a high degree of uncertainty with some projections indicating an increase in very severe windstorms. However, more work is required to increase confidence in these projections.

- Global sea level is expected to continue to rise and by up to 1m by 2100.
- Projections indicate that the Irish Sea could warm by a further 1.9 °C before the end of the 21st Century.

Source: Local Authority Climate Action Plan Guidelines, pages 26-29.

**https://www.epa.ie/publications/research/climate-change/Research_Report_386.pdf*

***https://www.epa.ie/publications/research/climate-change/Research_Report_386.pdf*

National and Local Response

Paris Agreement, 2015

The Paris Agreement, adopted in 2015 provides an internationally accepted and legally binding global framework to address climate change challenges. It has two clearly defined goals aimed at supporting progressive and ambitious climate action to avoid dangerous climate change:

I. holding global average temperature increase to well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels (i.e., **mitigation**);

II. increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience (i.e., **adaptation**).

European Climate Law, 2021

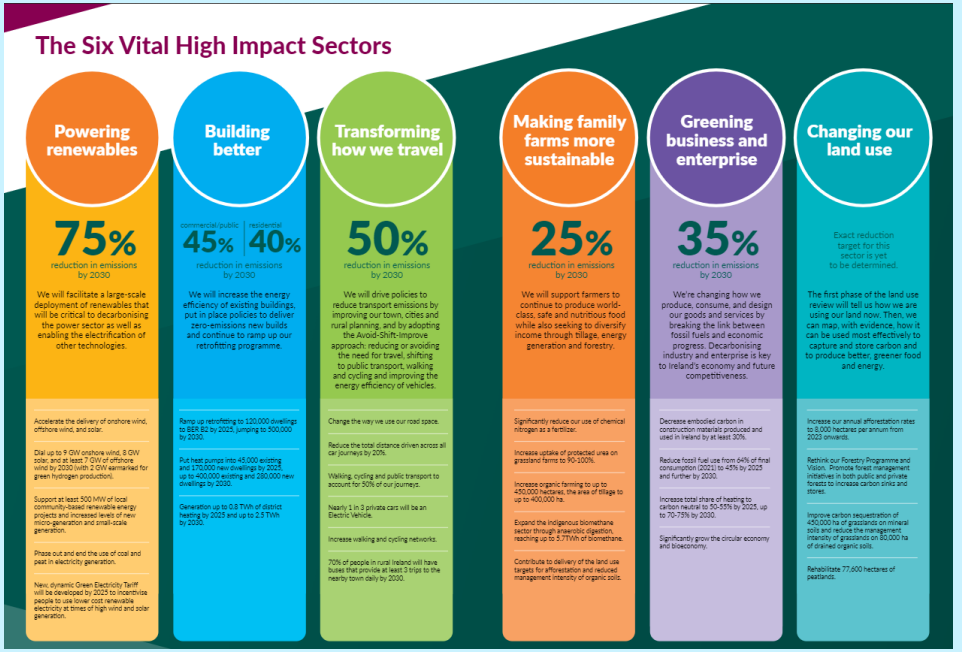
The EU adopted a legislative proposal for the European Climate Law in June 2021 to frame the climate neutrality objective by 2050 across the EU with an intermediate target of **reducing net greenhouse gas emissions by at least 55% by 2030**. The European Commission (EC) is clear in the commitment required by all Member States, and the use of all policy levers and instruments, to fight against the urgent challenge of climate change and to activate leadership efforts to reach climate neutrality by 2050.

Climate Action and Low Carbon Development (Amendment) Act, 2021

Climate policy in Ireland reflects the ambition of the EU and confronts the challenges of climate change. The Climate Action and Low Carbon Development (Amendment) Act, 2021 frames Ireland's legally binding climate ambition to deliver a **reduction in greenhouse gas emissions of 51% by 2030**, and to achieve climate neutrality by the end of 2050.

Through progressive economy-wide carbon budgets, sectoral ceilings, a suite of strategies devised to promote a **combination of adaptation and mitigation measures**, and robust oversight and reporting arrangements, climate policy is working to scale up efforts across all of society and deliver a step change on ambitious and transformative climate action to 2030 and beyond to 2050.

Climate Action Plan 2023 - Infographic



Source: Climate Action Plan 2023 – Summary Document

Project Overview

Legislative context

Climate Policy in Ireland is aligned with the EU's ambitions to combat climate change. The Climate Action and Low Carbon Development (Amendment) Act 2021 enshrines the National Climate Objective to "pursue and achieve, by no later than the end of 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy."

The importance of place-based approaches and the role of the Local Authority is highlighted in the Act, which stipulates that "each local authority shall prepare and make a plan relating to a period of five years (in this section referred to as a 'local authority climate action plan') which shall specify the **mitigation measures** and the **adaptation measures** to be adopted by the local authority."

These plans will drive the mitigation and adaptation measures at the local level and see local authorities translate national climate policy to local circumstances and to support the delivery of the National Climate Objective at local and community levels.

Preparing local authorities' climate action plans

To support local authorities in meeting their legislative requirements, the Climate Action Regional Offices (CAROs) developed the draft Local Authority Climate Action Plan (LACAP) Guidelines.

These guidelines issued by the Minister structure the development and implementation of LACAPs around a 4-step cycle, which is supported by four technical annexes[1].

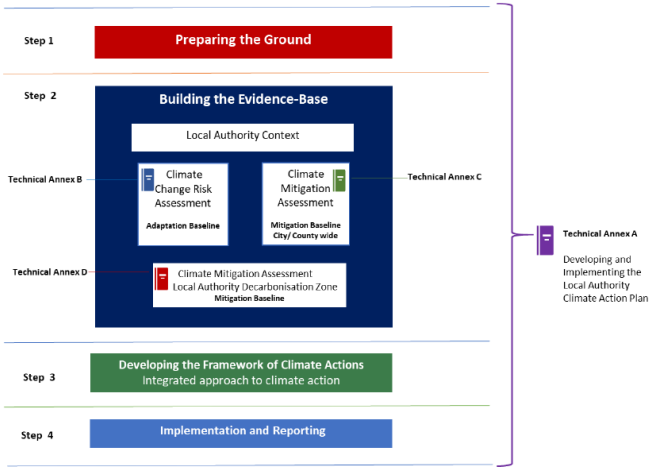


Figure 3: 4-step-cycle for development of the local authority climate action plan.

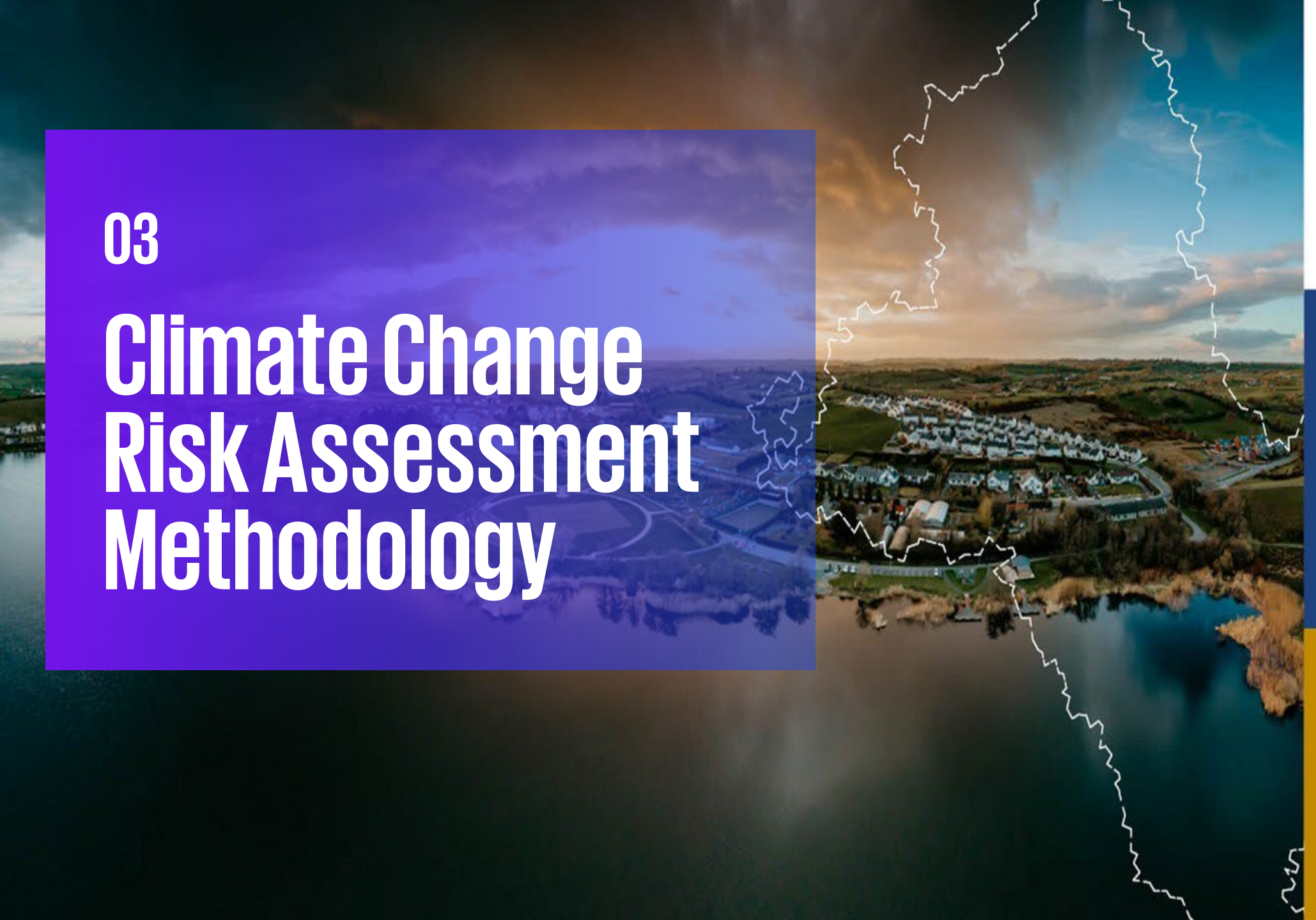
[1] *Source: Local Authority Climate Action Plan Guidelines, page 5.*

Scope of this report

Per Monaghan County Council's request, the KPMG team is supporting the council in Step 2 to build the adaptation baseline and develop a climate change risk assessment (CCRA) following **Technical Annex B of the LACAP Guidelines** in order to understand current and future risks posed by climate change for County Monaghan and the implications of these for Monaghan County Council.

03

Climate Change Risk Assessment Methodology



3.1 Introduction, Scope and Methodology

Understanding of Climate Change Risk Assessment

Purpose of Climate Change Risk Assessment

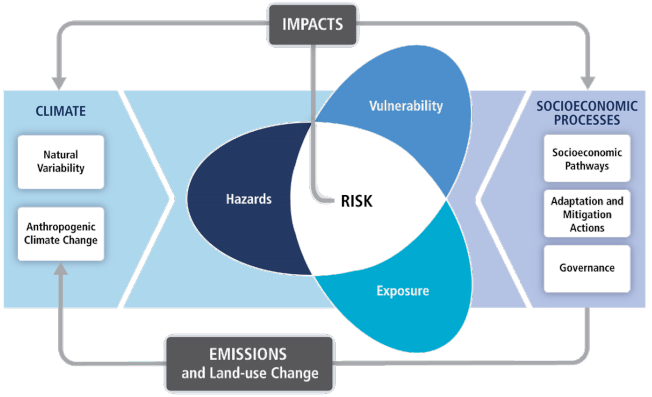
Responding to climate change impacts involves taking adaptation actions to reduce the adverse risks posed by current and projected climate change.

Climate change risk assessments identify the likelihood of future climate hazards and their potential impacts. This is fundamental for informing the prioritisation of climate action and investment in climate action.

Nature of Climate Change Risk Assessment

Conventional 'predict and act' approaches to risk assessment are challenged by the inherent uncertainty associated with climate change, the spatial and temporal dynamics of climate change, the amplification of risk through societal preferences and values and through the interaction of multiple risk factors.

In assessing climate change risk for Monaghan County Council, the risk assessment framework of the Intergovernmental Panel on Climate Change (IPCC) has been adopted. This framework identifies three key components of climate risk: hazard, exposure and vulnerability. Details of the framework are provided to the right.



Hazard: potential source of climate-related harm, i.e., damage or loss of property.

Exposure: presence of people, livelihoods, environmental services and resources, infrastructure, or economic and social or cultural assets in places that could be adversely affected.

Vulnerability: propensity / disposition to be adversely affected.

Risk: the potential for adverse consequences.

Anthropogenic Climate Change

Impact of human activity on climate; more specifically, the global warming caused by human-induced GHG emissions resulting in an enhanced greenhouse effect and increased global temperatures.

Natural Variability

Natural variability refers to the variation in global climate caused by non-human activities such as long term shifts in weather patterns.

Adaptation & Mitigation Actions

Adaptation actions aim to reduce adverse climate impact and risks.

Mitigation actions refer to those that address the causes of anthropogenic climate change.

Governance

Looks at how governance factors, e.g. Institutions, transparency, policies, etc. contribute or hinder adaptation or mitigation measures.

Socio-economic pathways

Looks at how changes in socio-economic factors, e.g. wealth & inequality, demographics, access to technology, etc. impact and contribute to mitigation and adaptation action.

Source: Local Auhtority Climate Action Plan Guidelines, Technical Annex B, Figure 1. (page 5)

Methodology Climate Change Risk Assessment (CCRA)

Qualitative Assessment

This Climate Change Risk Assessment has been undertaken in accordance with *Technical Annex B Climate Change Risk Assessment* of the Local Authorities Climate Action Plan Guidelines and provides a qualitative assessment of climate risk for County Monaghan.

A qualitative risk assessment provides the evidence base to identify potential climate risks for the administrative area of Monaghan County Council and for the delivery of services by Monaghan County Council.

The Technical Annex B provides a stepped approach to carrying out a climate change risk assessment:

1. Assess the climate impact baseline, identifying, assessing and characterising the climate and weather-related impacts already being experienced by the authority, and
2. Identify and assess potential future climate impacts and risks.

