CLIMAAX
climate ready regions

Deliverable Phase 1 – Climate Risk Assessment

CLIMAAX TIPPERARY

Tipperary, Ireland

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HORIZON-MISS-2021-CLIMA-02-01 - Development of climate change risk assessments in European regions and communities based on a transparent and harmonised Climate Risk Assessment approach

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Document Information

Deliverable Title	Phase 1 – Climate risk assessment
Brief Description	The report presents Phase 1 of the Climate Risk Assessment for County Tipperary, focusing on identifying and analysing key climate risks and their potential impacts on County Tipperary.
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Abbreviations and acronyms

Abbreviation / acronym	Description
AGS	An Garda Síochána
CARO	Climate Action Regional Office
CDP	County Development Plan
CMT	Crisis Management Team
CRA	Climate Risk Assessment
DCEE	Department of Climate, Energy and the Environment
ECMWF	European Centre for Medium-Range Weather Forecasts
EPA	Environmental Protection Agency
ERA5	ECMWF Reanalysis v5
FWI	Fire Weather Index
GDP	Gross Domestic Product
GNI*	Modified Gross National Income
HSE	Health Services Executive
ICCA	Irish Climate Change Assessment
LACAP	Local Authority Climate Action Plan
LECP	Local Economic and Community Plan
MEM	Major Emergency Management
NAF	National Adaptation Framework
NCCRA	National Climate Change Risk Assessment
NCFS	National Framework for Climate Services
NDFEM	National Directorate for Fire & Emergency Management
NECG	National Emergency Coordination Group
NPF	National Planning Framework
OPW	Office of Public Works
RCP	Representative Concentration Pathways
SEMP	Stakeholder Engagement and Management Plan
SMT	Senior Management Team
SPC	Strategic Policy Committee
SSP	Shared Socioeconomic Pathways
TCC	Tipperary County Council

Executive summary

This deliverable presents Phase 1 of the Climate Risk Assessment (CRA) for County Tipperary, part of the CLIMAAX TIPPERARY project funded by Horizon Europe. Developed to enhance regional climate resilience, this report assesses the current and future climate risks faced by Tipperary, particularly focusing on impacts to local government services, the community, and the environment. Key motivations for this deliverable include identifying critical climate hazards, determining their potential impacts, and facilitating relevant stakeholders' engagement.

Throughout this phase, significant actions were undertaken, including stakeholder mapping, risk exploration workshops, and screening of climate hazards using the CLIMAAX methodologies. The assessment identified seven main climate hazards, namely river flooding, windstorms, heavy rainfall, heatwaves, droughts, fires, and snow. Preliminary findings indicate that river flooding, windstorms, and heavy rainfall pose significant risks to the county's infrastructure and economy. Additionally, heatwaves and droughts were categorized as emerging risks that require future adaptive measures due to predicted increases in frequency and severity.

The outcomes of this deliverable lay the foundations for Phase 2, which will refine risk assessments and identify adaptation strategies across various climate hazards. This process aims to integrate local data on hazards, vulnerabilities, and exposures to enhance the accuracy of future risk evaluations and inform policy decisions. Engaging community stakeholders throughout this journey is vital to ensure that the CRA outcomes align with local needs and promote effective climate action.

In conclusion, this CRA Phase 1 represents a crucial step towards understanding and mitigating climate risks in County Tipperary. Implementing the recommended adaptive measures and policies will significantly contribute to building resilience within the region and serve as a potential model for other local authorities in Ireland facing similar challenges.

1 Introduction

Tipperary County Council (TCC) received funding in spring 2025 to carry out a Climate Risk Assessment. The Climate risk and vulnerability Assessment framework and toolbox (CLIMAAX) is a 4-year Horizon Europe project that provides financial, analytical, and practical support to improve regional climate and emergency risk management plans. CLIMAAX is designed to contribute to the harmonisation and consolidation of the practice of climate risk assessment, leaving a legacy for upcoming European initiatives. The Tipperary CLIMAAX project will run until December 2026. The area of focus of this project is County Tipperary (Figure 1-1).

1.1 Background

County Tipperary is located in the southern region of Ireland and one of the 26 counties in the Republic of Ireland. The island of Ireland is located in northwest Europe and is made up of 32 counties, 26 are within the Republic of Ireland and 6 in Northern Ireland. Tipperary is Irelands largest inland county, with a population of 167,661 (CSO, 2022) and is the geographical location of this climate risk assessment (CRA).

Tipperary has a diverse and striking landscape shaped by its varied topography and rich natural features. The terrain ranges from the fertile plains of the Golden Vale to the rugged uplands of the Galtee Mountains, Ireland's highest inland mountain range. With regards to hydrological features, Tipperary has a number of water bodies traversing the county, including the River Suir, River Shannon and Lough Derg, in addition to a number of smaller tributaries.

The county has a strong presence in the construction sector, accounting for 26% of economic activity, while the wholesale and retail sector represent 22% of economic activity, both of which are above the national average (Tipperary County Council, 2023). Roughly 11% of the workforce in Tipperary are employed in the agriculture, forestry and fishing sectors, which is more than double the national average, highlighting the importance of the sector for the county. Although Tipperary has three main towns and urban areas (Clonmel, Nenagh and Thurles), over half the population live in areas classified as rural (Tipperary County Council, 2023).

