



Galway City Council

Climate Change Risk Assessment

LACAP
Final Report
13th July 2023



KPMG
Sustainable
Futures



Future Analytics

Contents

1. Executive Summary	03
2. Introduction	05
3. Climate Change Risk Assessment Methodology	
3.1 Introduction, Scope and Methodology	12
3.2 Current Climate Risks and Impacts	19
3.2.1 Profile of Climate Hazards (incl. Frequency)	20
3.2.2 Exposure, Vulnerability and Impacts for Galway City	25
3.2.3 Impact Assessment (Service Delivery)	33
3.2.4 Current Climate Risk Matrix	41
3.3 Future Climate Risks and Impact Assessment	43
3.3.1 Future Changes in Climate Hazards	45
3.3.2 Future Changes in Exposure and Vulnerability (incl. Emergency Risk)	48
3.3.3 Future Climate Risk Matrix	53
3.3.4 Uncertainty Assessment	55
3.4 Summary	57
4. Appendices	59

An aerial photograph of a river flowing through a city. In the foreground, a large dam with a walkway spans across the river, with water cascading over it. To the right, a white church with a steeple sits on a grassy bank. In the background, a city with various buildings and a large cathedral is visible. A semi-transparent purple box is overlaid on the left side of the image, containing the text '01 Executive Summary'.

01

Executive Summary

Executive Summary

Context and Scope of this Report

Climate change poses a critical challenge for Galway City Council. It will result in a wide range of impacts across Galway City, from damaging infrastructure such as roads and bridges, to detrimental impacts on biodiversity and restrictions on water supply. These bring substantial implications for Galway City 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 and impacts on Galway City and for consequences of these for the delivery of services by Galway City Council. The aim of the report is to inform the development of the LACAP for Galway City Council.

Key Results and Findings

As illustrated in the climate risk matrix on the right, projections indicate that the level of risk associated with some hazards (e.g., coastal erosion, coastal, river and pluvial flooding, heatwaves and droughts) will increase while the level of risk will remain the same for others (e.g., severe windstorms). Risks associated with some hazards are expected to decrease due to projected reductions in hazard frequency, such as cold spells and

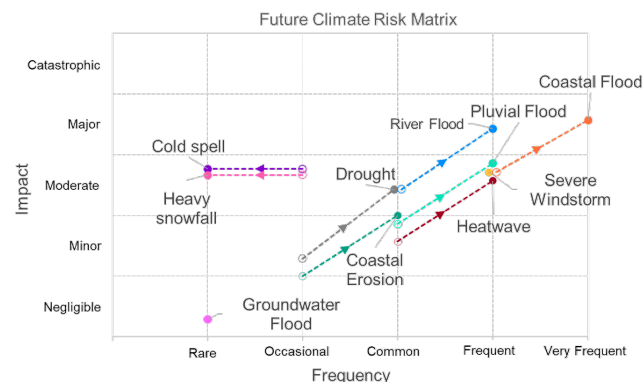
heavy snowfalls.

- **Coastal flooding** already poses a significant risk for Galway City and has resulted in the temporary inundation of buildings, damage to critical water supply infrastructure and disruption of transport networks (Bus Eireann services, during Storm Barra). Rising sea levels will increase the frequency and extent of coastal inundation across Galway City. Risk associated with coastal erosion is also projected to increase as a result of sea level rise.
- Recent experiences of **river and pluvial flooding** events in 2015/16, 2018 and 2022, resulted in damages to buildings, amenities and recreational areas, closure of businesses and disruption of transport networks. Projected increases in the frequency of extreme precipitation events will result in increased surface water and riverine flood risk for Galway City.
- **Severe windstorms** are currently experienced on a frequent basis in Galway City and result in wide-ranging impacts, including damages to buildings and infrastructure, disruption to energy supply and communication networks. Projections indicate no significant change to this frequency.
- Galway City experienced both a **heatwave and drought** in 2018 and 2022, while a heatwave was also recorded in 2021. These events resulted in damage to road surfaces, disruption of public transport networks, reduced river flow and increased demand on water resources (hosepipe bans). Projected increases in the frequency of heatwaves and 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 (e.g. Storm Emma) demonstrated the wide range of impacts for Galway City. These included, amongst others, road closures,

disruption to public transport, power outages, an increase in the frequency of trips and falls, and impacts on water resources (restricted water supply during storm Emma). Projected increases in average temperature and decreases in the frequency of snowfall indicate a decrease in the frequency of cold spells, heavy snowfall, and their associated impacts.

- **Groundwater flooding** is currently experienced rarely in Galway City and has limited impacts such as damages to roads and transport disruption.

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



The risk matrix above shows the current and future level of risk associated with climate hazards for Galway City. 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

IND

Aran Islands

Galway Bay

Galway

Tuam

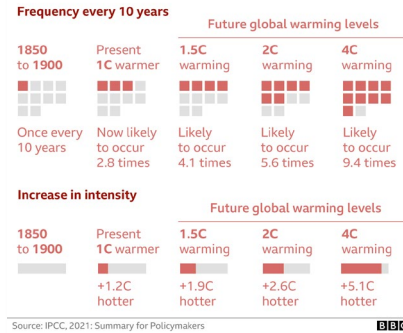


Global Response to the Challenge of Climate Change

Global Climate Change Challenge

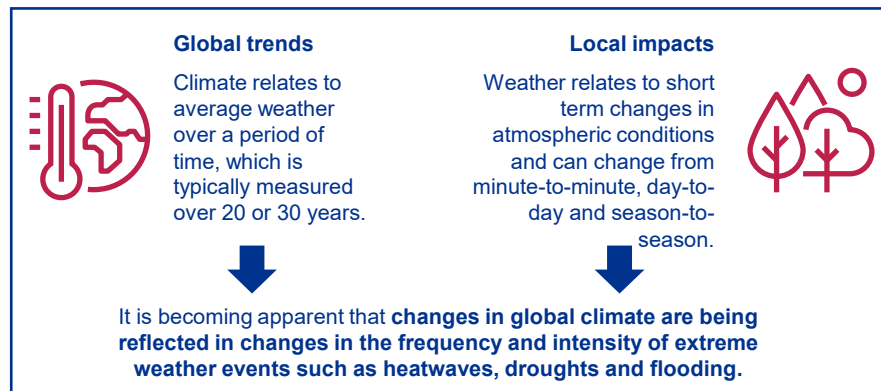
Extreme heat becomes more frequent

Projected increase in frequency and intensity of high temperatures which only occurred once in every 10 years on average in a climate without human influence



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).

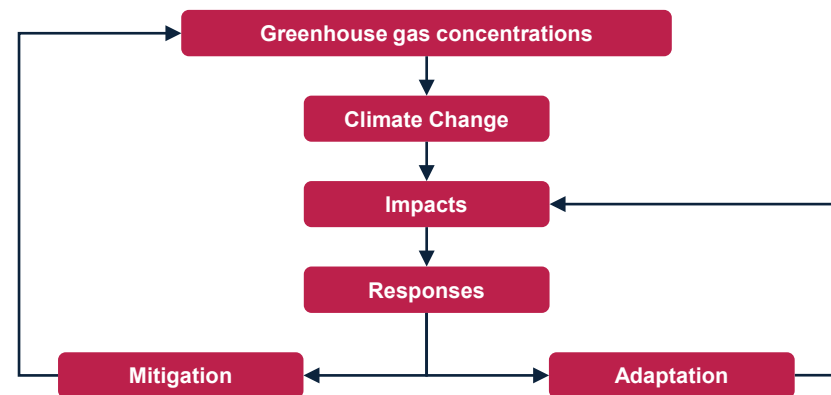


Global Climate Change Response Framework

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

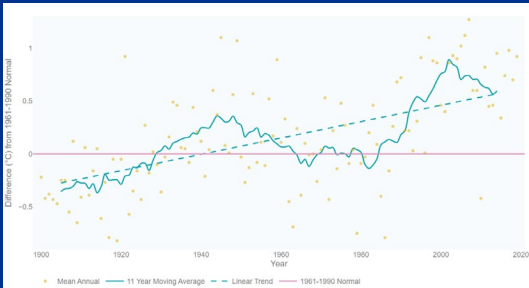
Mitigation: Making the impacts of climate change less severe by preventing or reducing the emission of greenhouse gases (GHGs) into the atmosphere. Mitigation is achieved either by reducing the sources of these gases (e.g. by increasing the share of renewable energies, or establishing a cleaner mobility 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 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.

National and Local Response

Paris Agreement, 2015

The Paris Agreement, adopted in 2015 provides an internationally accepted and legally binding global framework to addressing 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.

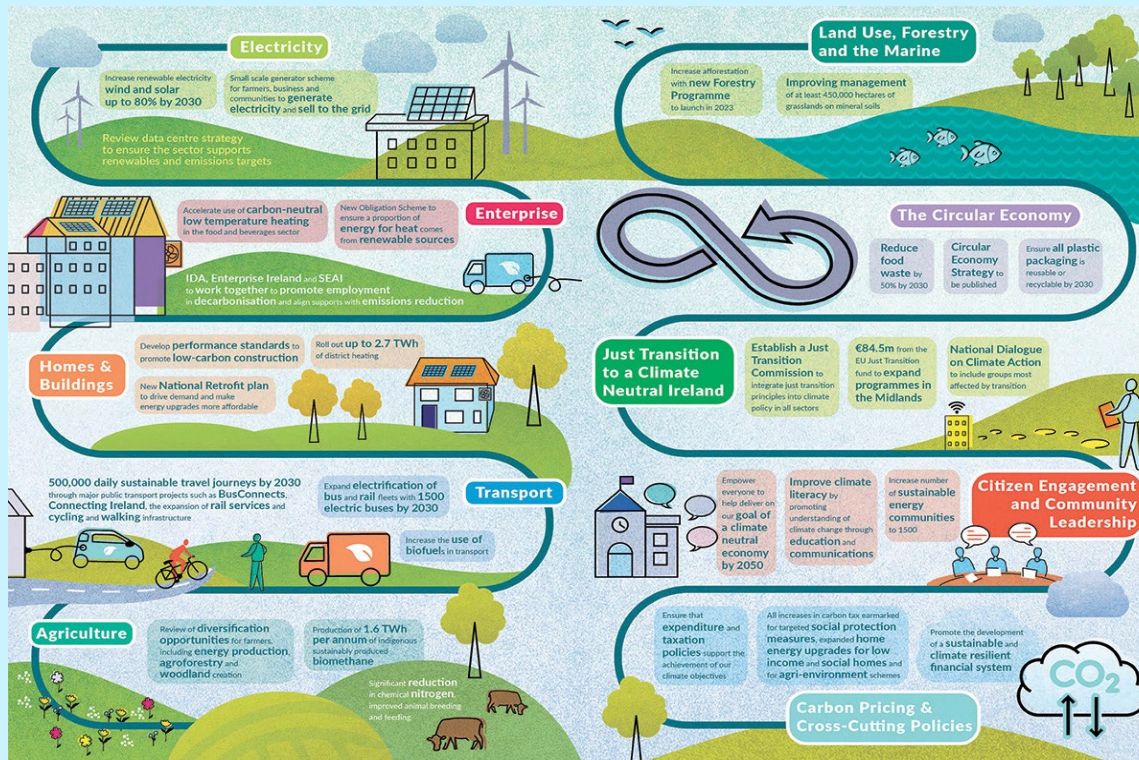
Climate Action and Low Carbon Development (Amendment) Act, 2021

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

The Climate Action Plan 2021 is Ireland's first detailed plan for taking decisive action to achieve a 51% reduction in overall greenhouse gas emissions by 2030 and setting us on a path to reach net-zero emissions by no later than 2050, as committed to in the Programme for Government and set out in the Climate Act 2021. The Plan lists the actions needed to deliver on climate targets and sets indicative ranges of emissions reductions for each sector of the economy. It is updated annually, with the latest Climate Action Plan for 2023 published in December 2022.



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."

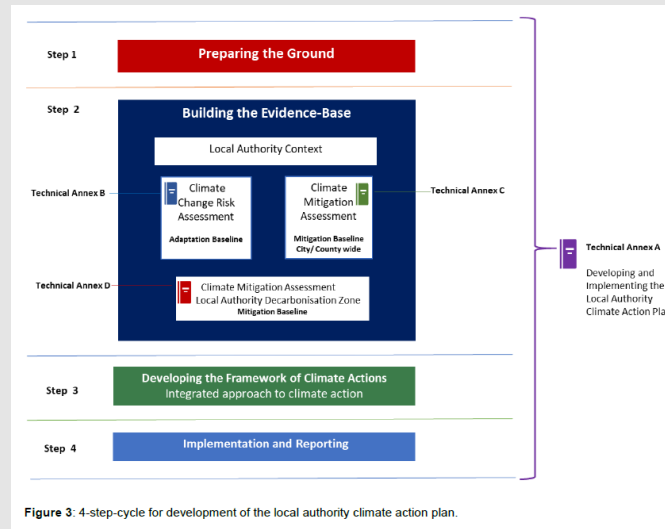
These plans will drive the mitigation and adaptation measures at the local level and see local authorities translate national climate policy to local circumstances and to support the delivery of the National Climate Objective at local and community levels.