In assessing climate change risk, we employ climate information derived from *Nolan and Flanagan (2020)* and *Climate Ireland* for two climate scenarios, RCP4.5 and RCP 8.5.

- RCP4.5 represents an 'intermediate emissions' scenario with an average global warming of 1.4°C for the 2046-2065 period.
- RCP8.5 represents a 'very high emissions' scenario with an average global warming of 2°C for the 2046-2065 period.

The RCP8.5 scenario was used as it represents a 'worst-case' scenario which allows for a conservative risk assessment approach.

Qualitative

- **A qualitative assessment is developed based on readily available information and provides for a screening of climate change related hazards and risks.**
- **This type of assessment helps to:**
  - **Identify the full range of climate-related risks;**
  - **Communicate identified risks to relevant stakeholders;**
  - **Prioritise risks for further more detailed analysis; and**
  - **Provide a broad understanding of where adaptation actions could be required.**

Semi-quantitative

- **A semi-quantitative risk assessment builds upon a qualitative screening assessment and provides a more detailed assessment of climate change risks. Semi-quantitative risk assessments use national and regional information and data along with expert judgement to explore potential risks in further detail.**
- **This type of assessment helps to:**
  - **Provide semi-quantitative risk analysis insights;**
  - **Identify on a spatial basis climate risk hotspots;**
  - **Identify where adaptation measures may be required.**

Quantitative

- **A quantitative risk assessment uses site-specific data and expert knowledge to establish a detailed understanding of risks and identify the point in time in the future when the risk will pass the tolerable limit and when implementation of action will be necessary.**
- **This type of assessment helps to:**
  - **Detail an estimation of rate of change (when the risk will cross the limit and need action); and**
  - **Identify the extent of impact (how badly it will affect the system).**

Methodology Overview

As detailed below, **Technical Annex B Climate Change Risk Assessment** provides for a proportionate and stepped approach for undertaking a Tier 1 Climate Change Risk Assessment. An assessment of the current climate hazards, exposure, vulnerabilities and impacts leads to the assessment of '**Current Climate Risks and Impacts**'. This is followed by an assessment of future climate risks and impacts, resulting in the '**Future Climate Risks and Impacts**'. The detailed steps for both current and future climate risk assessment and are discussed in further pages.

Step 1. Current Climate Risks and Impacts

- Develop Profile of Climate Hazards
- Characterise Climate Hazards Frequency
- Exposure, Vulnerability and Impacts for County Monaghan
- Impact Assessment (Service Delivery)
- Current Climate Risk Matrix

Step 2. Future Climate Risks and Impacts

- Assess Future Changes in Climate Hazards Frequency and Intensity
- Assess Future Change in Exposure and Vulnerability
- Assess Emerging Hazards and Potential Future Climate Risks
- Future Climate Risk Matrix
- Uncertainty Assessment

Step 1: Assess Current Climate Risks and Impacts

In assessing current climate risks and impacts, developing an understanding of the range of climate and weather related events currently affecting County Monaghan and the consequence of these for Monaghan County Council is essential. To achieve this, a number of steps have been undertaken as detailed below:

1.1

Develop Profile of Climate Hazards

The climate hazard profile provides an overview of climate and weather-related hazards that have impacted the County Monaghan.

We have updated the climate hazard profile developed through the existing Monaghan County Council Climate Adaptation Strategy (2019) in accordance with recent experiences of extreme weather and climate variability.

Section 3.2.1

1.2

Characterise Climate Hazards- Frequency

On the basis of the most up-to-date information on extreme weather events and observed climate changes for Ireland, the frequency of occurrence of the climate hazards identified through the climate hazard profile has been assessed according to the criteria provided through **Technical Annex B: Climate Change Risk Assessment**.

Section 3.2.1

1.3

Exposure, Vulnerability and Impacts for County Monaghan

For each of the climate hazards identified through the climate hazard profile, an assessment of the local-scale impacts, exposure, and vulnerability has been performed based on reported impacts and in discussion with the local authority.

Section 3.2.2

1.4

Impact Assessment (Service Delivery)

The level of disruption to the delivery of services by the council has been assessed for each of the identified climate hazards following the criteria provided through **Technical Annex B: Climate Change Risk Assessment**.

Section 3.2.3

1.5

Current Climate Risk Matrix

The overall impact of the identified climate hazards has been assessed according to the following categories of exposure: Asset Damage, Health and Wellbeing, Environment, Social, Financial, Reputation and Cultural Heritage. A summary of current climate impacts has been provided through a current climate risk matrix.

Section 3.2.4

Step 2: Assess Future Climate Risks and Impacts

Building on the assessment of current climate risks and impacts, assessing future climate risks and impacts is concerned with understanding and characterising how projected changes in the frequency and intensity of climate hazards may exacerbate existing climate impacts and risks for County Monaghan. To achieve this, a number of steps have been undertaken and as detailed below:

2.1

Assess Future Changes in Climate Hazards- Frequency and Intensity

The most up-to-date climate change projections have been employed to assess the changes in frequency and intensity of climate hazards identified through our assessment of current climate impacts.

Section 3.3.1

2.2

Assess Future Change in Exposure and Vulnerability

To identify and assess the potential future changes in exposure and vulnerability, projections of potential changes in non-climatic factors (e.g. *County Development Plans, Regional Social and Economic Strategies*) have been examined. The assessment of the projected future impacts have been provided.

Section 3.3.2

2.3

Assess Emerging Hazards and potential Future Climate Risks

In addition to those hazards and impacts identified through the current climate impact and risk assessment, projected climate change may result in new or emerging risks. Emerging risks for County Monaghan have been identified and considered as part of the CCRA.

Section 3.3.2

2.4

Future Climate Risk Matrix

Accounting for projected changes in hazard, exposure and vulnerability, future climate risk has been assessed according to the following categories of exposure: Asset Damage, Health and Wellbeing, Environment, Social, Financial, Reputation and Cultural Heritage. A summary of potential future climate impacts is provided through a future climate risk matrix.

Section 3.3.3

2.5

Uncertainty Assessment

In assessing future climate risks, there will be uncertainty in how hazards, exposure, and vulnerability will change. The level of uncertainty in projected changes in climate hazards, exposure, and vulnerability is assessed.

Section 3.3.4

Data and Information Sources

As detailed below, a wide range of qualitative and quantitative information was employed to inform the development of the CCRA for Monaghan County Council. The Monaghan Council Adaptation Strategy (2019-2024) was reviewed and updated using a range of national and local data sources. Climate Ireland was employed to access data and information on projected changes in the frequency and intensity of climate hazards while the National Planning Framework, the Regional , Spatial and Economic Strategy for the Northern & Western Region, and the Monaghan County Council Development Plan 2019-2025 were employed to assess future development patterns. In addition, two stakeholder workshops were held to garner further insights from Monaghan County Council.

Report Section	Sources
Introduction and scope	• Local Authority Climate Action Plan Guidelines, Technical Annex
Step 1: Current Climate Risks and Impacts	• Environmental Protection Agency (EPA) • Catchments.ie (EPA) • Climate Status Report 2020 (Cámaro García and Dwyer, 2021) • Water.ie • Floodinfo.ie (Office of Public Works) • Data.gov.ie • Department of Transport • Department of Housing, Local Government and Heritage • Department of transport, Sport and Tourism • National Directorate for Fire and Emergency Management • Teagasc • Monaghan County Council Website • Monaghan County Council Climate Change Adaptation Strategy 2019-2024 • Sectoral Climate Change Adaptation Strategies (2018) • Stakeholder Workshop • Met Éireann • RTE News • Irish Independent • Irish Examiner • The Irish Times • The Journal • The Farmers Journal • The Anglo-Celt • Northern Sound • Northern Standard
Step 2: Future Climate Risks and Impacts	• High-resolution Climate Projections for Ireland – A Multi-model Ensemble Approach (Nolan and Flanagan, 2020) accessed via Climate Ireland • Regional Spatial & Economic Strategy for the Northern & Western Region

3.2 Current Climate Risks and Impacts

3.2.1 Profile of Climate Hazards (incl. Frequency)

Characteristics of County Monaghan

Monaghan County Council is a member of the Eastern and Midlands Climate Action Regional Office (CARO) and serves **64,832** people (2022 Census). The county is characterised by a drumlin landscape interspersed with wetlands and woodlands. The county is strategically located between cities such as Dublin, Belfast, Derry and Galway/Limerick.

Physical & Environmental Characteristics

County Monaghan is approximately 1295km² making it the 5th smallest county on the island of Ireland. The inland county is bounded by Cavan, Meath, Louth, Armagh, Tyrone and Fermanagh and, as the most northerly inland county in the Republic of Ireland, some 90% of Monaghan is located within 10 miles of the border with Northern Ireland.

Largely shaped by the last ice-age, the county topography is characterised by rolling drumlins, lakes and
wetlands. In terms of land use, 69% of the county area is dedicated to agriculture, 4% to forestry and 1.7% is covered by lakes.

County Monaghan contains a wide range of wetlands which provide a habitat for species of national and international importance. These wetland habitats include cutover raised bog, blanket bogs, fens, marshes, rivers, lakes, turloughs, springs and wet woodland. These environmentally sensitive sites include Kilroosky Lough Cluster, Special Area of Conservation (SAC) and the Sliabh Beagh (Special Protection Area (SPA).

Socioeconomic Characteristics

County Monaghan benefits from its strategic location on the Donegal/Derry – Dublin corridor, adjacent to the M1 corridor and has strong links to Northern Ireland. There are a number of high-traffic volume routes within or in close proximity to County Monaghan that connect larger urban settlements, airports and sea ports on both sides of the border. The key road transport linkages in the region include the Dublin-Belfast Corridor, the North Western Route, and the East West Link Road (Dundalk/Sligo route).

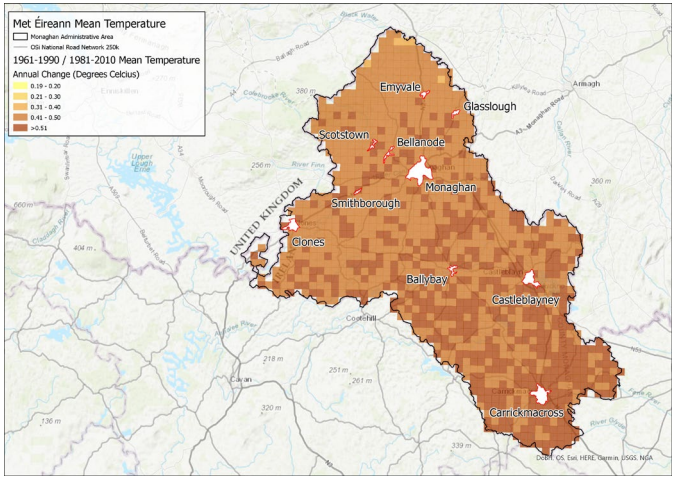
The county comprises of 3 municipal districts namely Monaghan Municipal District, Ballybay/Clones Municipal District and Carrickmacross/Castleblayney Municipal District. These districts help to enhance democratic governance, subsidiarity and accountability as well as to improve operational efficiencies in the county.

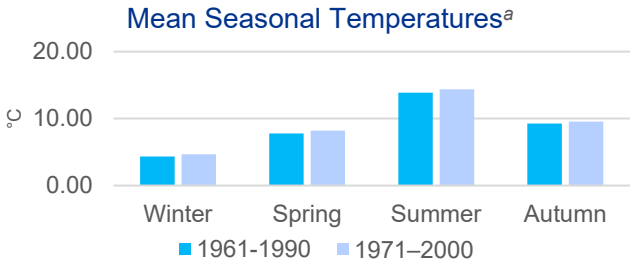
Most economic activity for the county is concentrated in the towns of Monaghan,Carrickmacross, Castleblayney, Clones, and Ballybay. The agriculture and food sector is the county's primary economic driver, providing over 60% of Monaghan's employment. Approximately 90% of foods produced in the county are exported and 14 of Ireland's top 100 food producing companies are based in Monaghan.

County Monaghan's development pattern is characterised by traditional dispersed settlement in rural areas tied together by a network of towns and villages. Today, less than 30% of the county's population lives in the urban areas.

Monaghan Town is the county's primary economic growth town. It is promoted for regional enterprise purposes and achieving critical mass is prioritised for the purpose of justifying strategic infrastructure provision. The towns of Carrickmacross and Castleblayney are identified as secondary economic centres and seen as strategic, accessible locations for providing new employment opportunities. This includes within the county itself, as well as for the wider region (including the eastern economic Dublin - Belfast Corridor).

Observed Changes in Monaghan's Climate





[a]*Met Éireann Long term weather station : Clones (Closed 2007)*
[b]*Historical Data - Met Éireann - The Irish Meteorological Service*
[c]*Uisce Éireann*

To assess changes in climatic conditions across Monaghan, we have employed data from Met Éireann's network of meteorological and climatological stations. To establish a long-term climatology, a 30-year period of data is required. The Clones station situated in Co. Monaghan was used for baseline assessment[a].

In line with global trends, the climate of Ireland and Monaghan is changing, temperatures are increasing and patterns of precipitation are changing. A summary of key climate and weather-related changes already observed for County Monaghan are detailed below.