Ireland has a temperate maritime climate, characterised by mild temperatures, high humidity, and frequent rainfall throughout the year. As an inland county with varied elevation, Tipperary experiences greater than average rainfall and more pronounced seasonal temperature variation than coastal regions. Influenced by the Atlantic Ocean and the North Atlantic Drift, Ireland experiences relatively cool winters and mild summers, with average summer temperatures ranging from 14°C to 16°C.

In Ireland, climate change has resulted in an increase of 0.7°C and an become 7% wetter when comparing the 1961-1990 and 1991-2020 periods (Met Éireann, 2024). In terms of climate hazards, Tipperary is particularly exposed to river (fluvial) flooding, with recurrent flood events historically linked to the River Suir and the Shannon River basin. In addition to flooding, Tipperary, like the rest of Ireland, is exposed to windstorm, heatwaves, droughts and other climate hazards. These extreme weather events and climate hazards can result in a range of impacts, such as disruptions to services delivered by TCC, damage to public and private assets, loss of critical services, e.g., power and communication, damage to the environment, and threats to public health.

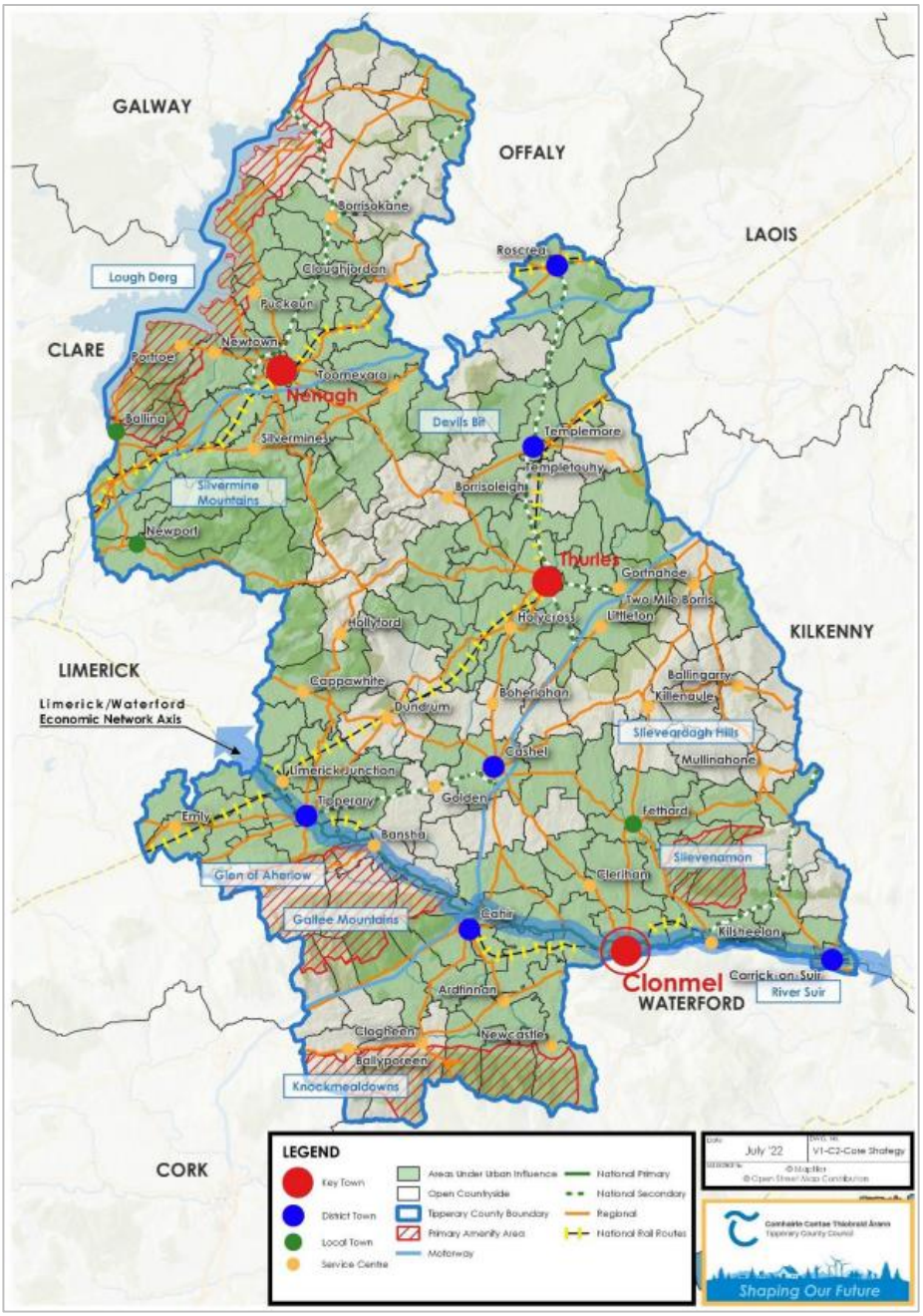

Figure 1-1: Map of County Tipperary (Tipperary County Council, 2022)

1.2 Objectives

The objective this project are to assess how key climate risks will impact County Tipperary and the services delivered by TCC (see TCC's Corporate Plan in the supporting material for further information on the services of the local authority), as well as identifying how best TCC can influence, co-ordinate and facilitate climate action and adaptation across the county, helping to increase its climate resilience. The outcomes of this project will help TCC understand where its assets, services and communities are exposed, helping develop and inform future policy and planning decisions within the county, to avoid maladaptation and where feasible minimise the impacts of climate change. That means breaking down silos across the Council itself, and working closely with community organisations, emergency services and providers such as the An Garda Síochána and the Health Services Executive (HSE), other sectors, researchers and other partners to turn findings into action.