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 structure the development and implementation of LACAP around a 4-step cycle, which is supported by four technical annexes¹:



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

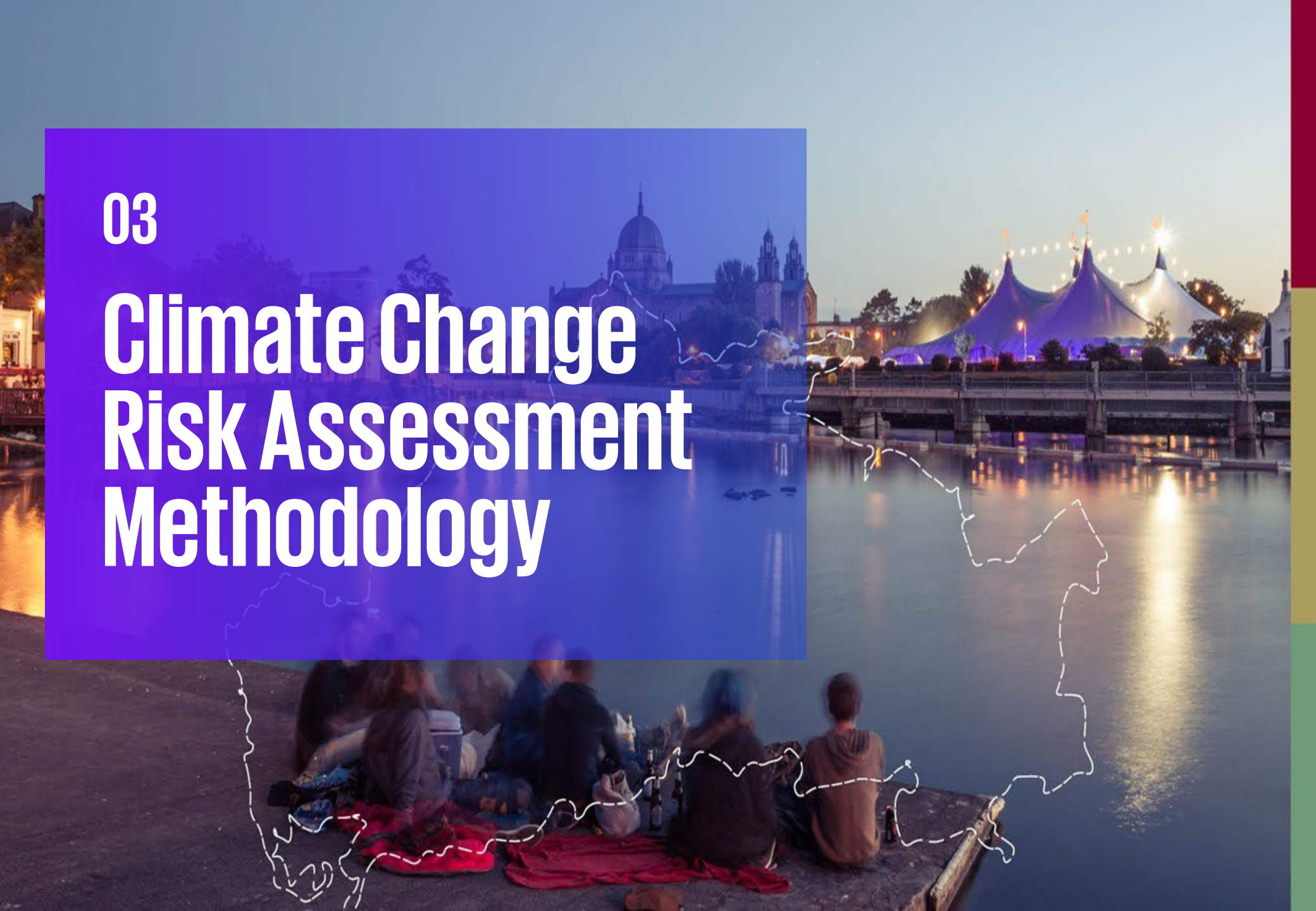


Scope of this report

Per Galway City 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 Galway City and the implications of these for Galway City 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

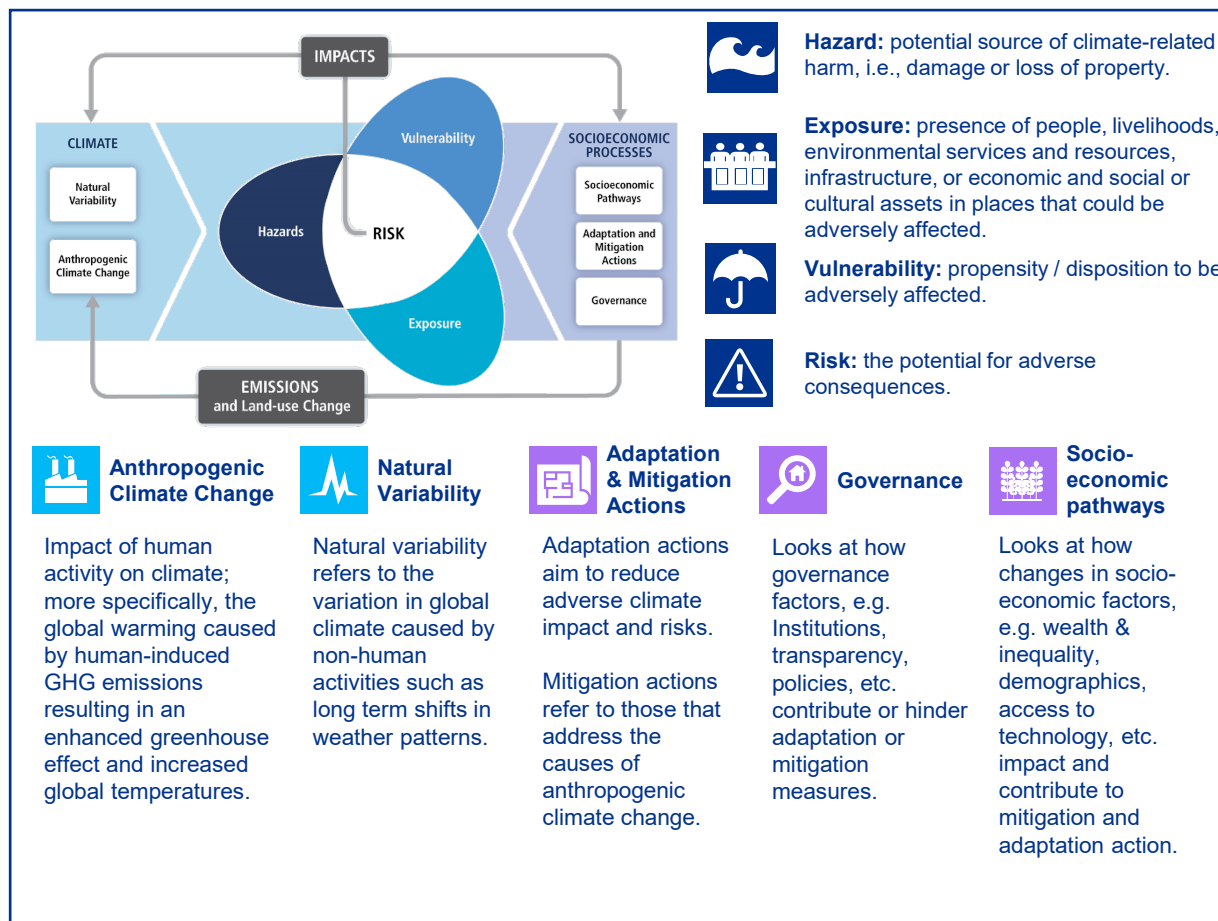
Responding to climate change impacts involves taking adaptation actions to reduce the adverse risks posed by current and projected climate change.

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 Galway City 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.



Source: Local Authority 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 Galway City.

A qualitative risk assessment provides the evidence base to identify potential climate risks for the administrative area of Galway City Council and for the delivery of services by Galway City 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 '**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 and impacts 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 Galway City
- 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 Galway City and the consequence of these for Galway City 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 to have impacted the Galway City.

We have updated the climate hazard profile developed through the existing Galway City 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 Galway City

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 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 Galway City. 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 Galway City 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 and information was employed to inform the development of the CCRA for Galway City Council. The Galway City 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 accessed while the National Planning Framework, Galway City Development Plan 2017-2023, Draft Galway City Council Development Plan 2023-2029 and the Regional Spatial and Economic Strategy for the Northern and Western Region were employed to assess future development patterns. In addition, two stakeholder workshops were held to garner further insights from Galway City Council.

Report Section	Sources
Introduction and scope	<ul style="list-style-type: none"> Local Authority Climate Action Plan Guidelines, Technical Annex
Step 1: Current Climate Risks and Impacts	<ul style="list-style-type: none"> Environmental Protection Agency (EPA) Catchments.ie (EPA) Climate Status Report 2020 (Cámaro García and Dwyer, 2021) Floodinfo.ie (Office of Public Works) Met Éireann Data.gov.ie Transport for Ireland Department of Transport Department of Housing, Local Government and Heritage Department of Transport, Sport and Tourism Teagasc Galway City Council (and Website) Galway City Council Adaptation Strategy 2019-2024 Sectoral Climate Change Adaptation Strategies (2018) Stakeholder Workshop Midwest Radio RTE News Joe.ie Irish Independent Irish Examiner The Irish Times The Journal The Farmers Journal Connacht Tribune Connaught Telegraph Galway Daily Galway Bay FM
Step 2: Future Climate Risks and Impacts	<ul style="list-style-type: none"> Galway City Development Plan 2017-2023 Galway City Development Plan 2023-2029 Galway City Council Regional Focus - Eolas High-resolution Climate Projections for Ireland – A Multi-model Ensemble Approach (Nolan and Flanagan, 2020) accessed via Climate Ireland Galway City Local Economic & Community Plan (LECP) 2015-2021 Regional Spatial & Economic Strategy for the Northern and Western Regional Assembly Transport Infrastructure Ireland

3.2

Current Climate Risks and Impacts

3.2.1 Profile of Climate Hazards (incl. Frequency)

Characteristics of Galway City

Galway City Council is a member of the Atlantic Seaboard North Climate Action Regional Office (CARO) which supports and coordinates climate action undertaken by the five Local Authorities of Donegal, Sligo, Mayo, Galway County and Galway City. The city council serves 83,456 people (2022 Census). The city is best known for its coastal and waterfront areas, rich cultural heritage and third level institutions, as well as its indigenous and international businesses.

Physical & Environmental Characteristics

The administrative area of Galway City is approximately 50.7 km², of which a fifth of the total land includes areas designated as protected habitats, recreational and amenity lands and lands in agricultural use. The city is bound by Lough Corrib to the north from which the River Corrib flows through the heart of the city to Galway Port and Galway Bay.

Galway is located on the Wild Atlantic Way and the city's coastline length is 50 km. The city has four beaches including Grattan, Ballyloughane, Salthill and Silverstrand (the latter two currently having Blueflag status). In terms of landscape and biodiversity, notable examples in the city include the Galway Bay Complex and Lough Corrib SACs and the Inner Galway Bay SPA.

The city's 'green network' include the Terryland Forest Park and Millennium Children's Park, various enclosed marine / wetland and coastal areas (e.g. Silverstrand to Roscam), as well as a number of greenways and green civic spaces such as the well-known Eyre Square and the university campus.

Socioeconomic Characteristics

As of the 2022 Census, Galway City has a population of 83,456 people, representing an increase of 4,788 since the previous census in 2016. The city has experienced relatively steady population growth over recent years and has a near-equal gender breakdown (52% female / 48% male) (2016).

In terms of transport infrastructure, Galway City is very accessible to the M6 to Dublin, the M18 to Limerick, and the N17 to Sligo. The railway station in Galway is the terminus station for the Dublin to Galway intercity service and the Limerick to Galway and Athenry to Galway commuter services. The city is located in proximity to international airports in counties Mayo and Clare and the city's port welcomes a range of cargo ships, sailing vessels, and tankers.

Galway City Council has three electoral areas: Galway City East, Galway City Central and Galway City West. Galway's land use is characterised by its city centre and waterside, suburban districts, college and hospital campuses as well as its enterprise lands in both the city and on the eastern boundary.

As per Q3 2020, there were 3,669 commercial addresses in the city, an increase of almost 10% from 2016 (GeoDirectory).

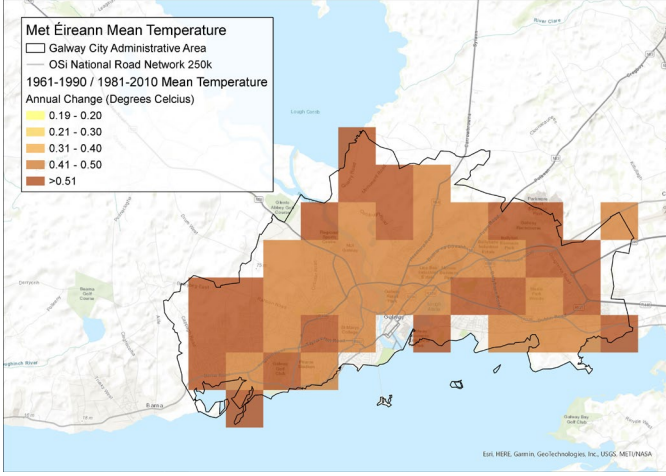
According to the 2016 Census, the city's main industries of employment include Professional Services (26%), Commerce and Trade (20%), Manufacturing (15%) and Transport and Communications (8%). Other Industries including Public Administration, Building & Construction and Agriculture, forestry and fishing.

The city's Household Median Gross Income in 2016 was €44,492 and in 2021 the council provided 1,434 Housing Assistance Payments (City west – 350, City Central – 354, City East – 730).

The Medieval city is famous for its annual arts, racing and oyster festivals and was the European Capital of Culture in 2020. As one of the most popular tourist destinations outside of Dublin, the city and county welcomed over 1.4 million overseas visitors in 2018. Another draw to the city is its major third level institutions namely the University of Galway and a campus which forms part of the Atlantic Technological University.