Highlights of Observed Climate Change for Ireland and Monaghan

Droughts

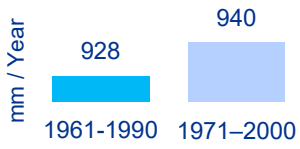
The 2018 Drought (24 days in duration) is the longest running summer drought in Monaghan[b]

31.1°C

Highest temperature on record recorded on July 18th 2022 at Carrickmacross, Dunoge[b]

Rainfall

Average annual rainfall increased by 1.3% for the most recent period of observations (1971-2000) compared to the 1961-1990 baseline [a]



0.4°C

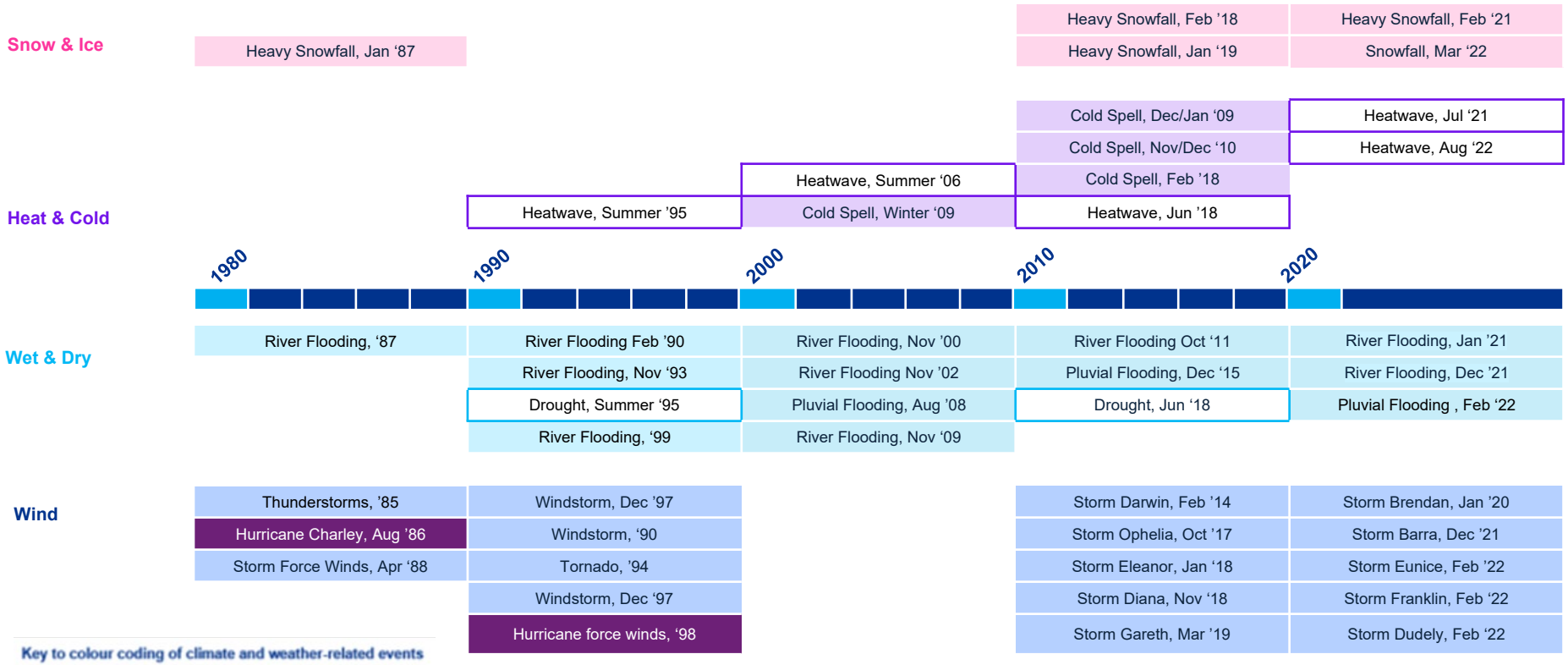
Average temperature increase for the most recent period of observations 1971-2000 when compared to the 1961-1990 baseline [b]

8 out of the last 10 winters have recorded greater precipitation levels when compared to the 1961-1990 baseline [a]

In August 2022 the Clones water treatment plant was put under Irish water notice due to drought conditions[c]

Climate Hazard Profile

In addition to observed changes in Monaghan's climate, we have identified significant climate and weather-related events to have impacted on County Monaghan over the period 1985-2022. To do this, we have further developed the existing climate hazard profile developed through the existing Monaghan County Council Adaptation Strategy (2019) and expanded the analysis to cover the period 2018-2022.



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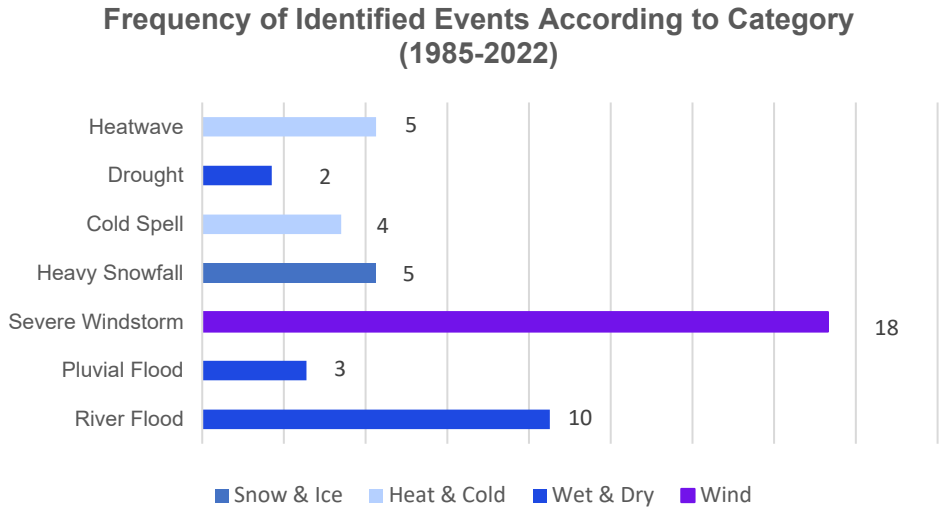
Frequency of Climate Hazards

For each of the climate hazards that have been identified through the climate hazard profile, an assessment of their frequency of occurrence has been conducted. Each hazard was assigned a frequency category according to Table 2 of the **Technical Annex B Climate Change Risk Assessment Guidelines** (top right).

Based on the climate hazard baseline, severe windstorm events have impacted upon Monaghan County most frequently over the period 1985-2022, with river flooding also affecting the County on a number of occasions. Pluvial flooding, cold spells and heavy snowfall events, heatwaves and droughts have also impacted County Monaghan, but less frequently.

The hazard frequency for each hazard is shown in the bottom right table, informed by past event occurrence and information received from Monaghan County Council.



Frequency classification from Technical Annex B Climate Change Risk Assessment Guidelines

Frequency	Frequency Occurrence in a Year	Description
Very Frequent	> 100%	Occurs several times in a single year
Frequent	50 to 100%	Occurs once in a 1-to-2-year period
Common	10 to 50%	Occurs once in a 2-to-10 years period
Occasional	1 to 10%	Occurs once in a 10-to-100-year period
Rare	< 1%	Occurs once in over 100 years

Current hazard frequency for County Monaghan, based upon analysis of past events and workshop feedback

Hazard Type	Current Frequency
Heatwave	Occasional
Drought	Occasional
Cold Spell	Common
Heavy Snowfall	Common
Severe Windstorm	Frequent
Pluvial Flood	Common
River Flood	Common

3.2.2 Exposure, Vulnerability and Impacts for County Monaghan

Exposure, Vulnerability and Impacts for County Monaghan

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

On the basis of identified exposures, vulnerabilities and impacts for County Monaghan, the impact of climate and weather-related hazards on key categories of exposure for County Monaghan was assessed according to the criteria provided through Technical Annex B: Climate Change Risk Assessment (catastrophic, major, moderate, minor and negligible) (Appendix 2).This assessment was undertaken on the basis of existing information on impacts and in consultation with Monaghan County Council.

Below we provide a summary of impacts across the key categories of exposure for the seven climate hazards identified. The following pages provides the information that informed this assessment with additional information provided in Appendix 3.

Hazard	Current Frequency	Assets	Health and Wellbeing	Environment	Social	Cultural Heritage	Financial	Reputational	Overall Impact Score
Heatwave	Occasional	Negligible	Minor	Minor	Minor	Negligible	Negligible	Negligible	1.4
Drought	Occasional	Negligible	Negligible	Moderate	Minor	Minor	Negligible	Minor	1.7
Cold Spell	Common	Major	Moderate	Moderate	Minor	Minor	Moderate	Minor	2.7
Heavy Snowfall	Common	Major	Moderate	Moderate	Minor	Minor	Moderate	Minor	2.7
Severe Windstorm	Frequent	Moderate	Minor	Negligible	Minor	Minor	Minor	Minor	2.0
Pluvial Flood	Common	Minor	Negligible	Minor	Minor	Negligible	Minor	Moderate	1.9
River Flood	Common	Minor	Minor	Minor	Minor	Negligible	Minor	Minor	1.9

Impacts of Current Climate Risks– Heatwaves & Drought

County Monaghan has been exposed to heatwave events (defined as 5 consecutive days with temperatures >25°C) over the period 1985-2022 with a wide range of impacts across the county. The most notable and costly impact relates to repair and maintenance of road surfaces. In addition, County Monaghan has experienced drought conditions over the period as exemplified by the drought event in 1995 and 2018.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

Hazard & Frequency	Exposure	Impact Description	Rating
Heatwave Occasional	Assets	• High temperatures have resulted in localised damage to road surfaces (tar and chip) across the County.	Negligible
	Health and Wellbeing	• High indoor temperatures have resulted in uncomfortable working conditions for staff and public with potential impacts for heat sensitive equipment. This has resulted in the increased requirement for active/mechanical cooling.	Minor
	Environment	• Heat waves provide suitable conditions for the ignition of uncontrolled fires, with high temperatures in 2021 leading to 27 wild fires reported throughout the county. • High water temperatures associated with heatwave events have also had significant impacts on freshwater and marine environments. • High temperatures have adverse impact on plants and wildlife.	Minor
	Social	• Heatwaves have resulted in congestion at key recreational areas with facilities (e.g., litter collection and parking) overwhelmed.	Minor
	Cultural Heritage	• Extreme temperatures are recognised as contributing to the increased weathering of cultural heritage sites.	Negligible
	Financial	• The financial implications of heatwaves are primarily associated with road maintenance and repair.	Negligible
	Reputational	• The potential for reputational risk associated with heatwaves is currently limited.	Negligible
Drought Occasional	Assets	• Drought conditions (e.g. Summer 2018) resulted in the imposition of restrictions on water supply on a national and county basis with implications for building operations. • Subsidence events in Monaghan County have been associated with low rainfall. In September 2018 lower than average rainfall led to river levels shrinking, restricting water discharges from a local gypsum mine. This led to a collapse and a significant sinkhole appearing at Magheracloone, causing the local GAA club and community centre to be condemned, and impacting on the local national school, local roads, at least 13 homes.	Negligible
	Health and Wellbeing	• Water restrictions, particularly in combination with extreme heat, have the potential to result in dehydration, particularly for vulnerable populations and outdoor workers.	Negligible
	Environment	• High temperatures and dry conditions, often compounded by high levels of ignition activity, have resulted in uncontrolled fires. In 2021 this led to 27 wild fires in the county. • Adverse impact on plants and wildlife.	Moderate
	Social	• Water restrictions can lead to inconvenience for local businesses and resident.	Minor
	Cultural Heritage	• Drought conditions results in damage to cultural heritage sites due to drying out of substrate.	Minor
	Financial	• The financial implications of drought are limited and restricted to responding to wildfire and supporting the provision of water (e.g., tankering).	Negligible
	Reputational	• The reputational impacts of drought conditions are localised and short term.	Minor

Impacts of Current Climate Risks – Cold Spells & Heavy Snowfall

Key to colour coding of impact ratings: Catastrophic; Major; Moderate; Minor; Negligible

County Monaghan has experienced cold spell and heavy snowfall events over the period 1985-2022 with significant events reported for 2018 (the 'Beast from the East'), January 2019 and March 2022. These events have wide ranging impacts across the County including disruption of transport routes, damage to buildings, and isolation of communities.

Hazard & Frequency	Exposure	Impact Description	Rating
Cold spell Common	Assets	• Cold spells have resulted in road closure, transport disruption and increased maintenance and repair costs across the county. • Freeze thaw action has resulted in damage to critical infrastructure (e.g., water infrastructure) and building stock. • Extreme cold conditions in combination with snowfall have resulted in the widespread closure of business (incl. LA business services).	Major
	Health and Wellbeing	• Extreme cold has resulted in treacherous conditions and increased incidence of slips and falls. • Exposure to extreme cold has had detrimental impacts for outdoor workers and vulnerable populations.	Moderate
	Environment	• Cold spells have led to decreased water availability and have detrimental impacts for biodiversity and habitats, resulting in a decrease of ecosystem health. • Increased use of salt on roads could pose water pollution issues.	Moderate
	Social	• Road closures have resulted in social isolation for remote communities. Treacherous conditions were reported on local roads across Monaghan during Storm Emma. • Elderly and vulnerable populations are required to stay in place resulting in isolation.	Minor
	Cultural Heritage	• Freeze thaw has been identified as having detrimental impacted on the structural integrity of cultural heritage sites.	Minor
	Financial	• The financial implications of cold spells are primarily associated with maintenance and repair costs for local and regional roads, buildings and assets, and can be significant.	Moderate
	Reputational	• Isolation of communities and council response (e.g., gritting) across the county receives media attention but with limited reputational impact for County Monaghan.	Minor
Heavy snowfall Common	Assets	• Heavy snowfall has resulted in road closures and transport disruption as evidenced with the closure of roads around Ballybay in February 2021, and with dangerous driving conditions across the county. • Accumulations of snowfall on roofs results in damage to buildings. Flooding post-heavy snowfall events results in the flooding of assets (e.g., roads and infrastructure).	Major
	Health and Wellbeing	• Extreme cold events have resulted in treacherous conditions and increased incidence of slips and falls amongst public and staff.	Moderate
	Environment	• Flooding post-heavy snowfall event results in overland flow of pollutants to habitats and ecosystems with detrimental effects.	Moderate
	Social	• Road closures can result in significant social isolation for remote communities.	Minor
	Cultural Heritage	• Accumulations of heavy snowfall can result in damage to cultural heritage sites.	Minor
	Financial	• The financial implications of cold spells are primarily associated with maintenance and repair costs for local and regional roads, buildings and assets. During Storm Emma, Monaghan County Council carried cleared and gritted national roads.	Moderate
	Reputational	• Isolation of communities and council response (e.g., gritting) across the county receives media attention but with limited reputational impact for the county.	Minor