In addition to enhancing Tipperary's resilience to climate change this project will also act as a pilot for other counties and local authorities in Ireland. It is expected that the CLIMAAX Handbook methodology and learnings from this project will be transferable to other counties across Ireland, helping to create a more uniform approach to addressing climate risks and implementing suitable adaptation measures. The benefits of applying the CLIMAAX Handbook to other counties in Ireland as well as across other countries in Europe allows for the harmonisation and consolidation of CRA.

1.3 Project team

Tipperary County Council's Climate Action Office, with the support of KPMG Ireland are carrying out the CRA based on the CLIMAAX methodologies. From the outset stakeholder engagement plays a key role in developing and delivering this CRA. While carrying out the CRA, key internal members across departments in TCC, as represented by the cross-department Climate Action Team and other relevant stakeholders, such as the Environmental Protection Agency (EPA), the Climate Change Regional Office (CARO), will be engaged to provide insight on the impact climate change is having on the county, with a specific focus on the impacts happening in their relevant department or sector.

1.4 Outline of the document's structure

This document is structured according to the CLIMAAX Phase 1 Deliverable guidelines, and has four main sections:

Section 1: This section provides a high-level introduction to the project, states the purpose and aim, and provides background information and an overview of the team who is carrying out the assessment.

Section 2: This section comprises the main body of the report and gives a detailed breakdown of the standardised CRA that was carried out on County Tipperary. It presents the findings of the risk analysis and identified climate risks, as well as a comprehensive breakdown of each of the 'workflows' included in this climate risk assessment.

Section 3: Building on the knowledge gained and outcomes of the risk analysis this section provides detail on the severity and urgency of each climate risk, in addition to TCC's current capacity and approach to addressing these climate risks.

Section 4: The final section of this report outlines the existing resilience measures that are currently addressing these climate risks. The key findings, recommendations and learnings that were identified during the CRA process will also be outlined.

Supporting documentation, references, and annexes can be found at the end of the report.

2 Climate risk assessment – Phase 1

2.1 Scoping

The main goal of this project is to identify, assess and address current and future climate risks for County Tipperary. In addition, the project aims to act as a 'pilot project' for other local authorities in Ireland who want to carry out CRA using the CLIMAAX methodology and also ensure this local authority CRA is fit for purpose in terms of its inter-dependence with other sectoral CRAs (under preparation) such as, agriculture, health, emergency services, transport etc.

2.1.1 Objectives

The objective of this CRA is to provide a clear, high-level overview of current and future climate-related risks affecting County Tipperary and their impact on both the county and TCC services. The outcomes of this CRA will identify the key climate hazards for the county, along with their impacts on Tipperary and TCC's own services (inward and outward facing); helping to identify areas where additional adaptation measures will be needed to address these risks.

Following the risk analysis, each risk will be assigned a severity and urgency rating, the results of which will help to highlight the key areas or 'hot spots' within the county that are particularly vulnerable to a given climate risk and its impact on the area and TCC services.

The findings of the CRA will be used to inform future planning and development within the county, as well as feeding into and influencing key local authority policies, budgets, reports and management plans.

A number of limitations were identified from the onset of the project, relating to:

- **Data Gaps:** At this stage of the project a number of data gaps have been identified that are pivotal to informing the identification and assessment of climate hazards, exposures and vulnerability.
- **Technical Expertise:** Although TCC have designated 'climate action' groups and teams there are no climate risk experts and therefore there may be knowledge gaps related to the hazard, exposure and vulnerability components of each risk.
- **Remit of TCC:** TCC are restricted to only working within their own remit, therefore outcomes of this assessment may be difficult to execute if they're outside their sphere of control.
- **Awareness:** TCC will play a key role in raising awareness on climate risks and using their authority to influence, co-ordinate and facilitate climate action – though this will be limited to actions within their remit.
- **Timeline:** To avoid resource constraints and project delays, TCC have allocated sufficient staff to ensure the project is completed by the end of 2026.
- **Financing:** Currently, TCC's financial systems are not well-adapted to support the planning, budgeting, and tracking of climate risk and climate adaptation expenditure.

2.1.2 Context

Legislative Requirements

Under Ireland's Climate Action and Low Carbon Development (Amendment) Act (2021) the 31 local authorities in the Republic of Ireland are required to develop a Local Authority Climate Action Plan (LACAPs). The initial LACAPs were commenced in March 2023 and formally adopted by no later than March 2024. The TCC LACAP was adopted in February 2024 and came into effect in March 2024. These plans are subject to mandatory updates every five years. Each of these plans included

a qualitative CRA to assess the climate risk relevant to each local authority. The CRAs were carried out using a standard methodology, that was outlined in the 'Guidelines for Local Authority Climate Action Plans' Technical Annex B (Government of Ireland, 2023).