In 2017, Galway became the first Irish city to be awarded the designation of European Green Leaf 2017 by the European Commission. The award recognised a commitment to better environmental outcomes in the city.

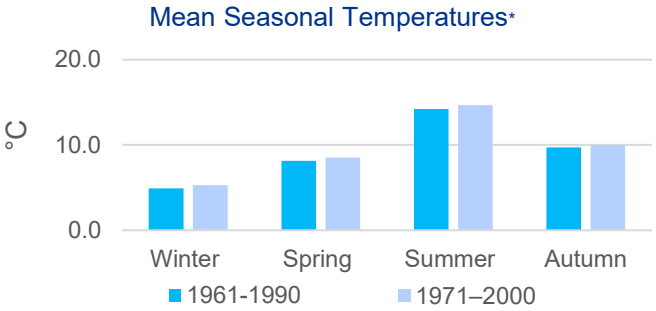
Observed Changes in Galway City's Climate



To assess changes in climatic conditions across Galway City, 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. Due to no designated long-term weather stations being located in Galway City, the Birr weather station was used to establish temperature baselines due to its close proximity to Galway City while Corrandulla weather station located to the north of the city in County Galway was used to establish rainfall baselines.

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

Highlights of Observed Climate Change for Ireland and Galway City



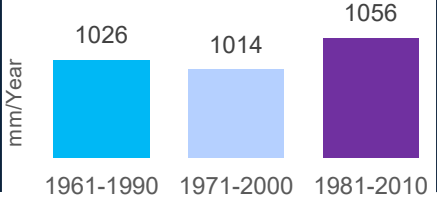
Sea Levels

Satellite observations indicate that the sea level around Ireland has risen by approximately 2-3 mm/year since the early 1990s*****

30.5°C
Highest temperature on record recorded on July 18th 2022 at Athens

Rainfall

Average annual rainfall at Corrandulla has increased by 3% for the most recent period (1981-2010) compared to the 1961-1990 baseline.**



0.49°C

Average temperature increase for the period 1981-2010 when compared to the 1961-1990 baseline.***

During Storm Eleanor (2018), water levels rose 90 cm above the base of the Spanish arch, increasing flooding to parts of the city.****

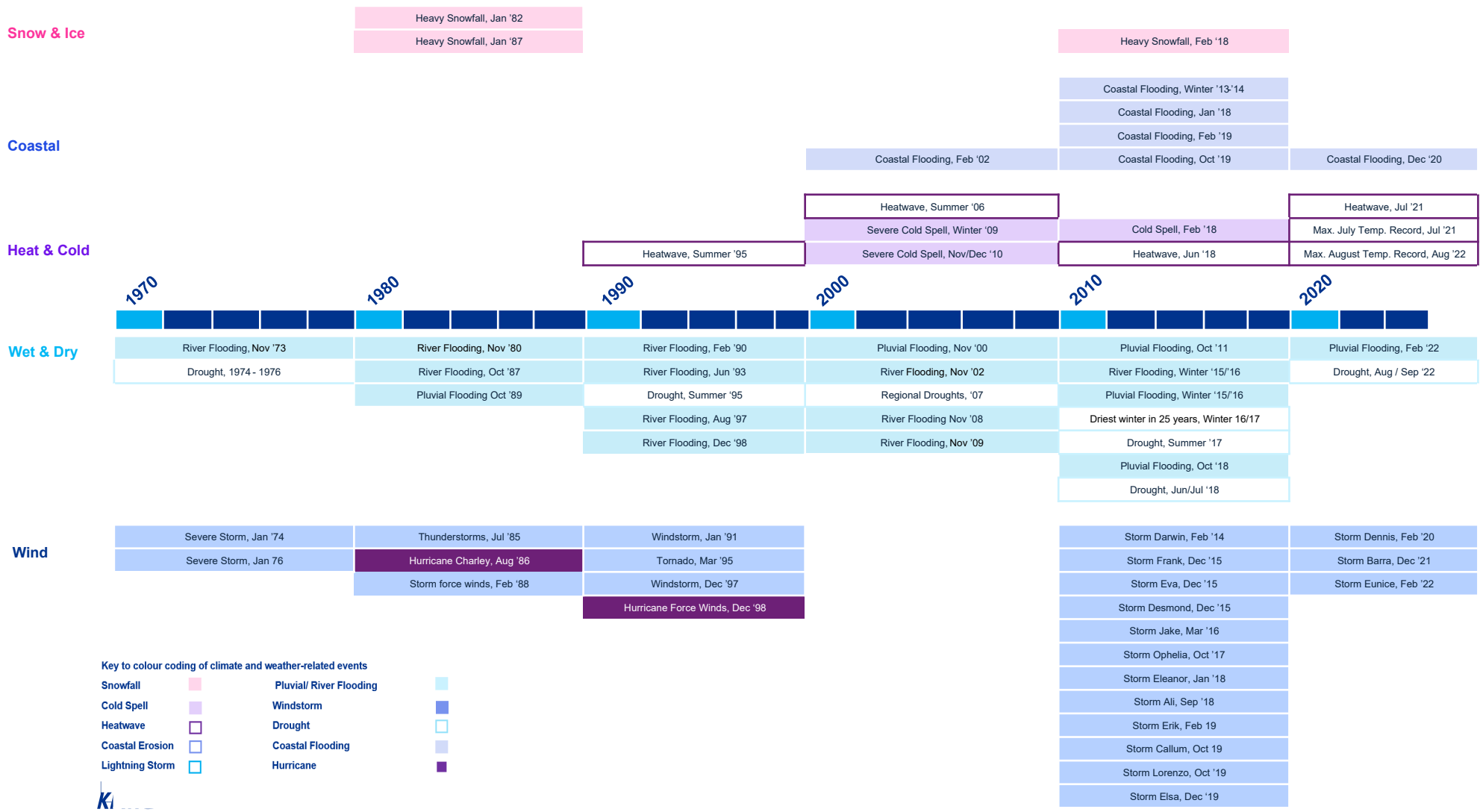
*Source: Met Éireann Long term weather station : Birr (Closed in 2007)
 **Source: Met Éireann weather station data: Corrandulla
 ***Source: interpolation from Long term Met Éireann mean temperature 1x1 Grid data
 ****Source: IrishTimes
 *****Source: EPA Climate Status Report 2020



16,500 Irish water customers in Galway City suffered restrictions to their water supply during storm Emma in 2018 due to frozen and burst pipes

Climate Hazard Profile

In addition to observed changes in Galway City's climate, we have identified significant climate and weather-related events to have impacted on the CARO ASBN region and Galway City over the period 1973-2022. To do this, we have further developed the existing climate hazard profile developed for the CARO ASBN region and Galway City through the Galway City Council Adaptation Strategy (2019) and expanded the analysis to cover the period 2018-2022.



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).

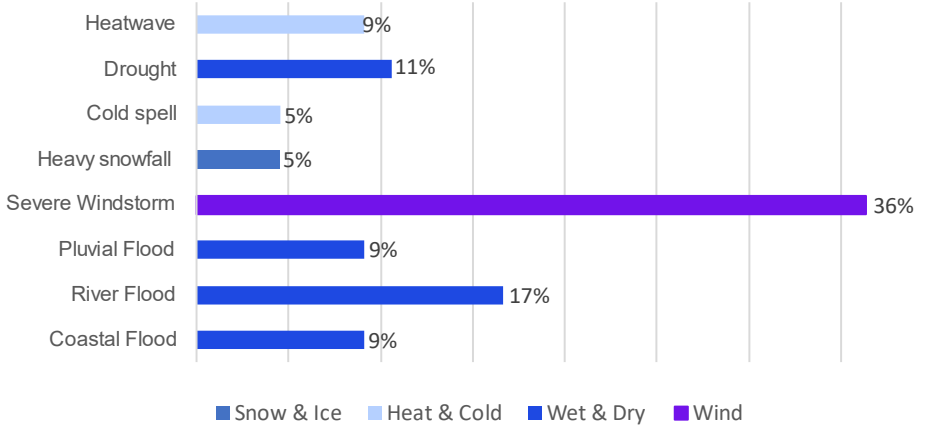
Based on the climate hazard baseline, severe storm events have impacted upon Galway City most frequently over the period 1973-2022, with river and pluvial flooding also affecting the City on a number of occasions. Coastal flooding, cold spells, heavy snowfall events, heatwaves and droughts have also impacted Galway City, but less frequently. Although individual events were not identified in the timeline, groundwater flooding and coastal erosion have occurred within Galway City.

The hazard frequency for each hazard is shown in the bottom right table, informed by past event occurrence and information received from Galway City 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

Frequency of identified hazard events for the ASBN region and Galway City (1973 -2022)



Current hazard frequency for Galway City, based upon analysis of past events and workshop feedback

Hazard Type	Current Frequency
Heatwave	Common
Drought	Occasional
Cold spell	Occasional
Heavy snowfall	Occasional
Severe windstorm	Frequent
Coastal Flood	Frequent
Coastal Erosion	Occasional
Pluvial Flood	Common
River Flood	Common
Groundwater Flood	Rare

3.2.2 Exposure, Vulnerability and Impacts for Galway City

Exposure, Vulnerability and Impacts for Galway City

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

On the basis of identified exposures, vulnerabilities and impacts for Galway City, the impact of climate and weather-related hazards on key categories of exposure for Galway City 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 Galway City 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 Type	Current Frequency	Assets	Health and Wellbeing	Environment	Social	Cultural Heritage	Financial	Reputational	Overall Impact Score
Heatwave	Common	Minor	Minor	Minor	Negligible	Minor	Negligible	Negligible	1.6
Drought	Occasional	Negligible	Negligible	Negligible	Minor	Minor	Negligible	Negligible	1.3
Cold spell	Occasional	Moderate	Moderate	Moderate	Moderate	Minor	Moderate	Minor	2.7
Heavy snowfall	Occasional	Moderate	Moderate	Moderate	Moderate	Minor	Moderate	Minor	2.7
Severe windstorm	Frequent	Moderate	Moderate	Minor	Moderate	Minor	Moderate	Moderate	2.7
Coastal Flood	Frequent	Major	Moderate	Minor	Moderate	Minor	Minor	Moderate	2.7
Coastal Erosion	Occasional	None	None	Moderate	None	None	Minor	Minor	1.0
Pluvial Flood	Common	Minor	Minor	Minor	Minor	Negligible	Minor	Minor	1.9
River Flood	Common	Moderate	Moderate	Moderate	Minor	Minor	Minor	Minor	2.3
Groundwater Flood	Rare	Negligible	None	None	None	None	Negligible	None	0.3

Impacts of Current Climate Risks– Heatwaves & Drought

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

Galway City has been exposed to heatwave events (defined as 5 consecutive days with temperatures >25°C) over the period 1973-2022 with a wide range of impacts across the city. The most notable and costly impact relates to repair and maintenance of road surfaces. In addition, Galway City has experienced drought conditions over the period as exemplified by the drought events in 2017, 2018 and 2022.

Hazard & Frequency	Exposure	Impact Description	Rating
 Heatwave Common	Assets	<ul style="list-style-type: none"> High temperatures have resulted in localised damage to road surfaces (tar and chip) across the city. High temperatures have resulted in disruption to travel networks. In August 2022 high rail temperatures led to delays to trains running between Galway and Dublin. 	Minor
	Health and Well being	<ul style="list-style-type: none"> High indoor temperatures have resulted in uncomfortable working conditions for staff and public with the potential for impacts on for heat sensitive equipment (e.g., Council laboratories). This has resulted in the increased requirement for active/mechanical cooling. 	Minor
	Environment	<ul style="list-style-type: none"> Heat waves provide suitable conditions for the ignition of uncontrolled fires. Increased sea surface temperatures can result in higher frequencies of jellyfish on coasts. In July 2022 a number of sightings of the potentially hazardous Portuguese Man o'War were recorded in waters off Galway, notably off Silverstrand Beach. 	Minor
	Social	<ul style="list-style-type: none"> Heatwaves have resulted in congestion at key recreational areas with facilities (e.g., litter collection and parking) overwhelmed. 	Negligible
	Cultural Heritage	<ul style="list-style-type: none"> Extreme temperatures are recognised as contributing to the increased weathering of cultural heritage sites. 	Minor
	Financial	<ul style="list-style-type: none"> The financial implications of heatwaves are primarily associated with road maintenance and repair. 	Negligible
	Reputational	<ul style="list-style-type: none"> Heatwaves, associated impacts and response have the potential for a localised and temporary impact on public opinion. 	Negligible
 Drought Occasional	Assets	<ul style="list-style-type: none"> Drought conditions (e.g. Summer 2018) resulted in the imposition of restrictions on water supply on a national and city basis with implications for building operation. Increased pressure on water treatment capacity to meet drinking water demand, e.g. Terryland Water Treatment Plant 	Negligible
	Health and Well being	<ul style="list-style-type: none"> Water restrictions, particularly in combination with extreme heat, have the potential to result in dehydration, this is particularly the case for vulnerable populations and outdoor workers. 	Negligible
	Environment	<ul style="list-style-type: none"> High temperatures and dry conditions, often result in road damages. 	Negligible
	Social	<ul style="list-style-type: none"> Water restrictions can lead to inconvenience for local businesses and residents. In August 2018, Irish Water imposed a hosepipe ban on Galway City in a bid to conserve depleted water resources. 	Minor
	Cultural Heritage	<ul style="list-style-type: none"> Drought conditions results in damage to cultural heritage sites due to weathering and drying out of substrate. 	Minor
	Financial	<ul style="list-style-type: none"> The financial implications of drought are limited and restricted to supporting the provision of water (e.g., tankering) and road maintenance. 	Negligible
	Reputational	<ul style="list-style-type: none"> Droughts, associated impacts and response have the potential for a localised and temporary impact on public opinion. 	Negligible

Impacts of Current Climate Risks – Cold Spells & Heavy Snowfall

Key to colour coding of impact ratings

Catastrophic

Major

Moderate

Minor

Negligible


Galway City has experienced cold spells and heavy snowfall events on an occasional basis with significant city wide events reported for 2018 (the 'Beast from the East'). These events have wide ranging impacts across the city including disruption of transport routes, damage to buildings, water supply restrictions, and isolation.