Impacts of Current Climate Risks - Windstorms

County Monaghan has been frequently exposed to wind storms over the period 1985-2022, notable examples being Storms Eleanor (2018), Barra (2021) and Eunice (2022). Impacts have been experienced across the county and relate to disruption of transport, electricity and communication networks. Severe windstorms also result in health and safety risks, e.g. associated with treefall.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

Hazard & Frequency	Exposure	Impact Description	Rating
Severe windstorm Frequent	Assets	• Windstorms has caused direct damage to building stock and other assets. • Windstorm damage to power and communication transmission infrastructure (e.g., tree fall on overhead lines) has resulted in disruption of communications and energy supply. During Storm Barra in 2022, over 2,500 houses across the county lost power. Locations primarily affected included Ballybay, Drumbear, Telaydan, Carrickmacross, Cornamundy and Aghaloughan. • Windstorms have caused disruption of transport routes as a result of treefall. Storm Eleanor in 2018 caused 20 roads to be either blocked or affected by fallen trees, including national roads such as the N12 at Drumrutagh and the N54 at Smithborough.	Moderate
	Health and Wellbeing	• Windstorms posed a health and safety risk with potential for injury.	Minor
	Environment	• Windstorms have resulted in loss of trees and this is particularly the case for vulnerable tree species. During Storm Eunice in 2022, Monaghan County Council reported approximately 22 incidents of fallen trees and road disruption. • Windstorms prevent council staff from safely taking accurate water samples from lakes, hindering monitoring of water quality.	Negligible
	Social	• Severe windstorms and disruption of transport and communication networks has resulted in isolation of communities. As a result of Storm Eleanor in 2018, Eir saw 50 sites affected nationally. Three and Vodafone had 71 and 30 affected sites respectively.	Minor
	Cultural Heritage	• Severe wind storms can cause structural damage to cultural heritage sites.	Minor
	Financial	• The financial impacts of severe wind storm are associated with clean-up and repair cost.	Minor
	Reputational	• Reputational damage as a result of wind storms is limited and associated with short term media reporting on council preparedness and response.	Minor

Impacts of Current Climate Risks - Pluvial and Fluvial Flooding

For County Monaghan in the period 1985-2022, pluvial and fluvial flooding have occurred on a common basis. Areas of exposure to fluvial flooding are limited geographically but with the potential for frequent exposure. Notable pluvial events include flooding in Castleblayney in 2021 and Monaghan town in 2022.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

Hazard & Frequency	Exposure	Impact Description	Rating
 **Pluvial flood** **Common**	**Assets**	• Pluvial flooding has resulted in the temporary inundation of assets. • Pluvial flooding results in disruption to transport networks. In February 2022, intense rainfall associated with storms Dudley, Eunice and Franklin caused considerable disruption to traffic in the centre of Monaghan town	**Minor**
	Health and Wellbeing	• Heavy precipitation and floodwater leads to dangerous driving conditions for both council staff and public	**Negligible**
	Environment	• Pluvial flooding has resulted in the overland flow of pollutants (nutrients, sediment and pesticides) with impacts on terrestrial and freshwater ecosystems. • Pluvial flooding can cause landslides and damage to local habitats.	**Minor**
	Social	• Road closures can result in significant social isolation for communities. • Flooding can impact on development. Concerns around flooding and flood management have hindered the development of an Aldi supermarket in Monaghan town centre.	**Minor**
	Cultural Heritage	• Pluvial flooding puts built heritage with stone cavities at risk of soakage and leakage.	**Negligible**
	Financial	• The financial implications of emergency response (e.g. pumping and emergency co-ordination, clean-up and repair) can be significant. • Increased budget pressure to adapt to impact of climate change, e.g. flood protection measures and upgrading of existing drainage systems.	**Minor**
	Reputational	• Pluvial flooding issues are localised but can result in reputational damage to the council.	**Moderate**
 **River flood** **Common**	**Assets**	• River flooding has resulted in the temporary inundation of buildings. Flooding in January 2021 limited access to homes in Castleblayney. • River flooding has resulted in disruption to transport networks. In December 2021 the L-16202-0 experienced flooding leading to dangerous driving conditions. • River flooding and fast flowing rivers can cause damage to bridges through hydrodynamic scour	**Minor**
	Health and Wellbeing	• Heavy precipitation and floodwater leads to dangerous driving conditions for both council staff and public • Fluvial floods can carry debris which can lead to injury of residents and pedestrians	**Minor**
	Environment	• River flooding can result in the overland flow of pollutants (nutrients, sediment and pesticides) with impacts on terrestrial and freshwater ecosystems.	**Minor**
	Social	• Road closures can result in significant social isolation for communities • Inhibited development of communities as a result of frequent river flooding	**Minor**
	Cultural Heritage	• A number of the county's cultural heritage and archaeological sites are situated near river systems and are particularly exposed to river flooding.	**Negligible**
	Financial	• The financial implications of fluvial flooding are associated with Increased costs associated with preparedness (e.g., sandbags and demountable defences) emergency response (e.g. pumping and emergency co-ordination), clean-up and repair.	**Minor**
	Reputational	• For areas that are subject to frequent inundation, there is the potential for localised reputational damage.	**Minor**

3.2.3 Impact Assessment (Service Delivery)

Summary of Service Level Impacts

Key to colour coding of impact ratings
Catastrophic
Major
Moderate
Minor
Negligible

The impacts of climate change hazards on County Monaghan will have direct and indirect consequences for the delivery of services by Monaghan County Council before, during and after climate and weather-related event.

On the basis of reported information and in consultation with Monaghan County Council, an assessment of the impacts of identified climate change hazards and impacts on the delivery of services by Monaghan County Council was undertaken in accordance with the criteria provided through Technical Annex B: Climate Change Risk Assessment (Appendix 2), with each service delivery area assigned an impact category of either negligible, minor, moderate, major, or catastrophic.

Below we provide a summary of the impacts on the delivery of services of Monaghan County Council as a result of the climate hazards identified within the climate hazard profile. This assessment was undertaken in accordance with the criteria provided through ***Technical Annex B: Climate Change Risk Assessment (see appendix 1)***, with each service delivery area assigned an impact category of either negligible, minor, moderate, major, or catastrophic. The following pages provide the detailed information that informed this assessment.

Hazard	Business Services	Roads, footpaths, bridges: construction and maintenance	Building Stock	Community Infrastructure	Cultural Heritage	Stormwater / Sewerage	Wastewater	Water Supply	Water Quality	Biodiversity	Community Development	Emergency Response
Heatwave	Minor	Moderate	Minor	Minor	Minor	None	None	Minor	Minor	Moderate	Minor	Moderate
Drought	None	None	Minor	Minor	Minor	None	Minor	Minor	Minor	Moderate	Minor	Minor
Cold Spell	Moderate	Major	Moderate	Moderate	Minor	Moderate	Moderate	Moderate	Moderate	Minor	Moderate	Moderate
Heavy Snowfall	Moderate	Moderate	Moderate	Moderate	Minor	Minor	Minor	Minor	None	None	Moderate	Minor
Severe Windstorm	Moderate	Moderate	Moderate	Moderate	Moderate	None	Moderate	Moderate	Minor	Minor	Moderate	Moderate
Pluvial Flood	Minor	Moderate	Minor	Minor	Minor	Minor	Minor	Minor	Moderate	Negligible	Moderate	Minor
River Flood	Minor	Moderate	Moderate	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Moderate

Service Level Impacts (Heatwaves & Drought)

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

Heatwaves and drought result in a range of impacts for service provision by Monaghan County Council. The primary impacts of heatwave relate to increased maintenance and repair requirements of road surfaces and increased pressure on emergency services. Decreased levels of water supply due to drought conditions put increased pressure on LA staff working under the Service Level Agreement (SLA) with Irish water. In addition, high temperatures result in staff and public discomfort and an increased requirement for mechanical and passive cooling. Heatwaves and drought put additional pressure on community infrastructure such as parks.

	Heatwaves	Drought
Business Services	• Decreased staff productivity and increased staff and customer discomfort.	• None
Roads, footpaths, bridges, construction and maintenance	• Increased costs associated with repair of road surfaces across the county. • Increased health and safety risk for outdoor staff members across the county.	• None
Building Stock	• Increased requirement for cooling in local council offices/buildings.	• Increased requirement for water supplies. • Implementation of drought prevention measures.
Community Infrastructure	• Increased requirement for waste collection and traffic management at key local recreational sites.	• Increased pressure on key local recreational sites to operate with limited water resources.
Cultural Heritage	• Increased requirements for monitoring and maintenance of cultural heritage sites.	• Localised degradation of cultural heritage sites due to drying out. • Increased requirements for monitoring and maintenance of cultural heritage sites.
Stormwater / Sewerage	• None	• None
Wastewater	• None	• Less assimilation capacity in watercourses due to reduced flows.
Water Supply	• Increased supply demand for water to cool infrastructure, communities, and livestock in local areas. • Implementation of water conservation measures (e.g., hosepipe bans) in local areas.	• Increased requirement to support provision of water to local communities suffering loss of water supply (e.g., Tankering).
Water Quality	• Reduced water flows impacting on water quality in local areas with increased requirement for monitoring and remediation.	• Reduced water flows impacting on water quality in local areas with increased requirement for monitoring and remediation.
Biodiversity	• Decreased ecosystem health across the county with potential for loss of priority habitats resulting in increased requirement for monitoring and remediation. • Loss of habitats due to wildfires.	• Reduced water flows impacting on biodiversity with potential for loss of priority species and habitats necessitating increased monitoring and remediation. • Loss of habitats due to wildfires.
Community Development	• Increased requirement for management at congested sites.	• Reduced grass growth causing increased supplementary feed requirement for cattle reducing farm incomes and the wider industry.
Emergency Response	• Increase in number of wildfire call-outs across the county. • Increase in number of call out to bathing areas throughout the county.	• Increase in number of localised uncontrolled fire call-outs.
Crosscutting	• None	

Service Level Impacts (Cold Spell & Heavy Snowfall)

Cold spells and heavy snowfall have significant impacts across County Monaghan with direct and indirect consequences for the delivery of services by Monaghan County Council. Impacts are related primarily to maintenance and repair of road surfaces and water infrastructure, closure of local authority offices and services, and increased demand on emergency response.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

	Cold Spell	Heavy Snowfall
Business Services	• Closure of business services across the county. • Health and safety risks for public and staff.	• Closure of business services across the county • Health and safety risks for public and staff
Roads, footpaths, bridges, construction and maintenance	• Severe transport disruptions and road closures. • Increased costs associated with gritting and salting roads across the county. • Increased repair and maintenance costs.	• County wide transport disruptions and road closures. • Increased costs associated with gritting and salting roads and footpaths around the county.
Building Stock	• Increased energy costs for buildings county wide. • Increased health and safety risks for public and staff countywide.	• Increased energy costs for buildings countywide. • Increased health and safety risks for public and staff countywide.
Community Infrastructure	• Increased energy costs in community buildings across the county. • Increased health and safety risks for public and staff working in community buildings.	• Increased health and safety risks for public and staff. • Closure of services throughout the county.
Cultural Heritage	• Increased energy costs for local cultural heritage sites. • Increased health and safety risks for public and staff at local community heritage sites.	• Increased health and safety risks for public and staff. • Localised closure of sites.
Stormwater / Sewerage	• Reduced capacity for drainage resulting in standing water due to post cold spell events. • Damage to stormwater infrastructure with increased requirement for maintenance and repair across the county.	• Reduced capacity for drainage resulting in standing water due to post cold spell events. • Damage to stormwater infrastructure with increased requirement for maintenance and repair in local areas.
Wastewater	• Overland flows of pollutants due to post freezing events, causing contamination of water supplies necessitating increased monitoring and remediation. • Damage to wastewater infrastructure with increased requirement for maintenance and repair.	• Overland flows of pollutants due to post snowfall events, causing contamination of water supplies necessitating increased monitoring and remediation in local areas .
Water Supply	• Countywide water supply issues due to damaged water supply infrastructure (e.g., burst pipes). • Increased maintenance and repair costs of water service infrastructure across the county.	• Localised water supply issues due damaged water supply infrastructure (e.g., burst pipes). • Increased maintenance and repair costs of water service infrastructure.
Water Quality	• Reduction and disruption of water supplies across the county due to decreased water quality necessitating increased requirement on council to supply water to affected communities.	• None
Biodiversity	• Prolonged cold spells impacting species not protected from the frigid temperatures in local communities requiring increased monitoring and remediation.	• None
Community Development	• Increased instances of community isolation county wide. • Significant impact on the county's economy.	• Increased instances of community isolation across the county • Significant impact on the economy of local communities.
Emergency Response	• Increased pressure on emergency response units across the county.	• Increased pressure on emergency response units in local areas. • Increase in response times due to heavy snowfall on local roads.
Crosscutting	• None	

Service Level Impacts (Severe Windstorm)

Severe windstorms can result in the closure and/or disruption of Monaghan County Council Offices and services. The primary impacts of severe windstorms are associated with the disruption of services and infrastructure due to loss of power supply and communications, damage to local authority assets and infrastructure, increased pressure on emergency response and redeployment of staff to support clean-up following a severe windstorm event.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

	Severe Windstorm
Business Services	• Closure of business services across the county. • Health and safety risks for public and staff
Roads, footpaths, bridges, construction and maintenance	• Countywide transport disruption and road closures affecting the wider community and local authority operations. • Increased clean-up and repair costs after weather events for areas all over the county. •
Building Stock	• Closure of buildings and disruption of services as a result of direct damage to buildings and disruption of power
Community Infrastructure	• Disruption to delivery of community services across the county • Increased clean-up and repair costs after an event
Cultural Heritage	• Increased maintenance and repair costs due to storm damage to cultural heritage sites
Stormwater / Sewerage	• None
Wastewater	• Increased drain maintenance costs for wastewater infrastructure across the county.
Water Supply	• Countywide water supply issues due to damaged water supply infrastructure.
Water Quality	• Disruption to water quality monitoring in local areas.
Biodiversity	• High winds result in damage to habitats in local areas. • Increased cost to protect habitats from wind damage in local areas.
Community Development	• Increased power outages and damages to infrastructure result in an impact on the county's economy.
Emergency Response	• Increased pressure on emergency services across the county. • Increase in response times due to heavy snowfall on roads around the county
Crosscutting	• None