Governance Framework

The governance framework for CRAs in the region are well-developed, overseen by the Climate Action Regional Office (CARO) and guided by the Department of Climate, Energy and the Environment (DCEE) national climate adaptation policies, e.g., the National Adaptation Framework (NAF). The TCCs LACAP, adopted in 2024, outlines a comprehensive approach with actions dedicated to both mitigation and adaptation. The LACAP, lists 64 (out of 100 actions)actions focused on both adaptation and mitigation, emphasising the region's commitment to addressing climate risks. These actions include assessing vulnerability of waterbodies to extreme weather events, enhancing monitoring systems for severe weather events, annually reviewing emergency response protocols, resolving local flooding issues using various funding schemes, inspecting bridge structures for climate-related risks, integrating nature-based solutions into flood risk management, and reviewing infrastructure flood risk assessments.

Economy and Infrastructure

County Tipperary is characterised by key sectors such as construction, agriculture, tourism, and forestry. These sectors are integral to the county's strengths and dependencies, as identified in development plans like the Local Authority Corporate Plan (2025), County Development Plan (CDP) and Local Economic 2022 and Community Plan (LECP) 2022. Each sector faces potential impacts from climate change associated with both acute and chronic climate risks, which may result in damage and disruption to normal operations and necessitate adaptation strategies to reduce these risks and build resilience.

As an inland county, Tipperary does not significantly face external influences that directly impact its climate change and risk profile. However, considerations about national and regional infrastructure management, such as energy generation and transmission, motorways, rail lines, water networks, and energy systems, remain important as part of strategic planning and risk mitigation processes.

Emergency Preparedness

In response to extreme weather events, TCC has established a Severe Weather Assessment Team, along with robust emergency response protocols as delivered by the Fire Services Department. These systems were effectively tested during Storm Eowyn and a snow/ice event in January 2025. TCCs Local Authority Climate Action Plan (LACAP) provided valuable insights on the risks facing the region, as well as the risks posed to services provided and delivered by TCC. This assessment allowed for the first consideration and integration of the climate risks impacting health and safety protocols, as well feeding in during the initial design phases of capital works projects.

Adaptation

To achieve climate resilience objectives, several adaptation interventions have been developed and proposed. These include the climate proofing of Local Authority own capital projects and investment and outward facing interventions such as the promotion of sustainable farming practices including bioeconomy, improving transport linkages, nature based solutions to flood risk management and implementing the Town Centre First programme to invigorate towns. Catchment management can reduce flood risks, while better management of local authority and community infrastructure can enhance durability against climate impacts. Strengthening communication networks and integrating

CRA considerations into planning, development, and policy processes are essential to finances and training efforts moving forward

2.1.3 Participation and risk ownership

As part of the CRA for TCC, a comprehensive Stakeholder Engagement and Management Plan (SEMP) has been developed, incorporating detailed stakeholder mapping to ensure effective participation across all relevant groups. In particular, it should be noted that the SEMP is designed to be easily transferable and applicable to all Irish Local Authorities in terms of their unique structures and outreach to sectoral and community stakeholders.

The SEMP encompasses a broad spectrum of stakeholder groups (see Figure 2-1), each contributing specialised insights and expertise. Central to this engagement is TCC, which includes the CLIMAAX Steering Committee, various departmental representatives, as represented by the Climate Action Team and affiliated entities such as the Climate Action Steering Group, comprising of senior management and who provide oversight to the Climate Action Team. These internal stakeholders are pivotal in steering the project and ensuring congruence with local governance imperatives. Furthermore, the CLIMAAX Advisory Group, comprised of national and regional entities, provides crucial scientific and policy guidance essential to the assessment process and maintain oversight in terms of how this first local authority semi-quantitative CRA is aligned with sectoral and national CRA systems

Regional and sectoral stakeholders, encompassing infrastructure providers, heritage organisations, and emergency services such as the An Garda Siochána and HSE, are vital in appraising findings through a lens of localised knowledge and empirical expertise. Additionally, community groups and outreach organisations—such as the Public Participation Network, Local Community Development Committees and Tidy Towns Committees—offer granular insights and are fundamental in cultivating public awareness and endorsement of climate adaptation frameworks.

The County Council in Tipperary comprises 40 elected members and the SEMP identifies how the elected representatives can be involved in the CRA process throughout and in particular, it is set out that the full Council will be briefed on the findings of the CRA. The Environment and Climate Action Strategic Policy Committee (SPC) for Environment and Climate Action are also included in the SEMP and members will be involved throughout and briefed at a SPC meeting on the findings of the CRA.

This robust engagement methodology ensures stakeholders are systematically informed, consulted, involved, and actively engaged in shaping the deliverables of the CRA, thereby enhancing community resilience and adaptive capacity in response to climate risks.