Hazard & Frequency	Exposure	Impact Description	Rating
 Cold spell Occasional	Assets	<ul style="list-style-type: none"> Cold spells have resulted in road closure, transport disruption and increased maintenance and repair costs across the city. Freeze thaw action has resulted in damage to building stock and critical infrastructure (e.g., water infrastructure). Storm Emma in 2018 led to 16,500 customers in Galway City suffering from restricted supply due to frozen or burst pipes. Extreme cold conditions in combination with snowfall have resulted in the widespread closure of business (incl. LA business services). 	Moderate
	Health and Well being	<ul style="list-style-type: none"> Extreme cold has resulted in treacherous conditions on roads and paths, and increased incidence of slips and falls. During Storm Emma in 2018 there were numerous reports of black ice around the city. Exposure to extreme cold has the potential to result in detrimental impacts for outdoor workers and vulnerable populations. 	Moderate
	Environment	<ul style="list-style-type: none"> Cold spells have led to decreased water availability with the potential for detrimental impacts for biodiversity and habitats. 	Moderate
	Social	<ul style="list-style-type: none"> Elderly and vulnerable populations are required to stay in place resulting in isolation. 	Moderate
	Cultural Heritage	<ul style="list-style-type: none"> Freeze thaw has been identified as having detrimental impact on the structural integrity of cultural heritage sites. 	Minor
	Financial	<ul style="list-style-type: none"> The financial implications of cold spells can be significant and are primarily associated with maintenance and repair costs for local and regional roads, buildings and assets. 	Moderate
	Reputational	<ul style="list-style-type: none"> Isolation of communities and council response (e.g., gritting) across the city receives media attention but with limited impact on public opinion. 	Minor
 Heavy snowfall Occasional	Assets	<ul style="list-style-type: none"> Heavy snowfall has resulted in road closures and transport disruption as evidenced by the closure of roads across the city as a result of Storm Emma in 2018 when 39 tonnes of salt were required to be spread on roads and footways. Accumulations of snowfall on roofs can result in damage to buildings. Flooding post-heavy snowfall events results in the inundation of assets (e.g., roads and infrastructure). 	Moderate
	Health and Well being	<ul style="list-style-type: none"> Extreme cold events have resulted in treacherous conditions and increased incidence of slips and falls amongst public and staff. 	Moderate
	Environment	<ul style="list-style-type: none"> Flooding post-heavy snowfall event result in overland flow of pollutants to habitats and ecosystems with detrimental effects. 	Moderate
	Social	<ul style="list-style-type: none"> Elderly and vulnerable populations are required to stay in place during snowfall events resulting in isolation. 	Moderate
	Cultural Heritage	<ul style="list-style-type: none"> Accumulations of heavy snowfall can result in damage to cultural heritage sites, e.g., freeze thaw. 	Minor
	Financial	<ul style="list-style-type: none"> The financial implications of cold spells are primarily associated with maintenance and repair costs for local and regional roads, buildings and assets. 	Moderate
	Reputational	<ul style="list-style-type: none"> Isolation of communities and council response (e.g., gritting) across the city receives media attention but with limited impact on public opinion. 	Minor

Impacts of Current Climate Risks - Windstorms

Galway City has been frequently exposed to wind storms over the period 1973-2022, notable examples being Storms Eleanor, Barra, Dennis and Franklin. Impacts have been experienced across the city and relate to disruption of transport, electricity and communication networks. Severe windstorms also result in health and safety risks, e.g. associated with treefall.

Catastrophic
Major
Moderate
Minor
Negligible



Hazard & Frequency	Exposure	Impact Description	Rating
 Severe windstorm Frequent	Assets	<ul style="list-style-type: none"> Windstorms have caused direct damage to building stock and other assets, as well as disrupted operations. Due to Storm Barra in December 2021, all schools and colleges in Galway were advised to close by the Department of Education. Windstorm damage to power and communication transmission infrastructure (e.g., tree fall on overhead lines) has resulted in disruption of communications and energy supply. Storm Dennis in February 2020 left 272 homes in the Salthill area without power. Windstorms have caused disruption of transport routes as a result of treefall. Preparations for Storm Lorenzo in September 2019 led to a number of road closures around Salthill and the Seapoint Promenades. Storm Ali in 2018 caused the closure of St Mary's Road, Crescent Road, Salthill Promenade and the Browne Roundabout, as well as blocking the walkway between Corrib Village and Dangan, and disrupting the Galway-Westport rail service. 	Moderate
	Health and Wellbeing	<ul style="list-style-type: none"> Windstorms posed a health and safety risk with potential for injury. Storm Lorenzo in September 2019 required additional emergency accommodation to be prepared for rough sleepers in Galway. 	Moderate
	Environment	<ul style="list-style-type: none"> Windstorms have resulted in loss of trees and this is particularly the case for vulnerable tree species. 	Minor
	Social	<ul style="list-style-type: none"> Severe windstorms and disruption of transport and communication networks has resulted in isolation. As a result of Storm Eleanor in 2018, Eir saw 50 sites affected nationally. Three and Vodafone had 71 and 30 affected sites respectively. 	Moderate
	Cultural Heritage	<ul style="list-style-type: none"> Severe wind storms can cause structural damage to cultural heritage sites. 	Minor
	Financial	<ul style="list-style-type: none"> The financial impacts of severe wind storm are associated with clean-up and repair cost. 	Moderate
	Reputational	<ul style="list-style-type: none"> Reputational damage as a result of wind storms is limited and associated with short term media reporting. 	Moderate

Impacts of Current Climate Risks - Coastal Flooding and Erosion

Key to colour coding of impact ratings

Catastrophic
Major
Moderate
Minor
Negligible

Galway City is exposed to coastal storms resulting in inundation of coastal areas. A number of areas are subject to frequent and recurring flooding. Coastal erosion is currently a potential risk for Galway City Council with impacts currently limited.

Hazard & Frequency	Exposure	Impact Description	Rating
 <p>Coastal erosion</p> <p>Occasional</p>	Assets	<ul style="list-style-type: none"> None 	None
	Health and Well being	<ul style="list-style-type: none"> None 	None
	Environment	<ul style="list-style-type: none"> Coastal erosion has resulted in loss of land and amenities (e.g. golf courses) and damage to coastal habitats. 	Moderate
	Social	<ul style="list-style-type: none"> None 	None
	Cultural Heritage	<ul style="list-style-type: none"> None 	None
	Financial	<ul style="list-style-type: none"> The financial implications of coastal erosion are primarily related to the development and maintenance of coastal defence works. 	Minor
	Reputational	<ul style="list-style-type: none"> Coastal erosion issues are localised and are associated with short term media reporting on preparedness and response. 	Minor
 <p>Coastal flood</p> <p>Frequent</p>	Assets	<ul style="list-style-type: none"> Coastal flooding can result in direct damage to buildings and other assets. Storm Elsa in December 2019 caused 10 houses and 50 cars in the Salthill area to be flooded. Storm Eleanor in January 2018 caused hundreds of thousands of euros worth of damage, flooding businesses near Claddagh Quay and in Shop Street. Coastal flooding can result in damage to road surfaces and footpaths, as well as disrupting transport networks. Storm Barra in December 2021 led to flood waters breaking over coastal defences making roads leading to Salthill Promenade impassable, as well as disrupting Bus Eireann services in the area. Flood waters arising from Storm Erik in February 2019 caused the Promenade in Salthill to be closed between Grattan Road and Leisureland. 	Major
	Health and Well being	<ul style="list-style-type: none"> Coastal flooding poses risks to health and well being of the public and staff working in exposed areas. 	Moderate
	Environment	<ul style="list-style-type: none"> Coastal flooding has detrimental impacts on coastal ecosystems, with the potential to cause an overall reduction in ecosystem health. 	Minor
	Social	<ul style="list-style-type: none"> Closure of transport routes due to coastal flooding results in significant social isolation for isolated communities. Coastal flooding results in damage to amenities located in coastal habitats. 	Moderate
	Cultural Heritage	<ul style="list-style-type: none"> Coastal flooding can cause structural damage to cultural heritage sites due to temporary inundation and exposure to corrosive salt water. 	Minor
	Financial	<ul style="list-style-type: none"> Financial implications associated with coastal flooding relate to increased costs associated with emergency response (e.g. pumping and emergency co-ordination), clean-up and repair). 	Minor
	Reputational	<ul style="list-style-type: none"> For those areas subject to inundation, there is a potential for a localised long term impact on public opinion. 	Moderate

Impacts of Current Climate Risks - Pluvial and Fluvial Flooding

Key to colour coding of impact ratings

Catastrophic

Major

Moderate

Minor

Negligible

For Galway City in the period 1973-2022, pluvial and fluvial flooding have occurred on common basis. Areas of exposure to fluvial flooding are limited geographically but with the potential for frequent exposure. Pluvial flooding can be experienced across the city with impacts associated with inundation of transport routes while bathing water quality has been impacted due to pollutant runoff following heavy rainfall events.


Hazard & Frequency	Exposure	Impact Description	Rating
 <p>Pluvial flood</p> <p>Common</p>	Assets	<ul style="list-style-type: none"> Pluvial flooding has resulted in the temporary inundation of assets. Pluvial flooding results in damage to road surfaces and disruption of transport. Heavy rainfall associated with Storm Eunice in February 2022 caused disruption to Lough Atalia road. 	Minor
	Health and Well being	<ul style="list-style-type: none"> Heavy precipitation and floodwater leads to dangerous driving conditions for both council staff and public. 	Minor
	Environment	<ul style="list-style-type: none"> Pluvial flooding has resulted in the overland flow of pollutants (nutrients, sediment and pesticides) with impacts on terrestrial, coastal and freshwater ecosystems. Warnings relating to increased bacteria in bathing waters at Ballyloughane, Grattan and Silverstrand Beaches were issued in 2020 following forecasts of increased rainfall and possible activation of storm overflow. 	Minor
	Social	<ul style="list-style-type: none"> Road closures can result in social isolation for communities, though on a more short-term basis (including due to the availability of alternative routes that are available during storm and flood events). 	Minor
	Cultural Heritage	<ul style="list-style-type: none"> Pluvial flooding puts built heritage with stone cavities at risk of soakage and leakage. 	Negligible
	Financial	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Pluvial flooding issues are localised and can result in short term impacts on public opinion. 	Minor
 <p>River flood</p> <p>Common</p>	Assets	<ul style="list-style-type: none"> River flooding has resulted in the temporary inundation of buildings, transport disruption and road closures. River flooding and fast flowing rivers has the potential to cause damage to bridges through hydrodynamic scour. 	Moderate
	Health and Well being	<ul style="list-style-type: none"> Heavy precipitation and floodwater leads to dangerous driving conditions. Fluvial floods can carry debris which can lead to injury of residents and pedestrians. 	Moderate
	Environment	<ul style="list-style-type: none"> River flooding results in the overland flow of pollutants (nutrients, sediment and pesticides) with impacts on terrestrial and freshwater ecosystems. 	Moderate
	Social	<ul style="list-style-type: none"> Road closures can result in short term social isolation. Inhibited development of communities as a result of frequent river flooding. 	Minor
	Cultural Heritage	<ul style="list-style-type: none"> A number of the city's cultural heritage and archaeological sites are situated near river systems and are particularly exposed to river flooding. 	Minor
	Financial	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> For areas that are subject to inundation, there is the potential for localised short term impact on public opinion. 	Minor

Impacts of Current Climate Risks – Groundwater Flooding

For the period 1973-2022, groundwater flooding has occurred on a rare basis with limited impact.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

Hazard & Frequency	Exposure	Impact description	Rating
 <p>Groundwater Flood</p> <p>Rare</p>	Assets	<ul style="list-style-type: none"> Groundwater flooding has the potential to result in flooding of road infrastructure, particularly for road with limited drainage capacity. 	Negligible
	Health and Wellbeing	<ul style="list-style-type: none"> None 	None
	Environment	<ul style="list-style-type: none"> None 	None
	Social	<ul style="list-style-type: none"> None 	None
	Cultural Heritage	<ul style="list-style-type: none"> None 	None
	Financial	<ul style="list-style-type: none"> Potential financial implications of groundwater are associated with emergency response (e.g. pumping and emergency co-ordination, clean-up and repair). 	Negligible
	Reputational	<ul style="list-style-type: none"> None 	None

3.2.3 Impact Assessment (Service Delivery)

Summary of Service Level Impacts

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

On the basis of reported information and in consultation with Galway City Council, an assessment of the impacts of identified climate change hazards and impacts on the delivery of services by Galway City 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 Galway City 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.