Service Level Impacts (Pluvial & River Flood)

Pluvial and river flooding have resulted in a wide range of impacts for Monaghan County Council. Impacts are primarily associated with transport disruption, clean-up and repair costs, water quality issues due to overland flows of pollutants, damage to environmentally sensitive areas, increased pressure on emergency response services and supporting communities during and following flood events.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

	Pluvial Flood	River Flood
Business Services	• Localised disruption and closure of local authority services	• Localised disruption and closure of local authority services
Roads, footpaths, bridges, construction and maintenance	• Transport disruption and road closures across the county. • Increased clean-up and repair costs after weather events around the county.	• Transport disruption and road closures across the county. • Increased clean-up and repair costs after weather events around the county.
Building stock	• Increased maintenance and repair costs in local areas. • Increased requirement for flood defence measures in local communities.	• Increased maintenance and repair costs • Increased requirement for flood defence measures
Community infrastructure	• Closure of community infrastructure and services at a localised level. • Increased repair and maintenance costs	• Localised closure of community infrastructure and services. • Increased repair and maintenance costs.
Cultural Heritage	• Damage to local heritage sites due to pluvial flooding requiring repair work. • Increased maintenance and repair costs for local heritage sites.	• Damage to local heritage sites due to river flooding requiring repair work • Increased maintenance and repair costs for local heritage sites.
Stormwater / Sewerage	• Reduced capacity for drainage resulting in standing water in local areas. • Damage to stormwater infrastructure at a localised level • Increased maintenance and repair costs for local communities.	• Reduced capacity for drainage resulting in standing water in local areas. • Increased maintenance and repair costs for local communities.
Wastewater	• Damage to local wastewater treatment plants • Increased maintenance and repair costs for wastewater treatment plants in local areas.	• Damage to local wastewater treatment plants. • Increased maintenance and repair costs for wastewater treatment plants in local areas.
Water Supply	• Water supply issues at a localised level requiring supplemental water provision (e.g., tankering) • Increased water treatment costs in local areas.	• Water supply issues at a localised level requiring supplemental water provision (e.g., tankering)
Water Quality	• Deterioration of water quality across the county due to overland flow of pollutants resulting in water supply issues and environmental degradation and an increased requirement for monitoring and remediation.	• Deterioration of water quality in local areas due to overland flow of pollutants resulting in water supply issues and an increased requirement for monitoring and remediation
Biodiversity	• Negligible damage to environmentally sensitive areas requiring monitoring and/or slight restoration work.	• Isolated and limited damage to local environmentally sensitive areas requiring monitoring and/or restoration work
Community Development	• Inhibited development of communities at a county wide level. • Damage to buildings and travel disruptions impact on the economy of County Monagahan.	• Inhibited development of impacted communities
Emergency Response	• Localised increased pressure on emergency response	• Increased pressure on emergency response across the county.
Crosscutting	• Staff redeployment	

3.2.4 Current Climate Risk Matrix

Current Climate Risk Matrix

Based on reported information and in consultation with Monaghan County Council, a current climate risk matrix for County Monaghan has been developed based on the frequency of hazard and the associated level of impact.

The assessment identified **severe windstorm** as posing the highest level of risk for County Monaghan with impacts primarily associated with disruption and damage to energy, communication and transport networks.

Cold spells and heavy snowfall occur on common basis across County Monaghan resulting in damages to critical energy, communication and water infrastructure while closure of transport infrastructure has the potential to result in isolation of remote communities.

River and pluvial flooding have also been identified as occurring on common basis in County Monaghan with impacts experienced including damage to assets and infrastructure, disruption of transport networks and mobilisation of pollutants with detrimental impacts on bathing water areas.

Heatwaves occur on an occasional basis across County Monaghan; however, the overall impact is currently considered minor. The impacts of heatwaves are associated with an increase in damage to road surfaces, increased incidence of uncontrolled fire and increased pressure on recreational sites

During the current period, **droughts** have occurred on an occasional basis but with relatively minor impacts and are associated with increased disruption of water supply.

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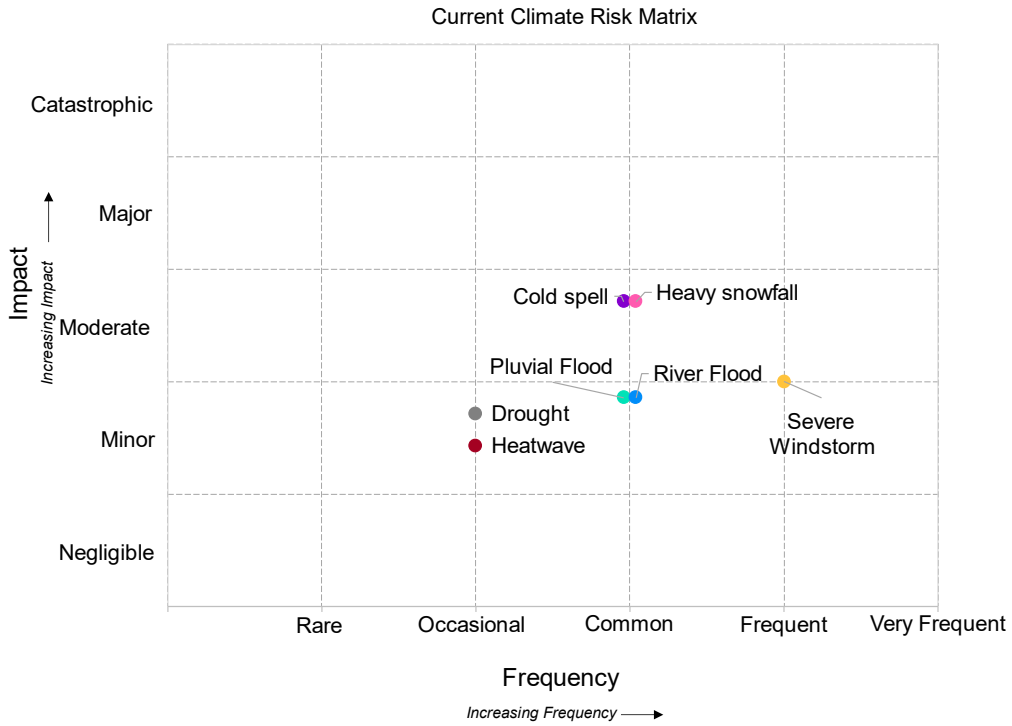


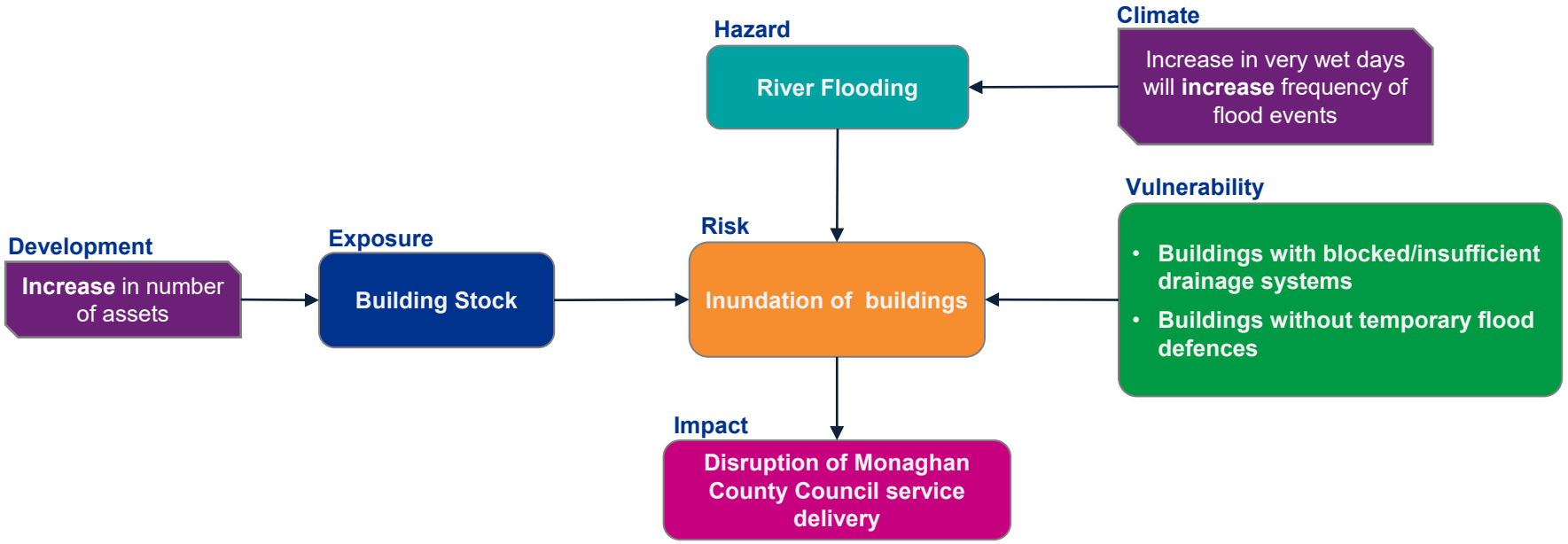
The risk matrix above shows the current risk for the identified hazards for County Monaghan.

3.3 Future Climate Risks and Impact Assessment

Future Climate Risk and Impact

Climate risks may increase, decrease, or emerge in the future due to a change in either the frequency and severity of climate hazards and/or changes in exposure and vulnerability. In the example below, the risk of inundation due to river flooding will increase due to an increase in the number of very wet days (> 30 mm precipitation) leading to an increase in the frequency of river flood events. Furthermore, there is likely to be an increased population in the region, possibly resulting in new buildings being constructed. This will potentially increase the number of assets exposed to river flooding. Therefore, due to changes in both the hazard and exposure, the risk of inundation of Monaghan County Council buildings will increase in the future.

In the following sections, we provide an assessment of potential future changes in the climate of County Monaghan by 2050 and its effects on the frequency of hazard occurrence. An assessment of the future changes in the population and development in the region by 2050 that could affect exposure and vulnerability was also undertaken. Finally, considering all three components, the future climate risk was assessed.

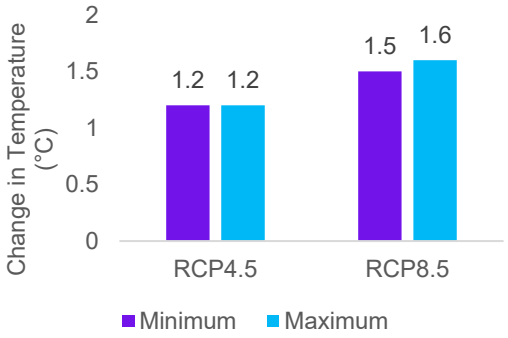


3.3.1 Future Changes in Climate Hazards

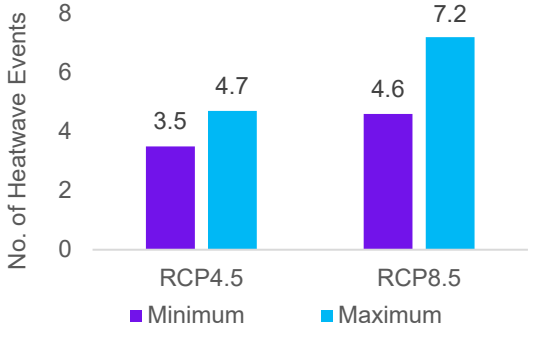
Climate Projections for County Monaghan in 2050 (1/2)

Having identified and assessed the range of climate hazards and impacts already experienced across County Monaghan, projected changes in the frequency and intensity of climate hazards (acute and chronic) were assessed to understand how existing climate impacts and risks faced by County Monaghan may change in the future. The information below summaries the climate projections for each hazard based on Nolan and Flanagan (2020).

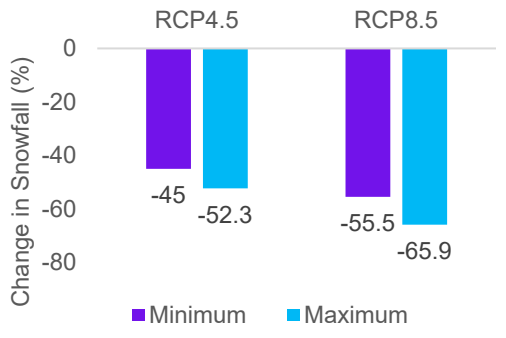
Hazard	Projected Change	Future Frequency
Heatwaves	• Projections indicate **an overall increase in average temperature** (bottom left) of between 1.2 and 1.6°C for County Monaghan relative to the 1981-2000 period. • Under a high emission scenario, projections indicate that heatwaves will become more frequent (bottom middle) by mid century.	Common
Droughts	• **Summer rainfall is expected to reduce** by between 5 and 11% in the future when compared with the baseline period of 1981 to 2000, in both the RCP4.5 and RCP8.5 scenario contributing to potential drought conditions.	Common
Cold Spell	• As a consequence of projected temperature increases and for both the RCP4.5 and RCP8.5 scenario, **a decrease in the number of frost days and ice days** is projected for the period 2041-2060 when compared with the baseline period of 1981 to 2000.	Occasional
Heavy Snowfall	• Annual **snowfall** in the region is projected to decrease substantially by the middle of the century for the RCP4.5 and RCP8.5 scenarios (bottom right).	Occasional
Severe Windstorms	• **Projections of storms are subject to a high level of uncertainty**. By mid century, projections indicate that average wind speed will remain similar to those currently experienced. There is limited evidence of a potential increase in the frequency of more intense storms which are currently rare events. However, more research is needed to confirm this increase.	Frequent



The projected minimum and maximum **increase in the mean annual temperature** for the area of County Monaghan for the period 2041-2060 compared to 1981-2000 for the medium (RCP4.5) and high (RCP8.5) emissions scenario *(Source: Nolan and Flanagan, 2020)*



The projected minimum and maximum **number of heatwaves** for the area of County Monaghan for the period 2041-2060 compared to 1981-2000 for the medium (RCP4.5) and high (RCP8.5) emissions scenario *(Source: Nolan and Flanagan, 2020)*

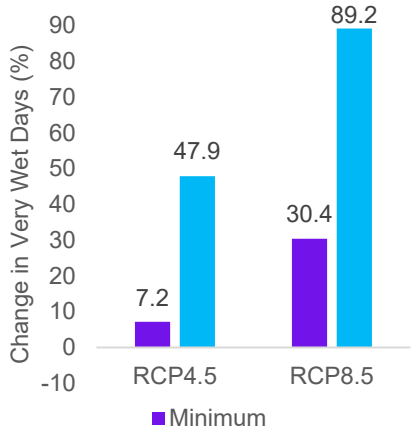


The projected minimum and maximum **reduction in snowfall (> 30 mm)** for the area of County Monaghan for the period 2041-2060 compared to 1981-2000 for a medium (RCP4.5) and high (RCP8.5) emissions scenario *(Source: Nolan and Flanagan, 2020)*

Climate Projections for County Monaghan in 2050 (2/2)

Having identified and assessed the range of climate hazards and impacts already experienced across County Monaghan, projected changes in the frequency and intensity of climate hazards (acute and chronic) were assessed to understand how existing climate impacts and risks faced by County Monaghan may change in the future. The information below summaries the climate projections for each hazard based on Nolan and Flanagan (2020).