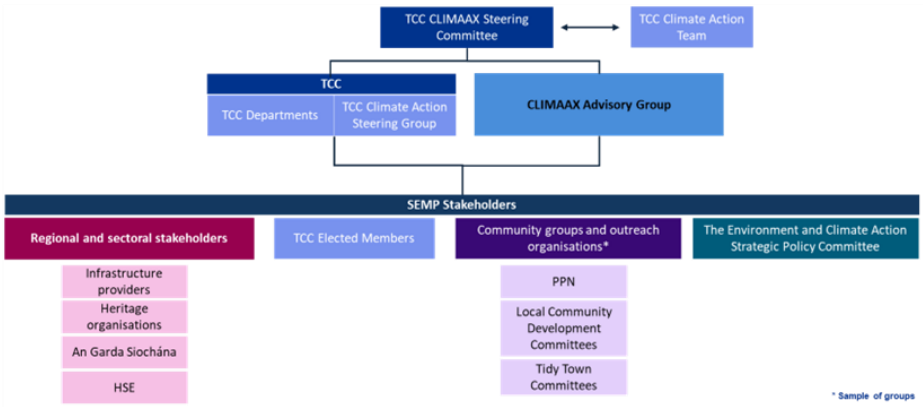

Figure 2-1 SEMP Stakeholder Groups

2.2 Risk Exploration

2.2.1 Screen risk

The proposed CRA to be prepared under the CLIMAAX project will incorporate a screening of key climate risks as the Phase 1 deliverable. The Tipperary County Council Climate Action Plan 2024-2029 included a qualitative climate risk assessment to determine the current and future climate risks for the region. The hazard with the highest risk currently was listed as river flooding, with extreme precipitation and windstorms a frequent hazard. The CRA identified key exposures for each of the current and future risks. For river flooding, damage to infrastructure (i.e., buildings and the transportation network, the electricity network, water services infrastructure) and the environment (i.e., water quality) and health and safety of the public and local authority staff and emergency responders, were most affected by river flooding hazard. Similar exposures were also identified for extreme precipitation and pluvial flooding events. For windstorms, the infrastructure (such as the communication networks, buildings, transport, water treatment plants) was identified as particularly exposed while potential impacts on the economy and culture were also noted, such as the cancellation of events.

The acute hazards of droughts, heatwaves, cold spells, and heavy snowfall all occur within the county; however, the risks associated with these hazards is considered minor. The chronic hazards of increase in temperature, changing patterns of precipitation, and sea level rise were also identified as having an impact on the region but these were also considered minor. The risk of wildfire was not identified within the qualitative CRA, however.

The National Climate Change Risk Assessment (NCCRA) (Environmental Protection Agency, 2025) identified extreme wind events and impacts to the electricity and communications networks as an immediate priority risk for the country. River flooding is also identified as a priority risk, as it impacts the country already, mainly the built environment and human health, and this risk is expected to increase in severity and frequency in the future due to changes in precipitation. By the end of the century, chronic and acute risks associated with increased temperatures and extreme heat are identified as an emerging risk to human health. County Tipperary is already, or will become, exposed to all of these national priority risks.

To validate the current understanding of risks in Tipperary, a workshop was conducted with TCC staff to identify recent extreme events that had impacted the region, and to identify potential future changes associated with exposure and vulnerability, such as change in population.

As part of Phase 1 of the CLIMAAX project, the key climate hazards of focus will be river flooding, windstorms, extreme precipitation, and drought. These hazards were chosen as they are hazards that are already occurring within the region, are of national importance, and are expected to increase in frequency and severity in the future due to climate change, and due to increases in exposure and vulnerability.

Heatwaves and wildfires are also a focus of this Phase 1 assessment as these are potentially emerging hazards for the region, and although the current risk is low, anticipatory adaptation to these hazards will be required in the medium to long term.

Finally, extreme snowfall is also a focus as this hazard has impacted the region previously, however, even though climate change may make these events less common, they will still occur in the future. This presents a management challenge for local authorities, as they must remain prepared to respond effectively when such occurrences arise. Achieving this in a cost-effective manner could be challenging, involving aspects like maintaining snowploughs and gritters and stockpiling salt.

2.2.2 Workflow selection

The CLIMAAX CRA Toolbox contains data, projections and risk assessment algorithms (contained in so-called "risk workflows") designed to support the compilation of regional climate multi-risk assessments. There are seven hazards types covered by the workflows; River & Coastal Floods, Heavy Rainfall, Heatwaves, Droughts, Fire, Snow and Wind. Below is a description of the applicability of these workflows to County Tipperary.

2.2.2.1 Workflow #1: River Flooding

River flooding is a key risk for County Tipperary, with the key urban areas exposed to river flooding are generally those along the River Suir, which includes the key towns of Clonmel, Carrick-on-Suir, and Thurles. There are 16 other towns noted as areas with river flood risk, and include Ardfinnan, Ballyporeen, Bansha, Borrisokane, Borrisoleigh, Cahir, Fethard, Golden, Marlfield, Mullinahone, Nenagh, Newcastle, Newport, Roscrea, Templemore, and Tipperary Town. Within these locations, higher levels of vulnerability are strongly associated with socio-economic factors, such as the elderly and the very young, those unable to understand and/or act on early warnings, the economically disadvantaged, and those working within emergency response. To assess this risk the river flooding hazard and risk workflows have been used.