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

Hazard	Internal LA Governance & Administration	Roads, Transportation & Critical Infrastructure Services	Built Environment & Asset Management Services	Community Development Services / Economic & Tourism Development Services	Arts, Culture & Heritage Services	Water Supply Services	Environment Services (Protection & Enhancement)	Emergency Services & Response
Heatwave	Minor	Moderate	Minor	Moderate	Minor	Moderate	Moderate	Moderate
Drought	None	None	None	Minor	Minor	Moderate	Minor	Minor
Cold spell	Moderate	Moderate	Moderate	Moderate	Minor	Moderate	Moderate	Moderate
Heavy snowfall	Minor	Moderate	Moderate	Moderate	Minor	Minor	Moderate	Moderate
Severe windstorm	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Coastal Flood	Moderate	Major	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Coastal Erosion	None	None	None	Minor	None	None	Minor	None
Pluvial Flood	Minor	Minor	Minor	Minor	Minor	Minor	Moderate	Minor
River Flood	Minor	Moderate	Moderate	Moderate	Minor	Negligible	Minor	Moderate
Groundwater Flood	None	Negligible	None	None	None	None	None	None

*Delivered through a Service Level Agreements (SLA) with Irish Water

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 Galway City Council. The primary impacts of heatwave relate to increased maintenance and repair requirements of road surfaces and increased pressure on service provision for recreational areas. 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
Internal LA Governance & Administration	<ul style="list-style-type: none"> Decreased staff productivity and increased staff and customer discomfort. 	<ul style="list-style-type: none"> None
Roads, Transportation & Critical Infrastructure Services	<ul style="list-style-type: none"> Increased costs associated with repair of road surfaces across the city. Increased health and safety risk for outdoor staff members across the city. 	<ul style="list-style-type: none"> None
Built Environment & Asset Management Services	<ul style="list-style-type: none"> Increased requirement for cooling in council offices/buildings. 	<ul style="list-style-type: none"> None
Arts, Culture & Heritage Services	<ul style="list-style-type: none"> Increased requirements for monitoring and maintenance of cultural heritage sites. Increased staff and customer discomfort. 	<ul style="list-style-type: none"> Localised degradation of cultural heritage sites due to drying out. Increased requirements for monitoring and maintenance of cultural heritage sites.
Water Supply Services	<ul style="list-style-type: none"> Increased demand for water to cool infrastructure, communities, and livestock. Implementation of water conservation measures (e.g., hosepipe bans). 	<ul style="list-style-type: none"> Increased requirement to support provision of water to communities suffering loss of water supply (e.g., Tankering).
Environment Services (Protection & Enhancement)	<ul style="list-style-type: none"> Reduced water flows impacting on water quality with increased requirement for monitoring and remediation. Decreased ecosystem health across the city with potential for loss of priority habitats resulting in increased requirement for monitoring and remediation. 	<ul style="list-style-type: none"> Reduced water flows impacting on water quality in local areas with increased requirement for monitoring and remediation. Reduced water flows impacting on biodiversity with potential for loss of priority species and habitats necessitating increased monitoring and remediation.
Community Development Services / Economic & Tourism Development Services	<ul style="list-style-type: none"> Increased requirement for waste collection and traffic management at key recreational sites. 	<ul style="list-style-type: none"> Disruption to delivery of community services across the city due to water shortages
Emergency Services & Response	<ul style="list-style-type: none"> Increase in number of call out to bathing areas throughout the city. 	<ul style="list-style-type: none"> Increased pressure on emergency services..
Crosscutting	<ul style="list-style-type: none"> Health and Safety of Staff 	

Service Level Impacts (Cold Spell & Heavy Snowfall)

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

	Cold Spell	Heavy Snowfall
Internal LA Governance & Administration	<ul style="list-style-type: none"> Closure of business services across the city. Health and safety risks for public and staff. 	<ul style="list-style-type: none"> Localised closure of business services. Health and safety risks for public and staff.
Roads, Transportation & Critical Infrastructure Services	<ul style="list-style-type: none"> Increased costs associated with gritting and salting roads across the city. Increased road repair and maintenance costs. 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 city. Damage to wastewater infrastructure with increased requirement for maintenance and repair. 	<ul style="list-style-type: none"> Transport disruption and road closures. Increased costs associated with gritting and salting roads and footpaths around the city.
Built Environment & Asset Management Services	<ul style="list-style-type: none"> Increased energy costs for buildings city wide. Increased health and safety risks for public and staff city wide. 	<ul style="list-style-type: none"> Increased energy costs for buildings city wide. Increased health and safety risks for public and staff city wide.
Community Development Services / Economic & Tourism Development Services	<ul style="list-style-type: none"> Increased energy costs in community buildings across the city. Increased health and safety risks for public and staff working in community buildings. Increased instances of community isolation city wide. 	<ul style="list-style-type: none"> Increased health and safety risks for public and staff. Closure of services across the city. Increased instances of community isolation across the city.
Arts, Culture & Heritage Services	<ul style="list-style-type: none"> Increased energy costs for cultural heritage sites. Increased health and safety risks for public and staff at community heritage sites. Increased repair costs associated with damage to cultural heritage sites. 	<ul style="list-style-type: none"> Increased health and safety risks for public and staff. Localised closure of sites.
Water Supply Services	<ul style="list-style-type: none"> City wide water supply issues due damaged water supply infrastructure (e.g., burst pipes). Increased maintenance and repair costs of water service infrastructure across the city. Overland flows of pollutants due to post freezing events, causing contamination of water supplies necessitating increased monitoring and remediation. 	<ul style="list-style-type: none"> Localised water supply issues due to damaged water supply infrastructure (e.g., burst pipes). Increased maintenance and repair costs of water service infrastructure.
Environment Services (Protection & Enhancement)	<ul style="list-style-type: none"> Overland flows of pollutants due to post freezing flood events resulting in decreased water quality necessitating increased requirement on council for monitoring. Prolonged cold spells impacting species requiring increased monitoring and remediation. 	<ul style="list-style-type: none"> Overland flows of pollutants due to post freezing flood events resulting in decreased water quality necessitating increased requirement for monitoring. Heavy Snowfall impacts species not protected from the frigid temperatures, with increased monitoring and remediation required at a city wide level.
Emergency Services & Response	<ul style="list-style-type: none"> Increased pressure on emergency response units across the city. Increase in response times due to treacherous road conditions around the city. 	<ul style="list-style-type: none"> Increased pressure on emergency response units across the city. Increase in response times due to heavy snowfall on roads around the city.
Crosscutting	<ul style="list-style-type: none"> Redeployment of staff 	

Key to colour coding of impact ratings

Catastrophic

Major

Moderate

Minor

Negligible

Service Level Impacts (Severe Windstorm)

Severe windstorms can result in the closure and/or disruption of Galway City Council Offices and services. Primary impacts of severe windstorms are associated with 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
Internal LA Governance & Administration	<ul style="list-style-type: none"> Widespread closure of business services. Health and safety risks for public and staff.
Roads, Transportation & Critical Infrastructure Services	<ul style="list-style-type: none"> City wide transport disruption and road closures affecting the wider community and local authority operations. Increased clean-up and repair costs after an event. Increased drain maintenance costs for wastewater infrastructure. Disruption of critical infrastructure services (e.g. electricity) impacting on wastewater treatment.
Built Environment & Asset Management Services	<ul style="list-style-type: none"> Closure of buildings and disruption of services as a result of direct damage to buildings and disruption of power and communications.
Community Development Services / Economic & Tourism Development Services	<ul style="list-style-type: none"> Disruption to delivery of community services across the city. Increased clean-up and repair costs after an event. Increased power outages and damages to infrastructure result in an impact on local economy.
Arts, Culture & Heritage Services	<ul style="list-style-type: none"> Closure of sites and events. Increased maintenance and repair costs due to storm damage to cultural heritage sites.
Water Supply Services	<ul style="list-style-type: none"> Water supply issues due to damaged water supply infrastructure.
Environment Services (Protection & Enhancement)	<ul style="list-style-type: none"> Increased cost to protect habitats from wind damage.
Emergency Services & Response	<ul style="list-style-type: none"> Increased pressure on emergency service.
Crosscutting	<ul style="list-style-type: none"> Staff redeployment

Service Level Impacts (Coastal Flood & Erosion)

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

Coastal flooding and erosion result in a range of impacts for service provision by Galway City Council. Impacts of coastal flooding are associated with clean-up and repair costs, damage to assets and infrastructure and damage to environmentally sensitive areas. The primary impacts of coastal erosion are associated with damages to community assets and infrastructure, and damages to coastal habitats.

	Coastal Flood	Coastal Erosion
Internal LA Governance & Administration	<ul style="list-style-type: none"> Temporary inundation of buildings in exposed area resulting in closure of services. 	<ul style="list-style-type: none"> None
Roads, Transportation & Critical Infrastructure Services	<ul style="list-style-type: none"> Transport disruption and road closures across the city. Increased clean-up and repair costs. Damage to stormwater systems with increased requirement for maintenance and repair. Damage to wastewater infrastructure with increased requirement for maintenance and repair. 	<ul style="list-style-type: none"> None
Built Environment & Asset Management Services	<ul style="list-style-type: none"> Inundation of building stock. 	<ul style="list-style-type: none"> None
Community Development Services / Economic & Tourism Development Services	<ul style="list-style-type: none"> Damage to community infrastructure such as parks and refuse collection points. Closure of community infrastructure and services. Increased repair and maintenance costs. Inhibited development of communities at risk of coastal flooding. 	<ul style="list-style-type: none"> Damage to recreational areas, Increased maintenance and repair costs.
Arts, Culture & Heritage Services	<ul style="list-style-type: none"> Damage to heritage sites exposed to coastal flooding. Increased Health and safety risks. Increased maintenance and repair costs. 	<ul style="list-style-type: none"> None
Water Supply Services	<ul style="list-style-type: none"> Damage to critical water supply infrastructure with increased requirement for maintenance and repair. 	<ul style="list-style-type: none"> None
Environment Services (Protection & Enhancement)	<ul style="list-style-type: none"> Impact on the water status of high-quality sites necessitating increased monitoring and remediation. Damage to coastal habitats resulting in a decrease in ecosystem health at a localised level and an increased requirement for monitoring and remediation. 	<ul style="list-style-type: none"> Damage to coastal habitats resulting in a decrease of ecosystem health at a localised level and an increased requirement for monitoring and remediation.
Emergency Services & Response	<ul style="list-style-type: none"> Increased pressure on emergency response units across the city. 	<ul style="list-style-type: none"> None
Crosscutting	<ul style="list-style-type: none"> Staff redeployment 	



Service Level Impacts (Pluvial & River Flood)

Pluvial and river flooding have resulted in a wide range of impacts for Galway City Council. Impacts are primarily associated with 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
Internal LA Governance & Administration	<ul style="list-style-type: none"> Localised disruption and closure of local authority services. 	<ul style="list-style-type: none"> Localised disruption and closure of local authority services.
Roads, Transportation & Critical Infrastructure Services	<ul style="list-style-type: none"> Localised transport disruption and road closures. Increased clean-up and repair costs after an event. Reduced capacity for drainage resulting in standing water. Damage to stormwater infrastructure at a localised level. Damage to wastewater treatment plants. 	<ul style="list-style-type: none"> Transport disruption and road closures. Increased clean-up and repair costs after an event. Reduced capacity for drainage resulting in standing water. Damage to stormwater infrastructure.
Built Environment & Asset Management Services	<ul style="list-style-type: none"> Damage to buildings and disruption of service at the localised level. Increased maintenance and repair costs. Increased requirement for flood defence measures. 	<ul style="list-style-type: none"> Damage to buildings and disruption of service across the city. Increased maintenance and repair costs. Increased requirement for flood defence measures.
Community Development Services / Economic & Tourism Development Services	<ul style="list-style-type: none"> Closure of community infrastructure and services at a localised level. Increased repair and maintenance costs. Inhibited development of communities at a localised level. Damage to buildings and travel disruptions impact on local economies. 	<ul style="list-style-type: none"> City wide closure of community infrastructure and services. Increased repair and maintenance costs. Inhibited development of communities across the city. Damage to buildings and travel disruptions impact on local economies.
Arts, Culture & Heritage Services	<ul style="list-style-type: none"> Damage to heritage sites due to pluvial flooding. Increased maintenance and repair costs. 	<ul style="list-style-type: none"> Damage to heritage sites due to river flooding requiring repair work. Increased maintenance and repair costs.
Water Supply Services	<ul style="list-style-type: none"> Water supply issues at a localised level requiring supplemental water provision (e.g. tankering). Increased water treatment costs due to contamination by overland pollutant flows. 	<ul style="list-style-type: none"> Appearance of threat to water supply levels.
Environment Services (Protection & Enhancement)	<ul style="list-style-type: none"> Deterioration of water quality due to overland flow of pollutants resulting in water supply issues, environmental degradation and an increased requirement for monitoring and remediation. Severe damage across the city to environmentally sensitive areas requiring monitoring and/or restoration work. 	<ul style="list-style-type: none"> Deterioration of water quality due to overland flow of pollutants resulting in water supply issues and an increased requirement for monitoring and remediation. Isolated and limited damage to environmentally sensitive areas requiring monitoring and/or restoration work.
Emergency Services & Response	<ul style="list-style-type: none"> Localised increased pressure on emergency response. 	<ul style="list-style-type: none"> Increased pressure on emergency response across the city.
Crosscutting	<ul style="list-style-type: none"> Staff redeployment 	

Service Level Impacts (Groundwater Flooding)

Groundwater flooding has the potential to impact on service delivery by Galway City Council. Potential impacts are primarily associated with transport disruption and repair of road surfaces.