Hazard	Projected Change	Future Frequency
Pluvial Flooding	• Projections indicate an **increase in the frequency of heavy rainfall days** (days with precipitation >30mm) for County Monaghan with some areas projected to see increase of up to 89% (bottom). This will likely result in an increase in the frequency of associated fluvial and pluvial flooding.	Frequent ↑
River Flooding		Frequent ↑



The projected minimum and maximum **increase in very wet days (> 30 mm)** for the area of County Monaghan for the period 2041-2060 compared to 1981-2000 for a medium (RCP4.5) and high (RCP8.5) emissions scenario *(Source: Nolan and Flanagan, 2020)*

3.3.2 Future Changes in Exposure and Vulnerability (incl. Emerging Risk)

Projected Changes in Exposure and Vulnerability

In the future, County Monaghan will change in terms of its population and developments. This will potentially affect the exposure and vulnerability of people and assets within the region. National, regional and local strategies that outlined expected and possible sociodemographic and infrastructure developments within County Monaghan were reviewed to understand how exposure and vulnerability may change by 2050. A summary of the results of this review are shown below.

How is Ireland projected to change by 2040?

- Extra **1m population**, 500,000 in rural areas / regional centres
- Extra 660,000 jobs

- Extra **550,000 homes**
- 'Housing for All' promotes a 'town centre first' approach

Cross-Sectoral National Priorities:

- Infrastructure and Services
- Climate Change Adaptation & Mitigation
- Regeneration, Repopulation, Resilience

How is County Monaghan projected to change?

- Population is projected to increase from **61,000** in 2016 to **69-71,000** in 2031 (NPF)
- Population of Monaghan Town is expected to grow by **c.1,700** by 2025 (CDP)
- **3,056** new housing units required by 2028 (ESRI NPF scenario)
- Shift towards living in urban areas where services and facilities are generally located, with more compact urban forms and redevelopment of existing urban areas in accordance with the National Planning Framework.

"It also targets 30% of new housing to be within the existing urban footprint of our towns and villages..."

Monaghan County Development Plan (2019-25)

Planning for adaptation

Wetland Action Plans:

- The council has been involved in the development of a Wetland Action Plan (2020-2021) which aims to enable the rehabilitation and restoration of the County's wetland resource. The plan also focuses on matters including sequestration improvement, flood mitigation and biodiversity protection.

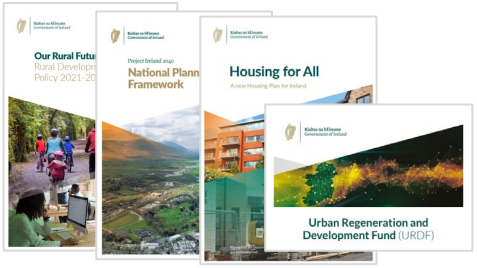
Key national road infrastructure projects for the council include:

- Upgrade Works to the Emyvale Road/N2
- N2 Clontibret to Border
- N2 Ardee to Castleblayney

Notable renewable energy initiatives include:

- 9 Sustainable Energy Communities (SEC)

Planning for mitigation



Case Study in Urban Planning: Dublin Street Regeneration Project

€13.11 million was awarded for the Dublin Street Regeneration Project in Monaghan town under the Urban Regeneration Development Fund (URDF).

- The Dublin Street Regeneration project aims to regenerate a large brownfield site in the core of Monaghan Town.
- The project aims to create new linkages between land-locked brownfield lands and the existing town street network, and to create new public spaces.

Future Exposure and Vulnerability (1/2)

In addition to the changes in the frequency of hazard events, future risk is also driven by the changes in exposure and vulnerability of assets. In order to estimate the potential change in risk, a number of assumptions have been made in relation to the seven impact areas, which are outlined below.

Assets	• Due to the expected increase in County Monaghan's population, there will be an **increase in the associated households and infrastructure** resulting in an increase in the number of assets exposed to hazard events • Due to the expected increase in the frequency of heatwaves, **road assets will be more regularly exposed to extreme temperatures** and **drought** conditions with the potential for increased damage to roads • Pluvial and river flooding events that were once considered extreme, will become more frequent. This will **increase damage in the areas already exposed to these hazards** and also expose new areas and therefore assets that were previously unaffected
Health and Wellbeing	• Due to the expected increase in the elderly population in County Monaghan there will be **a greater number of vulnerable people who are more sensitive to hazards**, particularly heatwaves • Pluvial and river flooding events that were once considered extreme, will become more frequent. Consequently, people will be more frequently exposed to flooding hazards, and higher flood levels which will mean **people previously unaffected by flooding may become exposed.** This could impact on both physical and mental health and wellbeing
Environment	• The potential increasing occurrence of heatwaves and drought conditions within County Monaghan will mean **increased temperatures in water bodies and lower water levels** which can decrease water quality resulting in short and long term impacts on the environment • Due to the potential increased frequency of exposure to hazards in County Monaghan, there could be an **increase in the impact on environmental assets** as the time/ability for the habitat/environment to recover is reduced • Pluvial and river flooding events that were once considered extreme, will become more frequent. Consequently, environmental assets will be more frequently exposed to flooding hazards, and higher flood levels will mean **environmental assets previously unaffected by flooding may become exposed** resulting in short and long term damage to habitats/environment by these hazards

Future Exposure and Vulnerability (2/2)

In addition to the changes in the frequency of hazard events, future risk is also driven by the changes in exposure and vulnerability of assets. In order to estimate the potential change in risk, a number of assumptions have been made in relation to the seven impact areas, which are outlined below.

Social	• Due to the expected increase in the total and elderly population in County Monaghan there will be an **increase in the number of people affected by social isolation during some hazard events** • In response to heatwaves, there will be an increased use of blue/green spaces by the public **putting increased pressure on local amenities** e.g. littering, traffic problems
Cultural Heritage	• Due to the potential increase in frequency of heatwave and drought events, **degradation rates will potentially increase resulting in an increase in the impact of cultural heritage assets** • Pluvial and river flooding events that were once considered extreme, will become more frequent. Consequently, **cultural heritage assets will be more frequently exposed to flooding hazards,** and higher flood levels will mean cultural heritage assets previously unaffected by flooding may become exposed resulting in short and long term damage to habitats/environment by these hazards
Financial	• Due to the potential increase in frequency of hazard events and exposure across County Monaghan, there will be an **associated increase in the actions the local authority takes before, during, and after and event.** • As a consequence, there will be an **increase in the costs associated with dealing with the events**, e.g. air conditioning, emergency service response, temporary and permanent flood defences, staff, training, and equipment purchase/maintenance
Reputational	• Due to the potential increase in frequency of hazard events and exposure across County Monaghan during an event there will be an **increasing demand/pressure on services/resources** potentially reducing the level of service delivery and harming the reputation of the local authority • For hazards which are existing long-term issues in County Monaghan, e.g. river flooding, if the response to the increased frequency and severity events is deemed insufficient by the public, this **may negatively impact on the reputation of the local authority**

Future Impacts

Taking into account the changes in exposure and vulnerability, the future change in impacts for each of the seven hazards was assessed. The potential future changes in impact are outlined below with the change in impact shown in bold.

Hazard	Assets		Health and Wellbeing		Environment		Social		Cultural Heritage		Financial		Reputational	
	Current	Future (2050)	Current	Future (2050)	Current	Future (2050)	Current	Future (2050)	Current	Future (2050)	Current	Future (2050)	Current	Future (2050)
Heatwave	Negligible	**Minor**	**Minor**	**Moderate**	**Minor**	**Moderate**	**Minor**	**Moderate**	Negligible	**Minor**	Negligible	**Minor**	Negligible	**Minor**
Drought	Negligible	**Minor**	Negligible	**Minor**	**Moderate**	**Major**	**Minor**	**Moderate**	**Minor**	**Moderate**	Negligible	**Minor**	**Minor**	**Moderate**
Cold Spell	Major	Major	Moderate	Moderate	Moderate	Moderate	Minor	Minor	Minor	Minor	Moderate	Moderate	Minor	Minor
Heavy Snowfall	Major	Major	Moderate	Moderate	Moderate	Moderate	Minor	Minor	Minor	Minor	Moderate	Moderate	Minor	Minor
Severe Windstorm	Moderate	Moderate	Minor	Minor	Negligible	Negligible	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor
Pluvial Flood	**Minor**	**Moderate**	Negligible	**Minor**	**Minor**	**Moderate**	**Minor**	**Moderate**	Negligible	**Minor**	**Minor**	**Moderate**	**Moderate**	**Major**
River Flood	**Minor**	**Moderate**	**Minor**	**Moderate**	**Minor**	**Moderate**	**Minor**	**Moderate**	Negligible	**Minor**	**Minor**	**Moderate**	**Minor**	**Moderate**

3.3.3 Future Climate Risk Matrix

Future Climate Risk Matrix

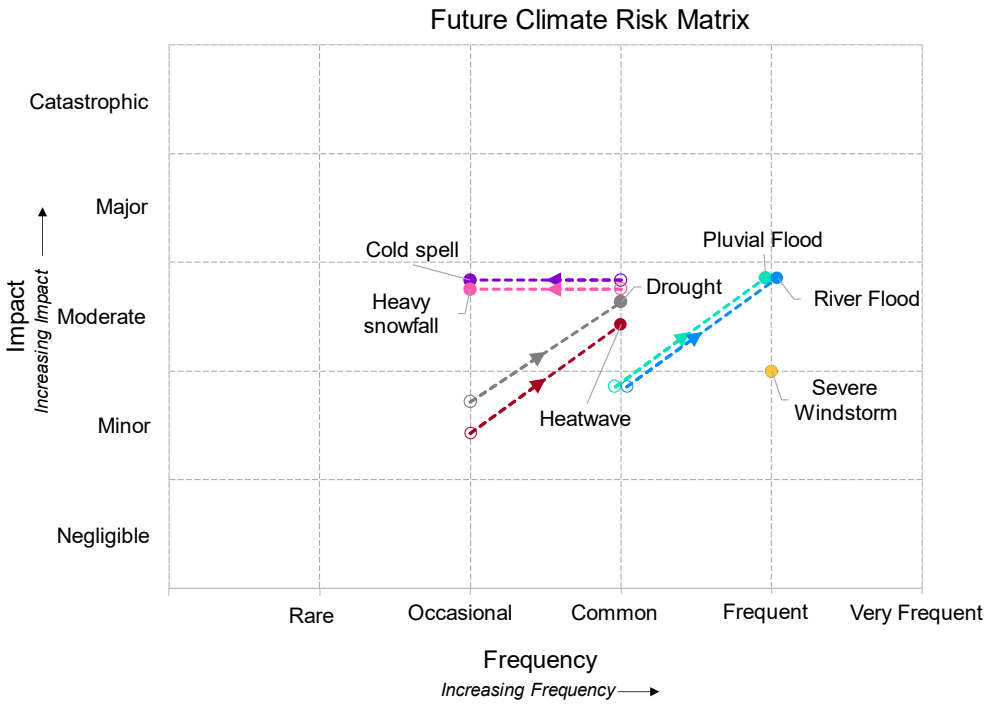
Projected changes in the hazard, exposure, and vulnerability, combine to form an assessment of future risks across County Monaghan. The risk matrix on the right shows the future change in risk with the hollow marker showing the current risk and the solid marker the future risk. The dotted line shows the change between the current and future risk.

The **risk** of existing hazards such as **river and pluvial flooding** are projected to **increase** as a result of projected increases in the frequency of hazard events and also due to an increase in the areas, assets and populations exposed to these hazards.

Heatwaves and droughts although already experienced in County Monaghan are expected to occur more frequently due to climate change and with a greater impact on County Monaghan in the future. The impact is exacerbated by not only projected changes in frequency of occurrence of heatwaves but also as a result of projected increases in population and the proportion of population considered vulnerable (those aged 65 years and over). These hazards can be therefore be considered as **emerging risks** for the region.

Although the frequency and impact of **severe windstorms** is projected to be **unchanged in the future**, these events will remain a risk for County Monaghan.

The impact of **heavy snowfall and cold spells** on County Monaghan remains constant, however, due to the potential decrease in hazard frequency, the overall risk associated with these hazards is likely to reduce in the future, resulting in less risk.



The risk matrix above shows the future changes in risk for the identified hazards within County Monaghan. For each hazard there is a solid marker, which identifies the future risk, and a hollow marker showing the current risk. The dotted line in between these markers shows the change between the current and future risk.