2.2.2.2 Workflow #2: Wind

Extreme wind events are a key risk for County Tipperary due to Ireland being exposed to Atlantic storm systems. All of the county is exposed, with vulnerability factors primarily associated with the indirect impacts of the event, i.e., loss of power, loss of water supply, loss of communications. Vulnerability factors therefore include people that live in rural areas, buildings with no back-up generators, and people with lower ability to prepare, respond, and recover, such as the elderly, and very young and, the economically disadvantaged. The hazard and risk workflows for wind have been used and focus on Storm Ophelia (October 2017) as an initial assessment of risk.

2.2.2.3 Workflow #3: Heavy Rainfall

Pluvial flooding associated with heavy rainfall events is a key risk for Tipperary, particularly within urban areas due to the potential for poor or blocked drainage and low permeability. Heavy rainfall events are also a climate impact driver for fluvial flooding due to the potential for high volumes of water entering the river systems in a short timeframe. Vulnerability factors include people that live in urban areas, people with lower ability to prepare, respond, and recover, such as the elderly, and very young and, the economically disadvantaged. The hazard and risk workflows for heavy rainfall have been used.

2.2.2.4 Workflow #4: Heatwaves

Heatwaves in Ireland are relatively uncommon events, however, with the increases in temperature associated with climate change, there is potential for heatwaves to become a more frequent hazard for the region. Vulnerability factors include people that live in urban areas, people with lower ability to prepare, respond, and recover, such as the elderly, and very young, those with jobs with high levels

of outdoor activity, and the economically disadvantaged. The hazard and workflows for heatwaves has been adjusted for the heatwave definition (5 or more days above 25°C) for Ireland (Met Éireann, 2022).

2.2.2.5 Workflow #5: Droughts

Agriculture and forestry form key parts of the economy within the region, therefore drought risk is a highly relevant to the region. The rural areas of County Tipperary are most exposed to drought conditions due to their reliance on agricultural activities and private water supply sources prone to shortages during dry periods. Areas with less robust infrastructure for water storage and management are particularly vulnerable.

2.2.2.6 Workflow #6: Fire

Wildfires have the potential to significantly impact on ecosystem and habitats, as well as agriculture and forestry. A large proportion of the county is rural, consisting of land cover that would provide a fuel source for wildfires, such as forestry, crops etc. To date, there has been limited examples of impacts of wildfire on people and infrastructure due to a fire occurring close to urban areas, however, this is an increasing risk in the future due to climate change.

2.2.2.7 Workflow #7: Snow

Snow events in County Tipperary are relatively uncommon to date, however, when they do occur, they can impact a large area and pose challenges to the provision of services by the local authority. While snow impacts can be widespread, remote rural areas with less access to snow clearance procedures and are particularly exposed. Communities that rely on the road transportation networks are particularly vulnerable, along with the elderly who may require additional support, i.e., healthcare.

2.2.3 Climate Scenario

Each of the workflows require the selection of a climate scenario that is to be used to assess future levels of risk. The NCCRA used the moderate emissions Representative Concentration Pathways (RCPs) 4.5 and the high-emissions RCP8.5 to the assess climate risks. These scenarios were chosen to ensure a conservative approach to the risk assessment. Standardised climate projections for Ireland based upon Shared Socioeconomic Pathways (SSPs) employed through the sixth IPCC Assessment Report (AR6) are currently not available for Ireland and were therefore not used within the NCCRA. This approach also aligns with the approach used by Irish sectors to develop their Sectoral Adaptation Plans, which align with Ireland's National Adaptation Framework. Consequently, the scenarios used throughout the CLIMAAX workflows will follow a similar approach and the high-emissions scenario (either RCP8.5 or SSP5-8.5) will be used where appropriate. In Phase 2 of CLIMAAX the moderate emissions scenario (RCP4.5 or SSP2-4.5) will be used alongside the high-emissions scenario.

Future climate risks are also driven by a number of non-climatic factors, such as urbanisation, pollution, socio-economic processes, population growth, demographic changes, economic development, and land use and land cover change. For Tipperary and Ireland, increasing population and an ageing population are key aspects of vulnerability that will greatly influence future levels of climate risk. Linked to the increase in population, is an increase in the built environment, such as residential and non-residential buildings, the electricity network, water services infrastructure, and transport. The National Planning Framework (NPF) supports policies aimed at densifying urban areas as part of broader sustainability and efficiency goals, which will also affect the future changes in exposure to risks. Currently, there are limited information sources or scenarios that explore these

future changes beyond the short-term time horizon and will be a key challenge to address during the Phase 2 assessment for this project.

2.3 Risk Analysis

The seven workflows described in Section 2.2.2 have been employed for County Tipperary, with the outcomes described in further detail below. The Phase 1 approach to CLIMAAX requires utilising a standard approach and European-wide datasets, in order to establish a consistent CRA across all CLIMAAX project partners. Consequently, tailoring of the workflows, such as local datasets, e.g., TRANSLATE climate projections, will occur in Phase 2. The Jupyter Notebooks to that were run to process these workflows are available in the supporting materials on Zenodo (LINK). The workflows assess risk across a number of future climate scenarios and time periods, however, for consistency results are presented for RCP8.5 and 2050 where possible.