Key to colour coding of impact ratings

- Catastrophic
- Major
- Moderate
- Minor
- Negligible

	Groundwater Flooding
Internal LA Governance & Administration	<ul style="list-style-type: none"> None
Roads, Transportation & Critical Infrastructure Services	<ul style="list-style-type: none"> Appearance of threat to road and other critical infrastructure
Built Environment & Asset Management Services	<ul style="list-style-type: none"> None
Community Development Services / Economic & Tourism Development Services	<ul style="list-style-type: none"> None
Arts, Culture & Heritage Services	<ul style="list-style-type: none"> None
Water Supply Services	<ul style="list-style-type: none"> None
Environment Services (Protection & Enhancement)	<ul style="list-style-type: none"> None
Emergency Services & Response	<ul style="list-style-type: none"> None
Crosscutting	<ul style="list-style-type: none"> Staff redeployment

3.2.4 Current Climate Risk Matrix

Current Climate Risk Matrix

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

The assessment identified **severe windstorm** and **coastal flooding** as posing the highest level of risk for Galway City with impacts of severe windstorm primarily associated with disruption and damage to energy, communication and transport networks while impacts of coastal flooding are associated with damage to assets and infrastructure, increased pressure on emergency response service and significant financial costs associated with clean-up operations.

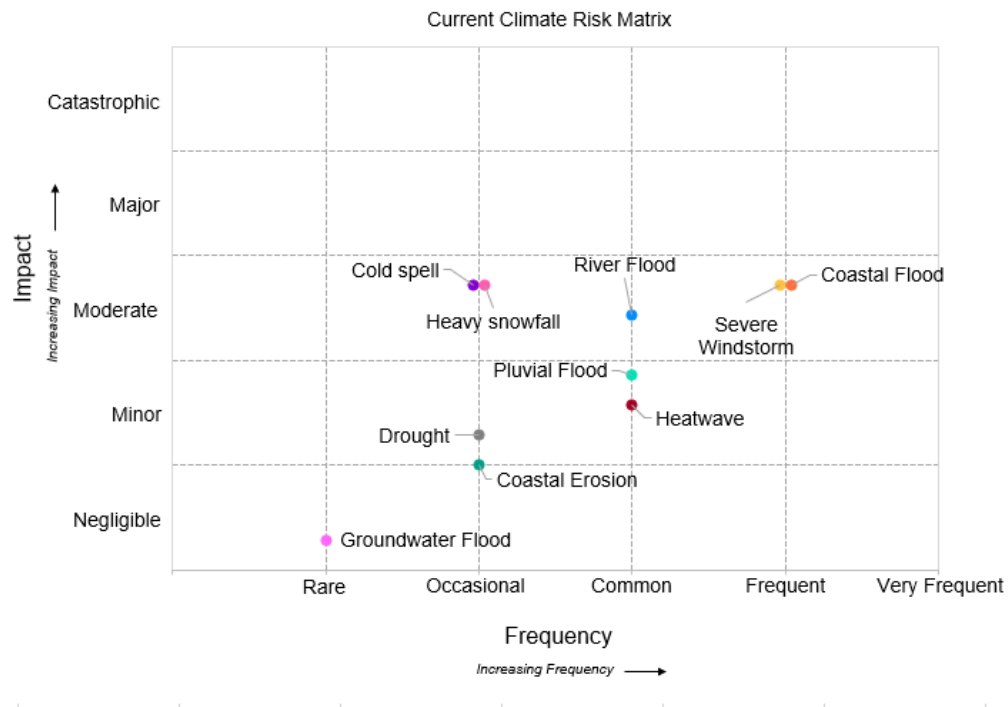
River and pluvial flooding have been identified as posing a relatively high risk for Galway City with impacts experienced including damage to assets and infrastructure, disruption of transport networks and mobilisation of pollutants with detrimental impacts on bathing water areas.

Heatwaves occur on a common basis across Galway City; however, the overall impact is currently considered minor. The impacts of heatwaves are associated with an increase in damage to road surfaces and increased pressure on recreational sites.

Coastal erosion occurs on occasional basis in Galway City, and has limited impacts on coastal assets and infrastructure and cultural heritage sites. **Cold spells and heavy snowfall** also occur on an occasional basis across Galway City 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..

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

Groundwater flooding is considered to occur rarely in Galway City with negligible impacts.



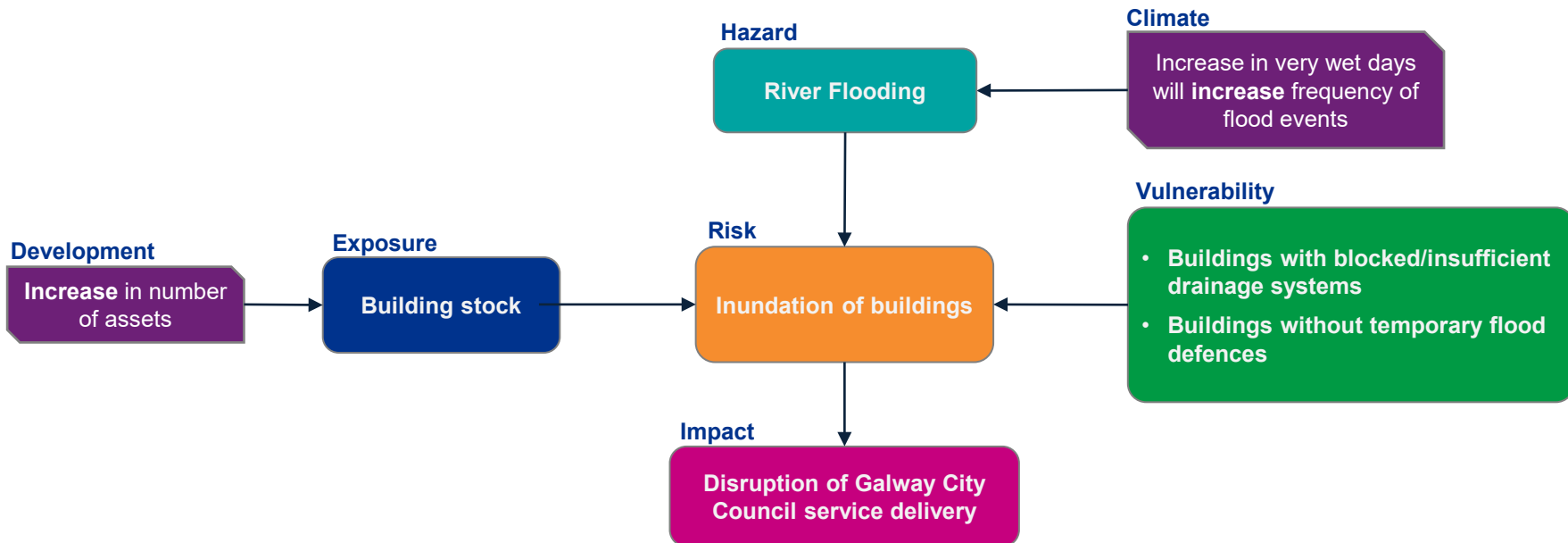
The risk matrix above shows the current risk for the identified hazards within Galway City.

3.3 Future Climate Risks and Impacts

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 Galway City Council buildings will increase in the future.











In the following sections, we provide an assessment of potential future changes in the climate of Galway City 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.

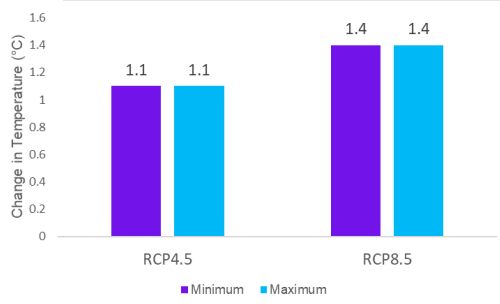


3.3.1 Future Changes in Climate Hazards

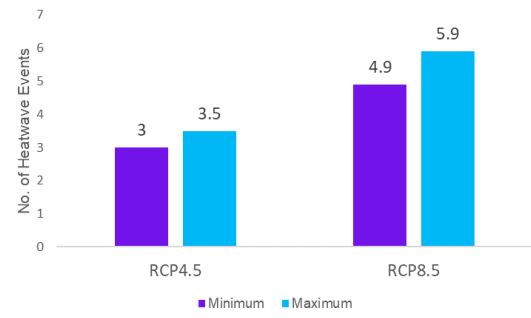
Climate Projections for Galway City in 2050 (1/2)

Having identified and assessed the range of climate hazards and impacts already experienced by Galway City Council, the 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 Galway City Council may change in the future. The information below summarizes the climate projections for each hazard based on Nolan and Flanagan (2020).

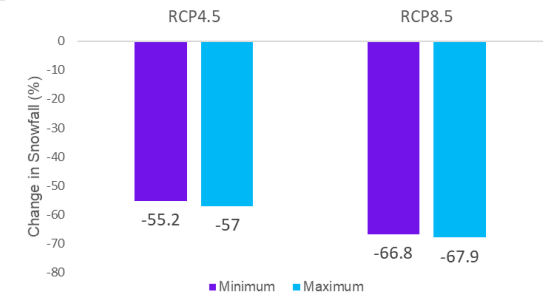
Hazard	Projected Change	Future Frequency
 Heatwave	<ul style="list-style-type: none"> Projections indicate an overall increase in average temperature (bottom left) of between 1.1 and 1.4°C for Galway City relative to the 1981-2000 period. Under a high emission scenario, projections indicate that heatwaves will become more frequent (bottom middle) by mid-century. 	Frequent 
 Drought	<ul style="list-style-type: none"> Summer rainfall is expected to reduce by between 6 and 8% 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	<ul style="list-style-type: none"> As a consequence of the increasing temperatures, a decrease in the number of frost days and ice days in the 2041-2060 future period when compared with the baseline period of 1981-2000, is projected for both the RCP4.5 and RCP8.5 scenario. 	Rare 
 Heavy Snowfall	<ul style="list-style-type: none"> The 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). 	Rare 
 Severe Windstorms	<ul style="list-style-type: none"> 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 Galway City 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)













The projected minimum and maximum **number of heatwaves** for the area of Galway City 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)

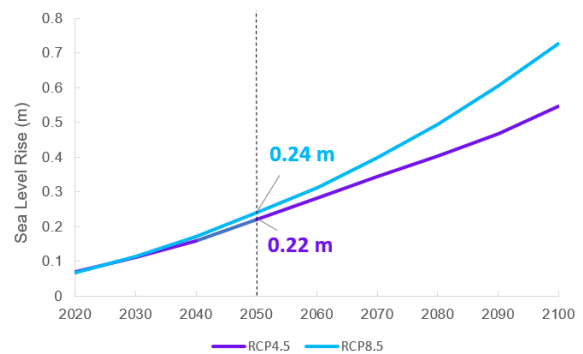


The projected minimum and maximum **reduction in snowfall** for the area of Galway City for the period 2041-2060 compared to 1981-2000 for a medium (RCP4.5) and high (RCP8.5) emissions scenario (Source: Nolan and Flanagan, 2020)

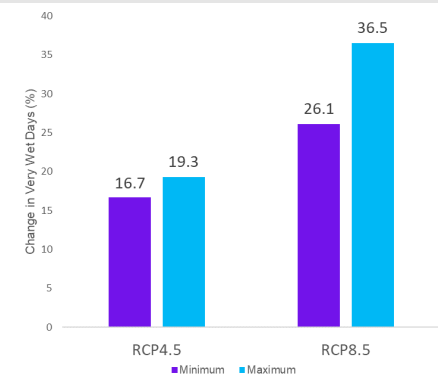
Climate Projections for Galway City in 2050 (2/2)

Having identified and assessed the range of climate hazards and impacts already experienced by Galway City Council, the 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 Galway City Council may change in the future. The information below summarizes the climate projections for each hazard based on Nolan and Flanagan (2020).

Hazard	Projected Change	Future Frequency
 Coastal Flooding	<ul style="list-style-type: none"> Rising sea levels projections under a high emissions scenario indicate an increase of up to 0.24 m by 2050 which will increase the frequency of coastal inundation (bottom left). 	Very Frequent 
 Coastal Erosion	<ul style="list-style-type: none"> A rising sea level is strongly linked with coastal erosion and an increase in erosion rates and extent. 	Common 
 Pluvial Flooding	<ul style="list-style-type: none"> Projections indicate an increase in the frequency of heavy rainfall days (days with precipitation >30mm) for Galway City with some areas projected to see increase of up to 37% (bottom right). This will likely result in an increased frequency of associated fluvial and pluvial flooding. 	Frequent 
 River Flooding	<ul style="list-style-type: none"> Projections indicate an increase in the frequency of heavy rainfall days (days with precipitation >30mm) for Galway City with some areas projected to see increase of up to 37% (bottom right). This will likely result in an increased frequency of associated fluvial and pluvial flooding. 	Frequent 
 Groundwater Flooding	<ul style="list-style-type: none"> Projections of changes in groundwater flooding are currently not available, therefore there is uncertainty in the change in groundwater flooding frequency that can be expected. 	Rare 



Projected **change in sea level** for a medium (RCP4.5) and high (RCP8.5) emissions scenario offshore of (Grid Reference: 53,-10) Galway City (Source: IPCC AR6 Sea-Level Rise Projections)



The projected **increase in very wet days (> 30 mm)** for the area of Galway City 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, Galway City will also change in terms of its population and developments with implications for levels of exposure and vulnerability across the region. National, regional and local strategies that outlined expected and possible sociodemographic and infrastructure developments within Galway City 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 Galway City projected to change?