3.3.4 Uncertainty Assessment

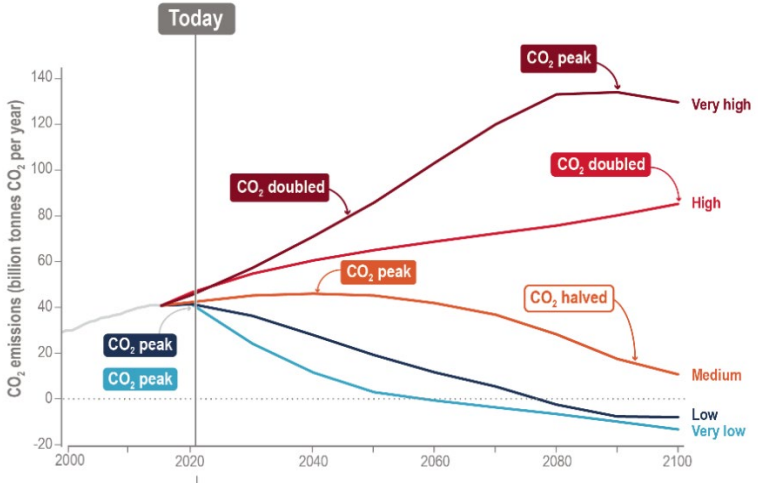
Uncertainty

In assessing future climate risks there are levels of uncertainty related to each of the three elements of risk, i.e., not only the magnitude and frequency of hazards but also the exposure and vulnerability to any given hazard.

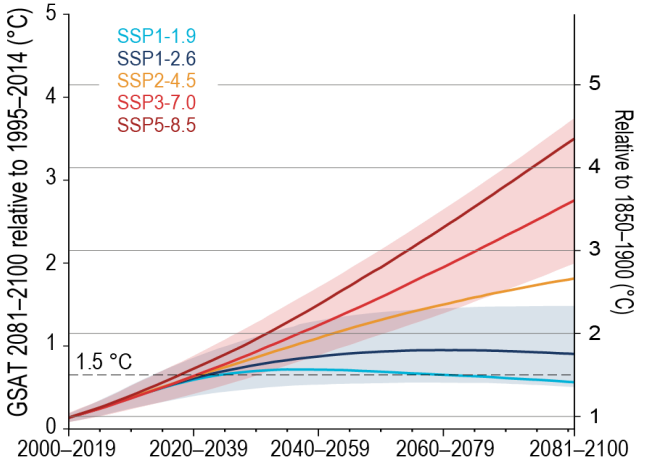
Different social and economic developments can lead to substantially different future emissions of carbon dioxide and other greenhouse gases (bottom left) resulting in uncertainty in what the future global climate will be. As an example of the possible future ranges in mean global surface temperature (bottom right) vary from below 1.5°C to over 4°C by 2100.

As a result of this uncertainty, climate projections include a range of scenarios, with SSP5-8.5 (AR6) or RCP8.5 (AR5) being the highest emission scenario and therefore the greatest change in future climate. When assessing climate risks with a qualitative approach, it is best practice to take a conservative or 'worst case scenario' to ensure that climate risks are not underestimated and dismissed as low or no risk. Climate risks identified within a qualitative risk assessment should be subsequently assessed using semi-quantitative or quantitative approaches to evaluate the risk in further detail.

Uncertainty also exists in relation to how County Monaghan will develop into the future. Although, in the near-term there is relatively good understanding as a result of strategies, such as the Monaghan County Development Plan 2019-2025, developments up to 2050 are less certain. A 'worst case scenario' approach has been taken here also, with the potential future impact being increased according to the indicative near-term trend and the assumption that adaptation actions are not implemented.



Annual emissions of CO_2 for the five core Shared Socio-economic Pathway (SSP) scenarios (very low: SSP1-1.9, low: SSP1-2.6, intermediate: SSP2-4.5, high: SSP3-7.0, very high: SSP5-8.5) (Source: IPCC AR6 Infographic TS.1).



Assessed projected change in mean global surface temperature for five future climate scenarios. Future global temperatures can vary from below 1.5°C to over 4°C by 2100 depending on the amount of future emissions (Source: IPCC AR6 Cross-Chapter Box TS.1, Figure 1).

3.4 Summary

Summary

This CCRA contained within this report provides an assessment of County Monaghan's climate change risks to support Monaghan County Council's efforts to prepare its LACAP. The CCRA has been carried out in line with the Local Authority Climate Action Plan Guidelines, Technical Annex B, drafted by the Climate Action Regional Offices (CAROs). The key results are summarised below:

- Recent **river** and **pluvial flooding** events in 2021 and 2022 demonstrated the typical type of impacts that Monaghan County Council is faced with, including, inundation of commercial and residential buildings, and transport disruptions (e.g. Monaghan Town). Projected increases in the frequency of extreme precipitation events will result in an increased river and pluvial flood risk for Monaghan
- **Severe windstorms** are currently experienced on a frequent basis in Monaghan with wide ranging impacts, including disruption to energy supply and transport networks across the county (e.g. fallen trees on the N12 and N54 in 2018). Future projections indicate no significant change in this frequency.
- **Heatwaves and droughts** have contributed to uncontrolled fires (e.g. 2018) and have also increased demand on available water resources, resulting in increased pressure on shared resources. Projected increases in the frequency of heatwaves and of drought conditions will mean that events, currently experienced on an infrequent basis, will become more frequent.
- Recent experiences of c**old spells and heavy snowfall** events in 2018 and 2021 had a wide range of impacts across Monaghan, such as closure of roads, disruption of transport networks, and damage to critical infrastructure (e.g., roads and water). Projected increases in average temperature and decreases in the frequency of snowfall indicate a decrease in the frequency of cold spells and heavy snowfall and associated impacts.

Limitations and Key Recommendations:

- This report has been developed on the basis of the most-up-to-date climate projection data available for Ireland at the time of writing. This data focuses on changes in average climatic conditions for a high emissions scenario (RCP8.5). Where risks have been identified as part of this initial qualitative CCRA, further more detailed assessment should be undertaken as part of semi-quantitative and/or quantitative site specific CCRAs which employ the full range of projected changes in climate parameters (including extremes) and more up-to-date climate projection information where available.
- This report focuses on the direct risks posed by climate change for County Monaghan and the implications of these for Monaghan County Council. It is important to note that climate change will also pose indirect risks for County Monaghan as a result of changes in climate conditions at international and global scales. These include amongst others forced migration of populations, increase in vector-borne disease and disruption of supply chains.

04
Appendices

4.1
Appendix 1

Glossary

Biodiversity: The variability among living organisms from terrestrial, marine and other ecosystems. Biodiversity includes variability at the genetic, species and ecosystem levels

Climate: The long-term average weather of area, usually taken over 30 years

Climate projection: A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models

Coastal erosion is the breaking down of land and removal of sediment and rocks by coastal processes. Factors affecting the rate of coastal erosion include sea level rise, strong wave action, and storms

Cold Spell: A sustained period of cold weather, where extreme low temperatures are recorded

Coastal Flooding: Coastal flooding occurs when sea levels along the coast or in estuaries exceed neighbouring land levels, or overcome coastal defences where these exist, or when waves overtop over the coast

Drought: A period of abnormally dry weather long enough to cause a serious hydrological imbalance

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected

Extreme weather event: An extreme weather event is an event that is rare at a particular place and time of year

Fluvial flooding occurs when rivers and streams break their banks and water flows out onto the adjacent low-lying areas (the natural floodplains)

Groundwater flooding occurs when the water table rises above the land surface. It generally requires sustained rainfall over relatively longer duration than other forms of flooding, its location is discontinuous, and they can last for weeks or months

Glossary

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Heat wave: A period of abnormally and uncomfortably hot weather

Heavy Snowfall: A substantial prolonged snowfall event resulting in substantial accumulations of snow on the ground over a period of consecutive days.

Landslide describes a wide variety of processes that result in the downward and outward movement of materials under the force of gravity

Pluvial flooding occurs when the amount of rainfall exceeds the capacity of urban storm water drainage systems or the ground to absorb it

Representative Concentration Pathways (RCPs): Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover

RCP4.5 and RCP6.0: Two intermediate stabilization pathways in which radiative forcing is stabilized at approximately 4.5 W/m2 and 6.0 W/m2 after 2100 (the corresponding ECPs assuming constant concentrations after 2150)

RCP8.5 One high pathway for which radiative forcing reaches >8.5 W/m2 by 2100 and continues to rise for some amount of time (the corresponding ECP assuming constant emissions after 2100 and constant concentrations after 2250)

Risk: The potential, when the outcome is uncertain, for adverse consequences on something of value (lives, ecosystems, assets, services, etc.)

Severe Windstorm: A windstorm is a wind that can cause at least light damage to trees and buildings, typically exceeds 34 mph (55 km/h), and may or may not be accompanied by rain

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt

4.2
Appendix 2

Service Area Descriptions

Acronym	Full form
Business Services	Corporate and customer facing services.
Roads, footpaths, bridges, construction and maintenance	Road and active travel, bridges, piers and harbours.
Building Stock	Local Authority buildings and social housing stock.
Community infrastructure	Recreation (incl. libraries and parks), tourism and economic development infrastructure.
Cultural Heritage	Arts and heritage protection.
Stormwater / Sewerage	Stormwater and sewerage infrastructure.
Wastewater	Foul and surface water sewers, water treatment plants and wastewater pumping stations.
Water Supply	Public water supply network (with Irish Water), public water treatment plant and pumping stations (with Irish Water) .
Water Quality	Water quality (rivers, lakes and marine).
Biodiversity	Biodiversity and habitat protection.
Community Development	Community development and co-ordination.
Emergency Response	Fire and water safety services, emergency response during severe weather response.

Acronyms

Acronym	Full form
CAPS	Climate Action Plans
CAROs	Climate Action Regional Offices
CCRA	Climate Change Risk Assessment
CDP	County Development Plan
CRA	Climate Risk Assessment
EPA	Environmental Protection Agency
EU	European Union
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
LA	Local Authority
NHA	National Heritage Area
RCP	Representative Concentration Pathways

Description of the levels of impact due to disruption of Local Authority Services (Source: Technical Annex B: Climate Change Risk Assessment

Impact	Description	Level of Impact
Catastrophic	Widespread service failure with services unable to cope with wide-scale impacts	5
Major	Services seen to be in danger of failing completely with severe widespread decline in service provision	4
Moderate	Service provision under severe pressure. Appreciable decline in service provision at community level	3
Minor	Isolated but noticeable examples of service decline	2
Negligible	Appearance of threat but no actual impact on service provision	1

Characterisation of the magnitude of impact across various risk areas (Source: Technical Annex B: Climate Change Risk Assessment)

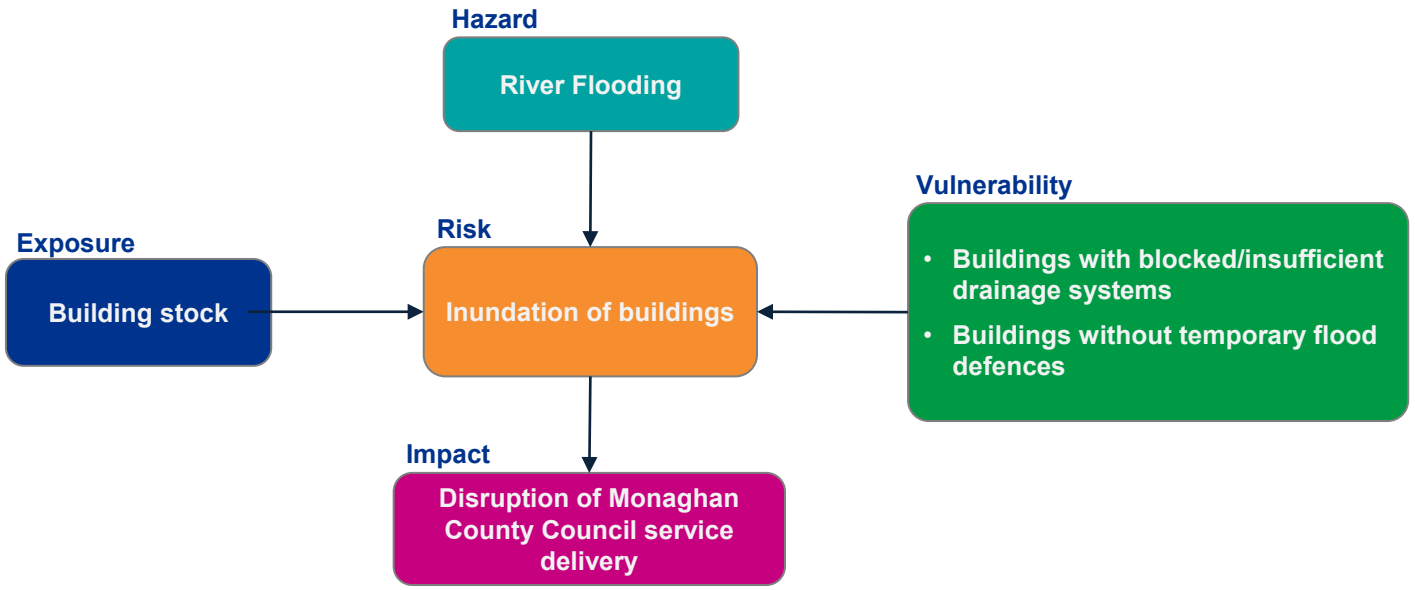
Risk Area	Negligible (Score; 1)	Minor (Score: 2)	Moderate (Score: 3)	Major (Score: 4)	Catastrophic (Score:5)
Asset Damage	Impact can be absorbed through normal activity	An adverse event that can be absorbed by taking business continuity action	A serious event that requires additional emergency business continuity actions	A critical event that requires extraordinary/ emergency business continuity actions	Disaster with the potential to lead to shutdown or collapse or loss of assets/ network
Health and Wellbeing	First aid case	Minor physical injury or mental health impact, medical treatment required	Serious physical or mental health impact, or lost work	Major or multiple injuries or mental health impact, permanent or physical disability	Single or multiple fatalities
Environment	No impact on baseline environment. Localised in the source area. No recovery required	Localised within site boundaries. Recovery measurable within one month of impact	Moderate harm with possible wider effect. Recovery in one year	Significant harm with local effect. Recovery longer than one year. Failure to comply with environmental regulations/ consent	Significant harm with widespread effect. Recovery longer than year. Limited prospect of full recovery
Social	No negative social impact.	Localised, temporary social impacts	Local, long-term impact on public opinion with adverse local media coverage	Failure to protect poor or vulnerable groups. National, long- term social impacts	Loss of social licence to operate. Community protests
Financial (for single extreme event or annual average impact)	x % IRR < 2% of turnover	x % IRR 2- 10% of turnover	x % of IRR 10-25% of turnover	x % IRR 25-50% of turnover	x % IRR > 50% of turnover
Reputation	Localised, temporary impact on public opinion	Localised, short-term impact on public opinion	Local, long-term impact on public opinion with adverse local media coverage	National, short-term impact on public opinion; negative media coverage	National, long-term impact with potential to affect stability of the government
Cultural Heritage	Insignificant impact	Short term impact. Possible recovery or repair	Serious damage with wider impact to tourism industry	Significant damage with national and international impact	Permanent loss with resulting impact on society

4.3
Appendix 3

Characterising Exposure, Vulnerability and Impacts of Climate Hazards

For County Monaghan and for each of the identified climate hazards, we characterised the exposures, vulnerabilities, and impacts associated with the relevant hazard events. For example, below shows the three risk components for a river flooding hazard which would pose an inundation risk to Monaghan County Council buildings. The buildings with insufficient drainage and with no temporary flood defences would be considered more vulnerable to this hazard. Consequently, if Monaghan County Council buildings were to be flooded, one of the possible impacts would be the disruption of Monaghan County Council's ability to deliver its services. This process was undertaken for each hazard and a range of exposures were identified along with their associated vulnerabilities.