2.3.1 Workflow #1: River Flooding

To assess the current and future changes in the river flooding hazard for County Tipperary, the hazard assessment (*Notebook: Hazard_assessment_FLOOD_RIVER*) and risk assessment (*Notebook: Risk_assessment_FLOOD_RIVER*) was applied to the Tipperary region using the data outlined in Table 2.1.

Table 2.1 Data overview for the River Flooding workflows (Hazard_assessment_FLOOD_RIVER and Risk_assessment_FLOOD_RIVER).

Hazard data	Vulnerability data	Exposure data	Risk output
River flood depth and extent maps (JRC and WRI Aqueduct)	Vulnerability damage curves	LUISA Base Map 2018	Map of flood depth and damage

2.3.1.1 Hazard assessment

The hazard workflow aligns with the existing evidence base that the region is currently exposed to river flooding, with the River Suir the source of much of the flooding. Considering the impacts of climate change, the assessment shows that an increase in flood depths across the region is projected in both RCP4.5 and RCP8.5 (Table 2.2), with the largest change occurring by ca. 2080 (Table 2.3). The hazard assessment shows that Tipperary is currently exposed to this hazard, and the severity/frequency of this hazard will increase in the future.

Table 2.2: The absolute flood depths across County Tipperary determined by the Hazard_assessment_FLOOD_RIVER workflow.

Scenario	Flood Depth (m)					
	2030		2050		2080	
	Mean	Max	Mean	Max	Mean	Max
RCP4.5	0.31	1.77	0.32	1.73	0.37	1.93
RCP8.5	0.31	1.78	0.33	1.75	0.46	1.94

Table 2.3: The change in flood depths across County Tipperary relative to 1980.

Scenario	Difference in Flood Depth (m) Compared to 1980					
	2030		2050		2080	
	Mean	Max	Mean	Max	Mean	Max
RCP4.5	0.05	0.23	0.06	0.18	0.11	0.39
RCP8.5	0.05	0.24	0.07	0.20	0.21	0.40

2.3.1.2 Risk assessment

The risk workflow was implemented using the Irish Modified gross national income (GNI*) as an alternative to the GDP statistic, as this is a metric used by the Central Statistics Office (Ireland) to measure the Irish economy rather than GDP. For 2023 GNI* per capita is €55,084 (CSO, 2025). This showed that the total damages for a 1 in 100-year event are €4.67 bn, with the majority of the economic damage associated with the pastural land use (€3.37 bn).

This workflow shows that river flooding has potential to be a significant risk for Tipperary and should be the focus of more detailed analysis in Phase 2, of this project, with focus on utilising the Irish flood hazard data and flood risk information available at the local authority level (including the outcomes of public consultation), and improving the vulnerability and exposure data to improve the assessment of risk.

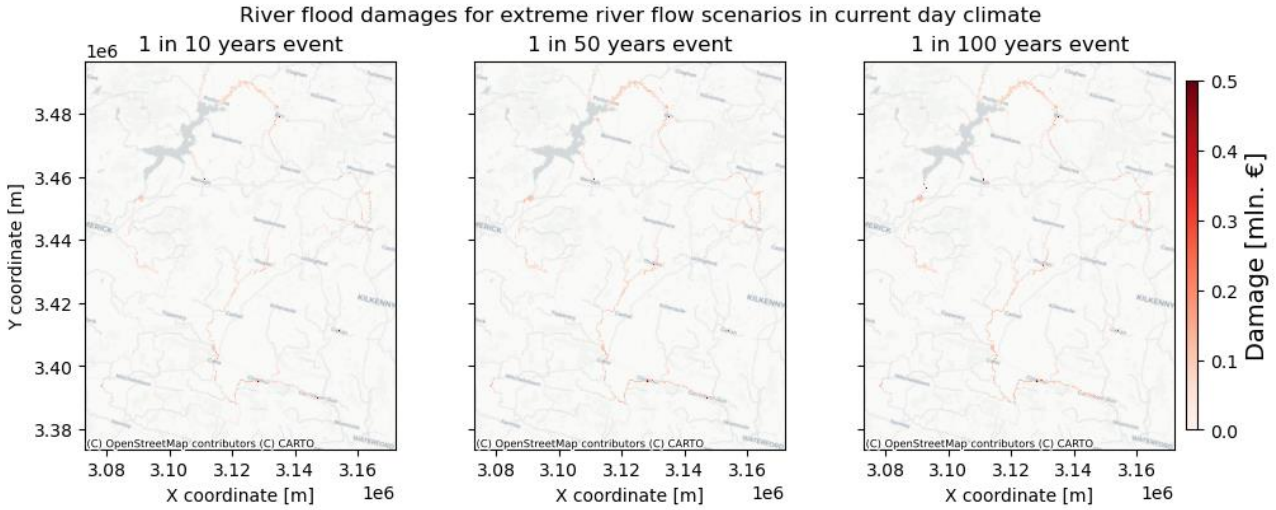

Figure 2-2: The estimated damages associated with a 1 in 10, 50, and 100 year river flooding event for the Tipperary region.