- Population to increase from 79,700 in 2016 to **97,500 in 2029** (CDP)
- **4,433** new housing units required by 2028 (CDP)
- By 2040 Galway City will require **150,000 m² commercial office space** & the capacity for **2.7 million additional visitors** each year (GCC, Eolas)

RSES Objectives: "Deliver at least 50% of all new city homes targeted in the Galway Metropolitan Strategic Plan, within the existing built-up footprint of Galway City and suburbs."

Planning for adaptation

Flood Defence Schemes:

The Office of Public Works-Council project includes the €9.5m 'Coirib go Cósta' - Galway City Flood Relief Scheme which aims to protect 312 properties (181 residential, 131 non-residential)



Key road infrastructure projects include focus for council:

- Salmon Weir pedestrian & cycle bridge
- Bus Connects Galway
- Martin roundabout junction



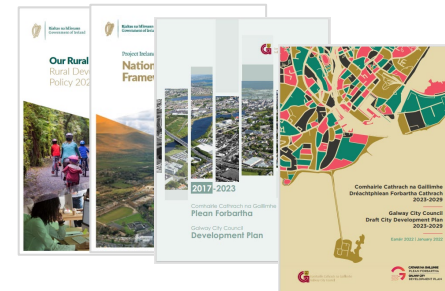
Notable clean energy initiatives:

- 10 X Sustainable Energy Communities (SEC) including Galway Energy Co-operative Ltd. NUIG Community and University Sustainability Planning Group
- A harbour redevelopment plan which envisions the development of a hydrogen energy hub (known as 'GH2').

Local Economic and Community Development (2015-2021)

Support sustainable development through improving the natural environment and providing a housing, energy, transport infrastructure consistent with meeting our commitments on GHG emissions

Planning for mitigation



Case Study in Urban Planning:

Galway City Council Approved URDF Projects

€53.24 funding allocated by Urban Regeneration and Development Fund (URDF) in 2021.

Approved projects include:

- A **€40.30 million Transport Connectivity Project** aiming to deliver a safe, cohesive city cycle network and pedestrian facilities. This forms part of the Galway Transport Strategy 2016-36 (in partnership with Galway City and County Councils, the National Transport Authority, Transport Infrastructure Ireland.
- Public Spaces & Streets Project (€8.64m)
- Innovation & Creativity District (€4.3m)

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.

<h2>Assets</h2>	<ul style="list-style-type: none"> • Due to the projected increase in Galway City’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
<h2>Health and Wellbeing</h2>	<ul style="list-style-type: none"> • Due to the projected increase in the elderly population in Galway City there will be a greater number of vulnerable people who are more sensitive to hazards, particularly heatwaves • Pluvial, river, and coastal 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.
<h2>Environment</h2>	<ul style="list-style-type: none"> • The potential increasing occurrence of heatwaves and drought conditions within Galway City 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 Galway City, 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.

<p>Social</p>	<ul style="list-style-type: none"> • Due to the projected increase in the total and elderly population in Galway City 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 and services e.g. litter collection, toilet and parking facilities.
<p>Cultural Heritage</p>	<ul style="list-style-type: none"> • 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, river, and coastal 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
<p>Financial</p>	<ul style="list-style-type: none"> • Due to the potential increase in frequency of hazard events and exposure across Galway City, there will be an associated increase in the actions the local authority takes before, during, and after an 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
<p>Reputational</p>	<ul style="list-style-type: none"> • Due to the potential increase in frequency of hazard events and exposure across Galway City during an event there will be an increase in 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 Galway City, 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 ten 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	Minor	Moderate	Minor	Moderate	Minor	Moderate	Negligible	Minor	Minor	Moderate	Negligible	Minor	Negligible	Minor
Drought	Negligible	Minor	Negligible	Minor	Negligible	Moderate	Minor	Moderate	Minor	Moderate	Negligible	Minor	Negligible	Minor
Cold spell	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Minor	Minor	Moderate	Moderate	Minor	Minor
Heavy snowfall	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Minor	Minor	Moderate	Moderate	Minor	Minor
Severe windstorm	Moderate	Moderate	Moderate	Moderate	Minor	Minor	Moderate	Moderate	Minor	Minor	Moderate	Moderate	Moderate	Moderate
Coastal Flood	Major	Major	Moderate	Major	Minor	Moderate	Moderate	Major	Minor	Moderate	Minor	Moderate	Moderate	Major
Coastal Erosion	None	Negligible	None	Negligible	Moderate	Major	None	Negligible	None	Negligible	Minor	Moderate	Minor	Moderate
Pluvial Flood	Minor	Moderate	Minor	Moderate	Minor	Moderate	Minor	Moderate	Negligible	Minor	Minor	Moderate	Minor	Moderate
River Flood	Moderate	Major	Moderate	Major	Moderate	Major	Minor	Moderate	Minor	Moderate	Minor	Moderate	Minor	Moderate
Groundwater Flood	Negligible	Negligible	None	None	None	None	None	None	None	None	Negligible	Negligible	None	None

3.3.3 Future Climate Risk Matrix

Future Climate Risk Matrix

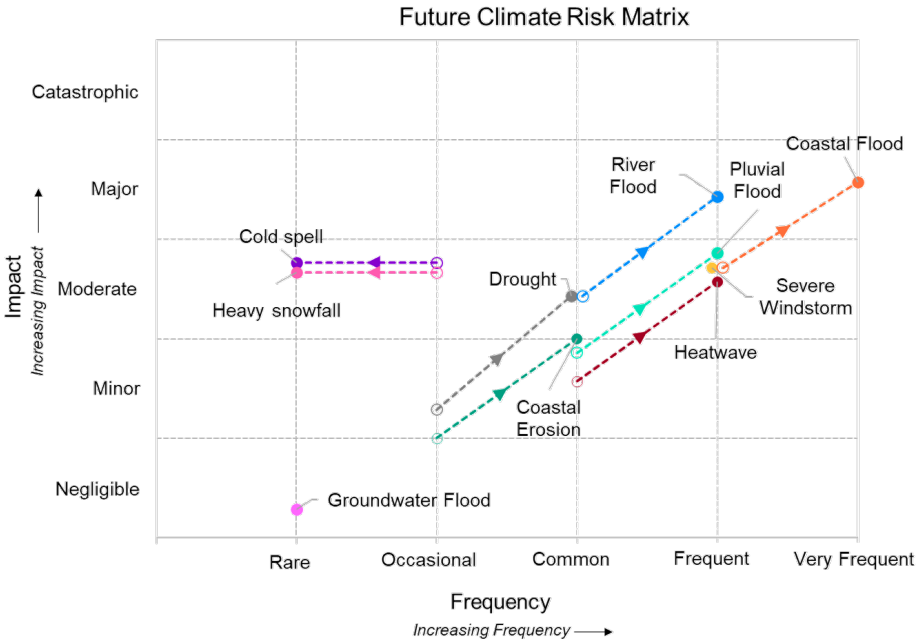
Projected changes in levels of hazard, exposure, and vulnerability for Galway City combine to form an assessment of future climate risks. The future climate risk matrix on the right shows projected change in risk with the hollow marker showing the current risk and the solid marker the future risk. The dotted line shows the change between the current and future risk.

The **risk** of existing hazards such as **coastal flooding, river, pluvial, and heatwave** is likely to **increase** in the future 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.

Coastal erosion and droughts although already experienced in Galway City, are expected to occur more frequently in the future and with a greater impact. These hazards can therefore be considered as **emerging risks** for the region.

The frequency and impact of **severe windstorms** is thought to be **unchanged in the future**, these events will remain a substantial risk for Galway City. The risk of **groundwater flooding** is also unchanged in the future, however, there is uncertainty associated with how climate change will impact the occurrence of this hazard.

The projected level of impact for **heavy snowfall and cold spells** on Galway City remains similar to the current period, however, due to the projected decreases in hazard frequency, the overall risk of these hazards is projected to **reduce** in the future.



The risk matrix above shows the future changes in risk for the identified hazards within Galway City. 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

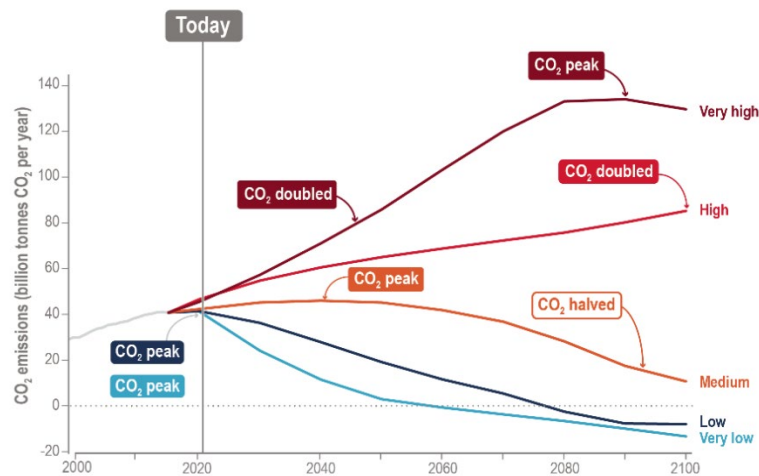
Uncertainty

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.

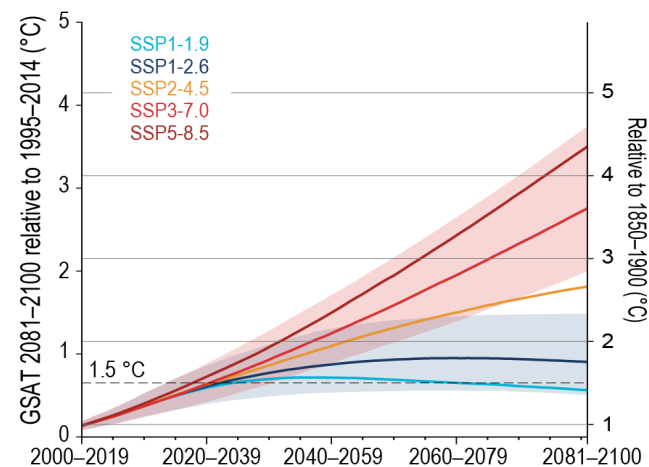
Different social and economic developments can lead to substantially different future emissions of carbon dioxide and other greenhouse gases (bottom left) resulting in uncertainty in what the future global climate will be. As an example of the possible future ranges in mean global surface temperature (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 Galway City will develop into the future. Although, in the near-term there is relatively good understanding as a result of strategies, such as the Galway City Development Plan 2023-2029, 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 CO₂ 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

The CCRA detailed within this report provides an assessment of Galway city's climate change risks to support Galway City 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:

- 
 - **Coastal erosion** and **flooding** already pose a significant risk for Galway City and have resulted in temporary inundation of buildings, damage to critical water supply infrastructure and disruption of transport networks (Bus Eireann services, during Storm Barra). Rising sea levels will increase the rate of coastal erosion and frequency of coastal inundation, resulting in an increased coastal erosion and flood risk for Galway City.
- 
 - Recent experiences of **river** and **pluvial flooding** events in 2015/16, 2018 and 2022, resulted in damages to buildings, amenities and recreational areas, closure of businesses and disruption of transport networks. Projected increases in the frequency of extreme precipitation events will result in increased surface water and riverine flood risk for Galway city.
- 
 - **Severe windstorms** are currently experienced on a frequent basis in Galway City and result in wide-ranging impacts, including damages to buildings and infrastructure, disruption to energy supply and transport networks. Projections indicate no significant change to this frequency.
- 
 - Galway City experienced both a **heatwave** and **drought** in 2018 and 2022, with a heatwave was also recorded in 2021. These events resulted in damage to road surfaces, disruption of public transport networks, increased demand placed on water resources (hosepipe bans) and reduced river flow. Projected increases in the frequency of heatwaves and 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 (e.g. Storm Emma) demonstrated the wide range of impacts for Galway City. These included, amongst others, road closures, disruption to public transport, power outages, increase in the frequency of trips and falls, and impacts on water resources (restricted water supply during storm Emma). Projected increases in average temperature and decreases in the frequency of snowfall indicate a decrease in the frequency of cold spells, heavy snowfall, and their associated impacts.
- 
 - **Groundwater flooding** is currently experienced rarely in Galway City and has limited impacts such as damages to roads and transport disruption.

To increase resilience, Galway City Council will need to proactively plan for and adapt to the current and future climate change risks identified through this CCRA.