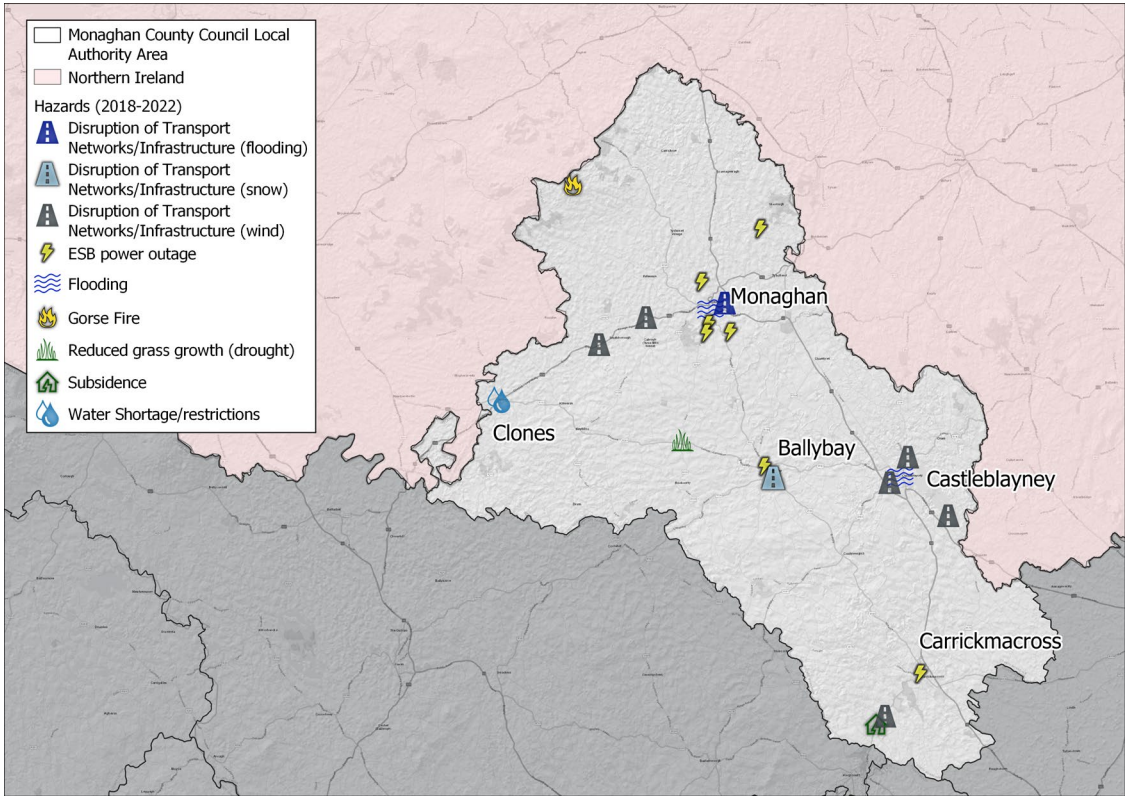
The following pages summarise the exposures, vulnerabilities and impacts for the hazards that exist within the County Monaghan region.



Exposure, Vulnerability and Impacts of Climate Hazards

Employing and integrating information derived a wide range of sources, we have characterised the exposures, vulnerabilities, and impacts of the climate and weather-related hazards for County Monaghan. Below and to the right we provide an example of exposures and impacts of hazard events experienced between 2018 and 2022.

- **Storm Barra** in 2021 brought power outages to over **2,500 homes** in Monaghan with communities such as Ballybay, Drumbear, Telaydan, Carrickmacross, Cornamundy and Aghaloughan being primarily affected.
- **Storm Eleanor** in 2018 caused 20 roads to be either blocked or affected by fallen trees, including national roads such as the N12 at Drumrutagh and the N54 at Smithborough.
- In September 2018 **lower than average rainfall** led to river levels shrinking, restricting water discharges from a local gypsum mine. This led to a collapse and a **significant sinkhole** appearing at Magheracloone, causing the local GAA club and community centre to be condemned, and impacting on the local national school, local roads, at least 13 homes.
- In February 2022, intense rainfall associated with **storms Dudley, Eunice and Franklin** caused considerable disruption to traffic in the centre of Monaghan town
- **Heavy snowfall** resulted in road closures and transport disruption as evidenced by the closure of roads around Ballybay in February 2021, and with dangerous driving conditions across the county.
- In 2021, Monaghan Fire & Civil Protection attended to **27 wild fires**, an increase on 14 in 2020 and 12 in 2019.



Impacts of climate hazards (1/4)

The table below shows the key impacts and exposures associated with each climate and weather-related hazard. Detailed information on exposure specific vulnerabilities (physical, social and environmental) are provided in the associated impacts and risks spreadsheet.

Hazard	Key Impacts	Key Exposures (and Key Vulnerabilities)
Heatwave	• Hot and uncomfortable working/living conditions • Increased demand on recreational areas • Damage to road surface, hazardous driving conditions and impact on road surface maintenance • Heat stress for animals and livestock resulting in the adoption of unsustainable mitigation measures • Increased frequency of swimming area closures • Increase in the frequency of uncontrolled fire • Increased demand on available water resources, leading to increasing pressure to share resources. • Detrimental impacts on freshwater quality for fish populations • Increased strain on natural biodiversity	• Housing (social and private), buildings (including LA offices), outdoor workers (elderly, with limited access to water, shade and sunscreen), care home/leisure centres/recreational facilities • Lakes • Parks (with easy access to urban areas) • Local roads (surface-dressed roads, located in areas of high solar radiation) • Pasture • Gorse and Forest areas • Beaches/swimming areas (heavily utilised, with low access to shade) • Reservoirs/Lakes • European/Irish designated sites (SPAs, SACs, Ramsar sites, NHAs)
Drought	• Decreased grass growth and increased supplementary feed requirements for cattle • Increased demand on available water resources, leading to increasing pressure to share resources • Increase in the frequency of uncontrolled fire • Increased strain on natural biodiversity • Reduced river flow • Increased degradation rates	• Pasture (in marginal areas of production) • Reservoirs/lakes/groundwater supplies (already depleted/under stress) • Gorse and forest areas • Natural areas incl. European / Irish designated sites (SPAs, SACs, Ramsar sites, NHAs) • Biodiversity (water bodies, areas with diverse wildlife populations) • Cultural heritage (wooden/decomposable material based assets)

Impacts of climate hazards (2/4)

The table below shows the key impacts and exposures associated with each climate and weather-related hazard. Detailed information on exposure specific vulnerabilities (physical, social and environmental) are provided in the associated impacts and risks spreadsheet.

Hazard	Key Impacts	Key Exposures (and Key Vulnerabilities)
Cold Spell	• Extreme cold results in increased requirement for heating and associated economic costs. • Cold conditions result in increased damage to vehicles • Disruption to road networks, including increases in costs associated with gritting fuel and overtime. • Disruption to public transport networks • Cold conditions leading to damage of road surfaces (i.e., freeze thaw) • Increase in the frequency of trips and falls. • Reduction in agricultural production • Difficulties in accessing land • Freeze thaw damage to critical infrastructure • Impacts on water resources • Increases in cold-related mortality and morbidity • Delay of infrastructure/development projects • Increased strain on natural biodiversity • Damage and disruption of electricity supply • Damage to built heritage	• Buildings (poorly insulated, with elderly residents, in isolated locations) • Public/private transport vehicles (exposed vehicles) • Road network (untreated road surfaces, near isolated communities) • Transport network (untreated road surfaces, roads at higher elevations, isolated and vulnerable communities) • Public/staff (elderly populations, people with pre-existing conditions) • Crops, livestock (cold-sensitive crops, areas with low solar radiation) • Land (marginal farms, areas of low solar radiation) • Water infrastructure/pipes (older pipes, in areas of freezing soil conditions) • Water resources (waterbodies in lower altitudes) • People at high risk of exposure to cold (people in insulated buildings, vulnerable communities) • Development projects (ongoing construction with loose materials) • European/Irish designated sites (SPAs, SACs, Ramsar sites, NHAs) • Homes/Businesses/Local Govt Office (without on-site electricity generation)/Agricultural Sites
Heavy Snowfall	• Damage to buildings • Disruption of transport network and isolation of communities • Heavy snowfall and freezing conditions impacting on livestock • Snow melt resulting in increased risk of flooding • Disruption to energy supply • Disruption to waste collection	• Buildings (vacant/flat roof properties, higher elevation, elderly residents) • Offices (incl. LA) (single story/flat roof, higher elevation, impervious surfaces) • Transport network (in terrain with a with higher propensity of snow drifts, isolated roads) • Agricultural sites (livestock unprotected) (farms at higher elevations, marginal farms) • Energy (energy infrastructure in need of maintenance, older infrastructure) • Waste collection routes (in terrain with a with higher propensity of snow drifts)

Impacts of climate hazards (3/4)

The table below shows the key impacts and exposures associated with each climate and weather-related hazard. Detailed information on exposure specific vulnerabilities (physical, social and environmental) are provided in the associated impacts and risks spreadsheet.

Hazard	Key Impacts	Key Exposures (and Key Vulnerabilities)
Severe Windstorm	• Direct wind damage to buildings and infrastructure. • Disruption of communications infrastructure. • Wind damage to crops, forestry, trees and hedgerows. • Disruption of wind energy generation • Disruption to energy supply • Disruption of transport networks. • Closure of parks and public buildings • Disruption to waste collection • Disruption to water quality monitoring	• Buildings, development sites (buildings w. rooftop equip., vulnerable populations, high-rise structures) • Overhead telephone lines and masts (situated in upland and exposed sites) • Crops and livestock (crops which are more vulnerable to wind, arable and forestry situated in upland and /or exposed areas)/trees/hedgerows (loss of habitats, shelter and carbon capture) • Wind turbines (turbines with lower shut-down thresholds for high winds • Power supply (infrastructure in exposed locations, vulnerable populations, isolated communities) • Road network (in exposed locations) • Parks, public buildings (populations requiring essential council services, exposed, locations) • Waste collection routes (terrain with a with higher propensity of snow drifts) • Waterbodies (exposed waterbodies and waterbodies in need of water quality monitoring)

Impacts of climate hazards (4/4)

The table below shows the key impacts and exposures associated with each climate and weather-related hazard. Detailed information on exposure specific vulnerabilities (physical, social and environmental) are provided in the associated impacts and risks spreadsheet.

Hazard	Key Impacts	Key Exposures (and Key Vulnerabilities)
Pluvial Flood	• Direct rain and surface water damage to buildings and infrastructure • Damage to amenities and recreational areas. • Disruption of transport networks/Infrastructure. • Surface water (run-off) pollutants. • Impact on business and local economy.	• Buildings, local authority offices, heritage sites (blocked drainage systems, high levels of impervious surfaces, etc) • Recreational amenities (low-lying parks and other amenities, locate near water bodies such as lakes and rivers) • Road network (low-lying roads with no alternative access routes and which allows for the pooling of water) • Natural resources/sensitive materials (Enviro. sensitive areas, heavily fertilised agric. land close to water bodies) • Employers, employees, customers, students (business in low-lying areas, lacking remote work/study options, etc.) • Wastewater Infrastructure
River Flood	• Flood damage to buildings and infrastructure. • Damage to amenities and recreational areas. • Disruption of transport networks/Infrastructure. • Surface water (run-off) pollutants. • Impact on business and local economy. • Damage/degradation to automobiles and public transport. • Potential bridge failure • Farmland erosion	• Buildings, local authority offices, heritage sites (blocked drainage, loc. on floodplains, vulnerable residents) • Recreational amenities (low-lying parks, located near water bodies, parks and amenities in need of investment) • Road network (low lying roads/railways, located near water bodies, limited drainage) • Natural resources/sensitive materials (Env. sensitive areas, networks with polluting vehicles, near waterbodies) • Employers, employees, customers, students (located in at-risk areas, lack of access to early warning systems). • Council fleets, public transport, private vehicles (underground/low-lying carparks, fleets sensitive to submergence) • Bridges (older bridges, bridges in need of investment and maintenance) • Farmland situated on riverbanks (economically marginalised farmers, rivers susceptible to soil bank erosion, etc)