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

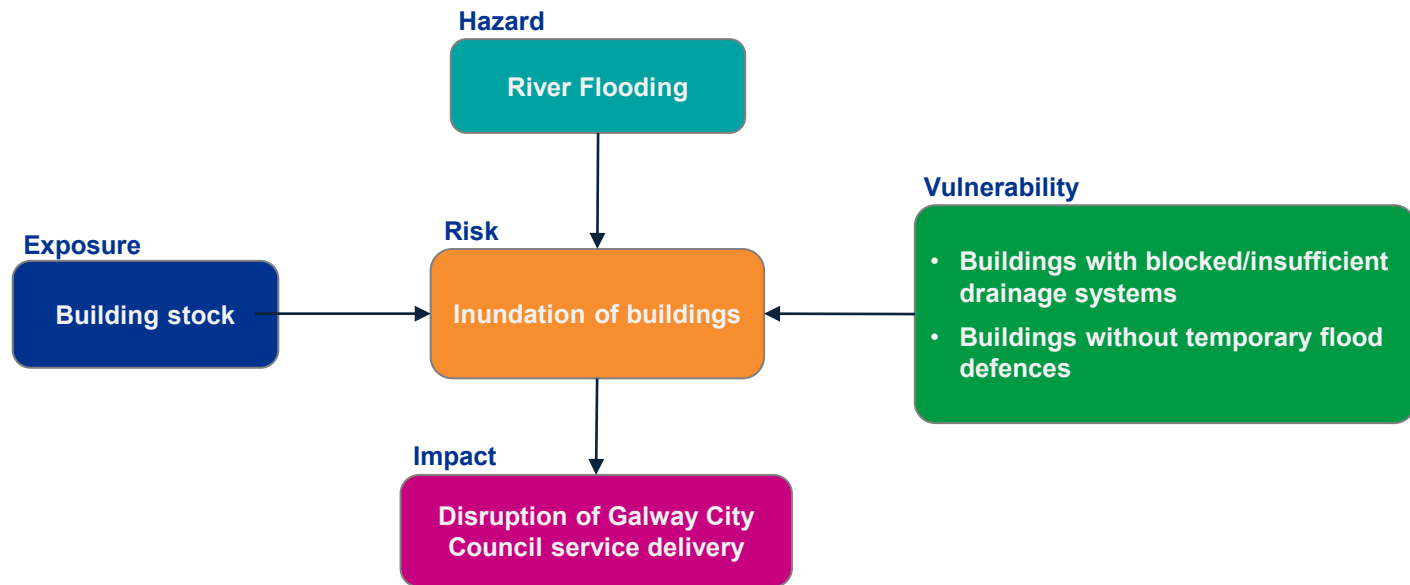
4.3

Appendix 3

Characterising Exposure, Vulnerability and Impacts of Climate Hazards

For Galway City 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 building stock. The buildings with insufficient drainage and with no temporary flood defences would be considered more vulnerable to this hazard. Consequently, if Galway City Council buildings were to be flooded, one of the possible impacts would be the disruption of Galway City 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 Galway City region.

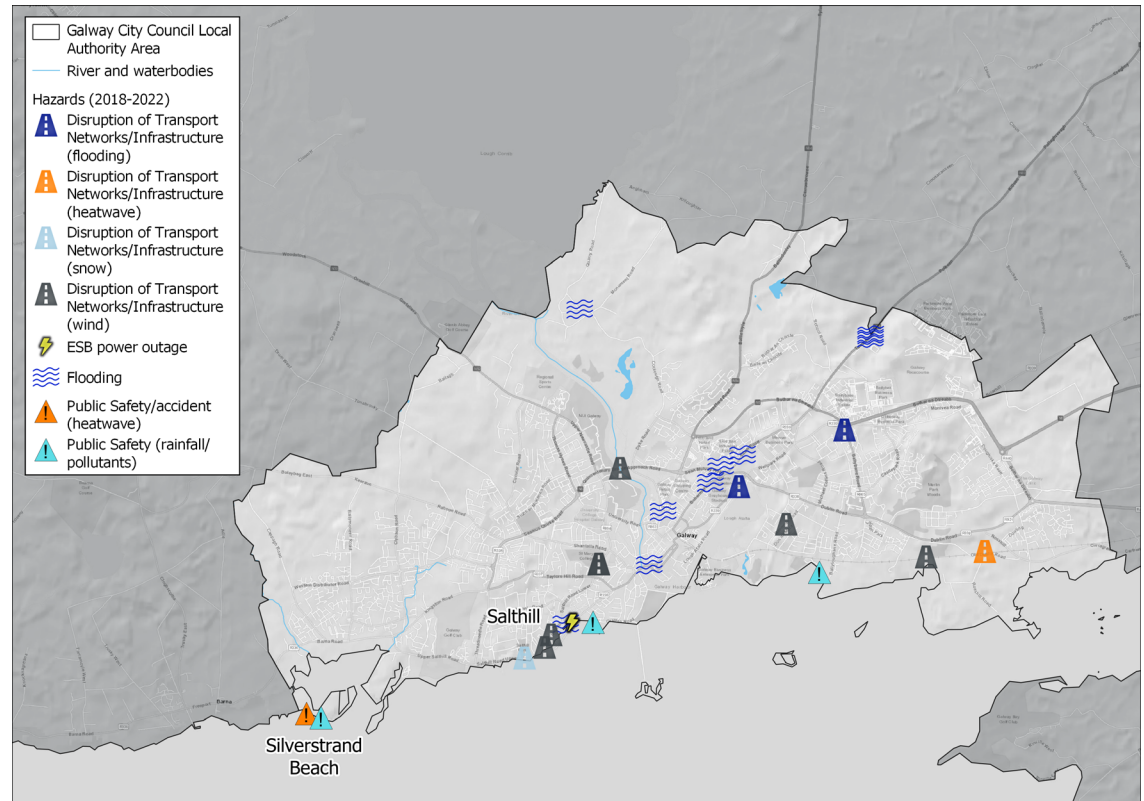


Note: The analysis of climate hazards, risks and vulnerabilities for buildings does not necessarily distinguish between private housing stock and social housing stock.

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 Galway city. Below and to the right we provide an example of exposures and impacts of hazard events experienced between 2018 and 2022.

- **High rail temperatures** in August 2022 caused train services between Galway and Dublin to be delayed.
- **High sea temperatures** in July 2022 contributed to an increase in the frequency of jellyfish with a potentially hazardous Portuguese man o' war being captured at Silverstrand Beach.
- **Storm Emma** in March 2018 led to 16,500 customers in Galway suffering from **restricted water supply** due to frozen or burst pipes. **Heavy snowfall** associated with Storm Emma also led to the closure of roads and required 39 tonnes of salt to be spread on roads throughout the city.
- Preparations for **Storm Lorenzo** in September 2019 led to a number of road closures around Salthill and the Seapoint Promenades, in addition to requiring additional emergency accommodation to be prepared for rough sleepers in Galway.
- **Storm Ali** in September 2018 caused the closure of St Mary's Road, Crescent Road, Salthill Promenade and the Browne Roundabout, as well as blocking the walkway between Corrib Village and Dangan, and disrupting the Galway-Westport rail service.
- Warnings relating to **increased bacteria in bathing waters** at Ballyloughane, Grattan and Silverstrand Beaches were issued in 2020 following forecasts of **increased rainfall** and possible activation of storm overflow.



Impacts of climate hazards (1/5)

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	<ul style="list-style-type: none"> Hot and uncomfortable working/living conditions Increased demand on recreational areas Damage to road surface, hazardous driving conditions and impact on road surface maintenance Disruption of Public transport networks Increased frequency of beach/swimming area closures Increased demand on available water resources, leading to increasing pressure to share resources Detrimental impacts on freshwater quality and fish populations Disruption of recreational activities Increase in the frequency of uncontrolled fire Increased strain on natural biodiversity 	<ul style="list-style-type: none"> Housing, buildings, care home/leisure centres/recreational facilities, outdoor workers (elderly, with limited access to water, shade and sunscreen) Beaches, parks (with easy access to urban areas) Local roads (surface-dressed roads, located in areas of high solar radiation) Public/staff (communities with limited transports network) Beaches / swimming areas (heavily utilised, with low access to shade) Reservoirs/lakes (sites with deteriorated water quality/eutrophic status) Recreational areas (recreational users with lack of access to water, shade, and sunscreen) European/Irish designated sites (SPAs, SACs, Ramsar sites and NHAs)
Drought	<ul style="list-style-type: none"> Increased demand on available water resources, leading to increasing pressure to share resources Reduced river flow Increased degradation rates 	<ul style="list-style-type: none"> Reservoirs/lakes/groundwater supplies (already depleted/under stress) Biodiversity (water bodies, areas with diverse wildlife populations) Cultural heritage (wooden/decomposable material based assets)

Impacts of climate hazards (2/5)

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	<ul style="list-style-type: none"> • Extreme cold results in increased requirement for heating and associated economic costs • Cold conditions result in increased damage to vehicles • Disruption to road networks • 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 • 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 	<ul style="list-style-type: none"> • Buildings (poorly insulated, with elderly residents, in isolated locations) • Public/private transport vehicles (exposed vehicles) • Transport network (road and rail) (untreated road surfaces, near isolated communities) • Public/staff (elderly populations, people with pre-existing conditions) • 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 poorly insulated buildings, vulnerable communities) • Development projects (ongoing construction with loose materials) • European/Irish designated sites (SPAs, SACs, Ramsar sites and NHAs) • Homes/businesses/local govt office (without on-site electricity generation) • Built heritage sites (structures which are more vulnerable to freeze-thaw action)
Heavy Snowfall	<ul style="list-style-type: none"> • Damage to buildings • Disruption of transport network • Impact on business and local economy • Snow melt resulting in increased risk of flooding • Damage and disruption of electricity supply • Disruption to waste collection • Runoff from snow melt impacting on environmentally sensitive areas 	<ul style="list-style-type: none"> • Buildings (vacant/flat roof properties, higher elevation, elderly residents), offices (incl. LA) (single story/flat roof, higher elevation, impervious surfaces) • Energy (energy infrastructure in need of maintenance, older infrastructure) • Employers, employees, customers, students (business in low-lying areas, lacking remote work/study options, etc.) • Waste collection routes • Natural resources/sensitive materials (env. sensitive areas, networks with polluting vehicles, near waterbodies) • Areas prone to flooding (areas prone to pooling of water, inadequate drainage) • Transport networks (in terrain with a with higher propensity of snow drifts, isolated roads)

Impacts of climate hazards (3/5)

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)
<p style="text-align: center;">Severe Windstorm</p>	<ul style="list-style-type: none"> • Direct rain and surface water damage to buildings and infrastructure • Disruption of communications infrastructure • Wind damage to trees resulting in tree fall • Wind damage to habitats and sensitive species • Treacherous conditions at coast and on land • Disruption of wind energy generation • Disruption to energy supply • Disruption to transport networks • Disruption to waste collection • Disruption to water quality monitoring • Closure of parks and public building • Impacts on community and council services 	<ul style="list-style-type: none"> • Buildings, development sites (buildings w. rooftop equip., vulnerable populations, high-rise structures) • Overhead power lines (situated in upland and exposed sites) • Trees (forestry situated in exposed areas) • Habitats and sensitive species • Coastal areas • Power supply (infrastructure in exposed locations, vulnerable populations, isolated communities) • Road and rail network (in 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) • Public buildings (exposed locations), parks (population requiring essential council services) • Wider community (populations requiring essential council services. homeless community and public availing of recreational amenities)

Impacts of climate hazards (4/5)

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	<ul style="list-style-type: none"> • Direct rain and surface water damage to buildings and infrastructure • Damage to amenities and recreational areas • Pluvial debris • Disruption to transport networks/Infrastructure • Surface water (run-off) pollutants • Impact on business and local economy 	<ul style="list-style-type: none"> • 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) • People (areas where there is a lot of un-reinforced waste management systems containing potential debris) • Stormwater Infrastructure – e.g. riversides and parks with reduced drainage potential - especially ones located near sources of debris • Road/railways (low-lying roads with no alternative access routes and which allows for the pooling of water) • Natural resources/sensitive materials (environmentally. sensitive areas, tourist locations) • Employers, employees, customers, students (business in low-lying areas, lacking remote work/study options, etc.) • Wastewater treatment infrastructure
River Flood	<ul style="list-style-type: none"> • Flood damage to buildings and infrastructure. • Damage to amenities and recreational areas. • Physical and health danger to individuals • 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 	<ul style="list-style-type: none"> • 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), stormwater infrastructure • People (river banks and parks which lack man-made/natural drainage- especially ones located near sources of debris), road/railways (low lying roads/railways, located near water bodies, limited drainage) • Public/ staff (located in low-lying areas, near water bodies, limited surrounding drainage and low-quality signage) • Natural resources/sensitive materials (env. sensitive areas, tourist locations) • 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) • Bridges (older bridges, bridges in need of investment and maintenance)

Impacts of climate hazards (5/5)

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)
Coastal Erosion	<ul style="list-style-type: none"> Deterioration of transport and subterranean infrastructure Disruption and loss of transport infrastructure Damage to recreational amenities Damage to coastal habitat Damage to heritage sites 	<ul style="list-style-type: none"> Coastal roads and rail infrastructure. Public/Staff (located in low-lying areas, near water bodies, limited surrounding drainage and low-quality signage) Recreational amenities (low-lying parks and other amenities, locate near water bodies such as lakes and rivers) Coastal habitat (sites exposed to existing coastal erosion) Heritage sites (environmentally sensitive areas)
Coastal Flood	<ul style="list-style-type: none"> Temporary inundation of buildings Deterioration of transport infrastructure Closure/inundation of transport routes and impact on commuting, accessibility and travellers Treacherous conditions at coast and on land Damage to recreational amenities and facilities provided by the council Damage to coastal habitat Damage to critical water supply infrastructure Damage to wastewater infrastructure 	<ul style="list-style-type: none"> Housing buildings (located in low lying coastal areas), heritage sites (elderly, underlying conditions) Coastal roads and rail infrastructure (roads, bridges and infrastructure not designed to withstand corrosive salt-water) Coastal roads and rail infrastructure (road and rail situated in low-lying coastal areas) Footpaths, parks and recreational amenities (amenities situated in coastal areas) Coastal habitat (sites exposed to coastal storms) Water infrastructure/pipes Wastewater treatment plants (water restrictions, boil water notices and bathing water notices) Coastal areas (coastal low-lying amenity areas exposed to storms)
Groundwater Flood	<ul style="list-style-type: none"> Inundation and damage to road infrastructure 	<ul style="list-style-type: none"> National road (roads with limited drainage capacity)



The information contained herein is of a general nature and is not intended to address the circumstances of any particular individual or entity. Although we endeavour to provide accurate and timely information, there can be no guarantee that such information is accurate as of the date it is received or that it will continue to be accurate in the future. No one should act on such information without appropriate professional advice after a thorough examination of the particular situation.

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