2.3.2 Workflow #2: Wind

The wind workflow required the selection of past events to assess the hazard aspect of the risk. Storm Ophelia (17/10/2017) which occurred in Ireland on 17th October 2017 was the event chosen as it was a significant wind event in Ireland that occurred prior to 2021. Since 2021, Storm Éyown occurred in January 2025, which resulting in significant impacts across Ireland, however this storm is not covered by the hazard data within the workflow (due to the temporal coverage of the hazard dataset (1979-2021)).

Table 2.4 Data overview workflow #2: Wind used within the Hazard_assessment_STORMS and Risk_assessment_STORMS notebooks.

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Winter windstorm indicators for Europe from 1979 to 2021 derived from reanalysis	Vulnerability damage curves	LUISA Base Map 2018	Economic Damages (€)

2.3.2.1 Hazard assessment

Storm Ophelia had a significant impact on the country including three deaths, and damage to infrastructure. The hazard assessment (*Notebook: Hazard_assessment_STORMS*) shows that for Storm Ophelia; the maximum wind gust speed was 49 m s^{-1} with an average wind gust speed of 31 ms^{-1}. The storm hazard dataset shows that Ireland has been exposed to a number of winter windstorm events due to its proximity to the North Atlantic. There is large uncertainty about the future changes in extreme wind in Ireland, however, future changes in wind should be assessed further in Phase 2 through the inclusion of national datasets where possible.

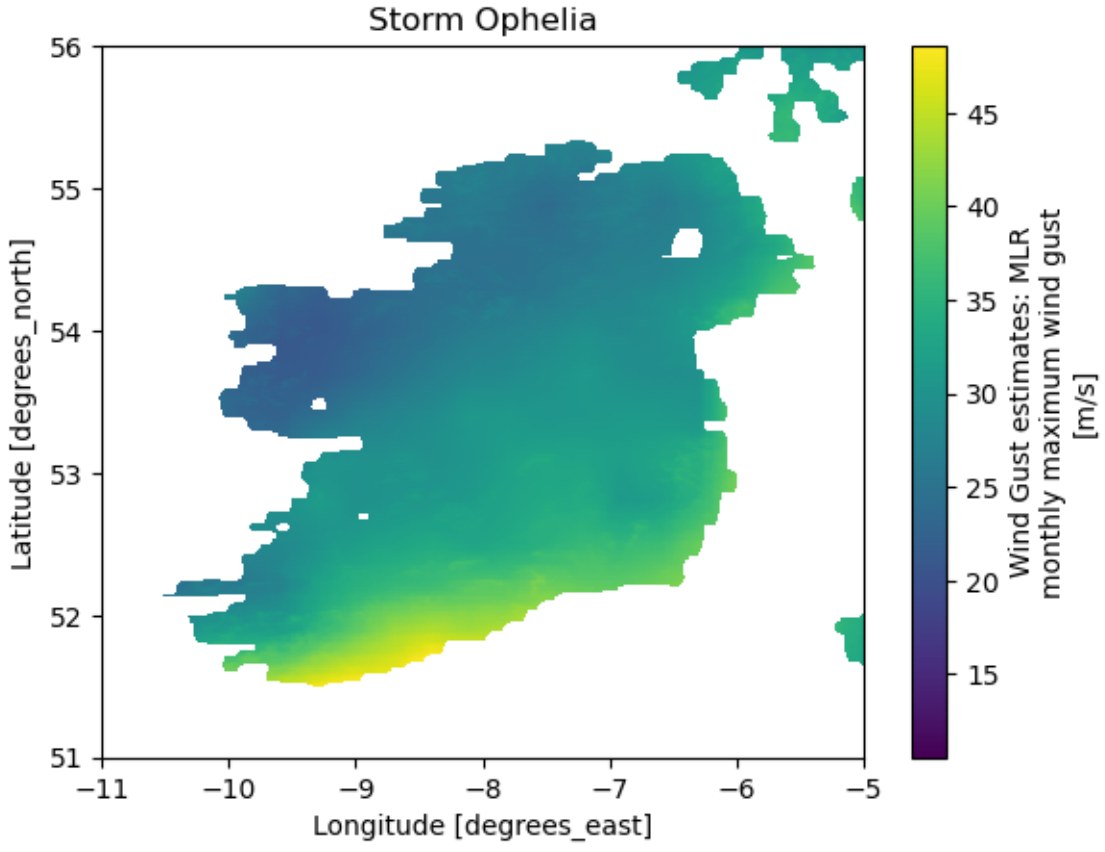

Figure 2-3: Wind gust estimates associated with Storm Ophelia (17/10/2017).

2.3.2.2 Risk assessment

To assess the risk associated with Storm Ophelia, the standard vulnerability curves provided by the workflow (*Notebook: Risk_assessment_STORMS*) were applied (Figure 2-4), which shows for Storm Ophelia a total economic damage for County Tipperary was €329 million. The vulnerability curves

shows that damage is mostly associated with the pasture land use type (€200 million). The estimates of the impact of this event at the national level has been estimated to be €70 m (Irish Times, 2019). The relatively high damage estimates for County Tipperary from the workflow are attributed to the rural nature of the region, with the vulnerability curves not accurately representing the actual impacts of agricultural and forestry activities that are prominent in the region. The CRA in Phase 2 should focus on improving the asset types covered by these vulnerability curves in order to improve the risk assessment.

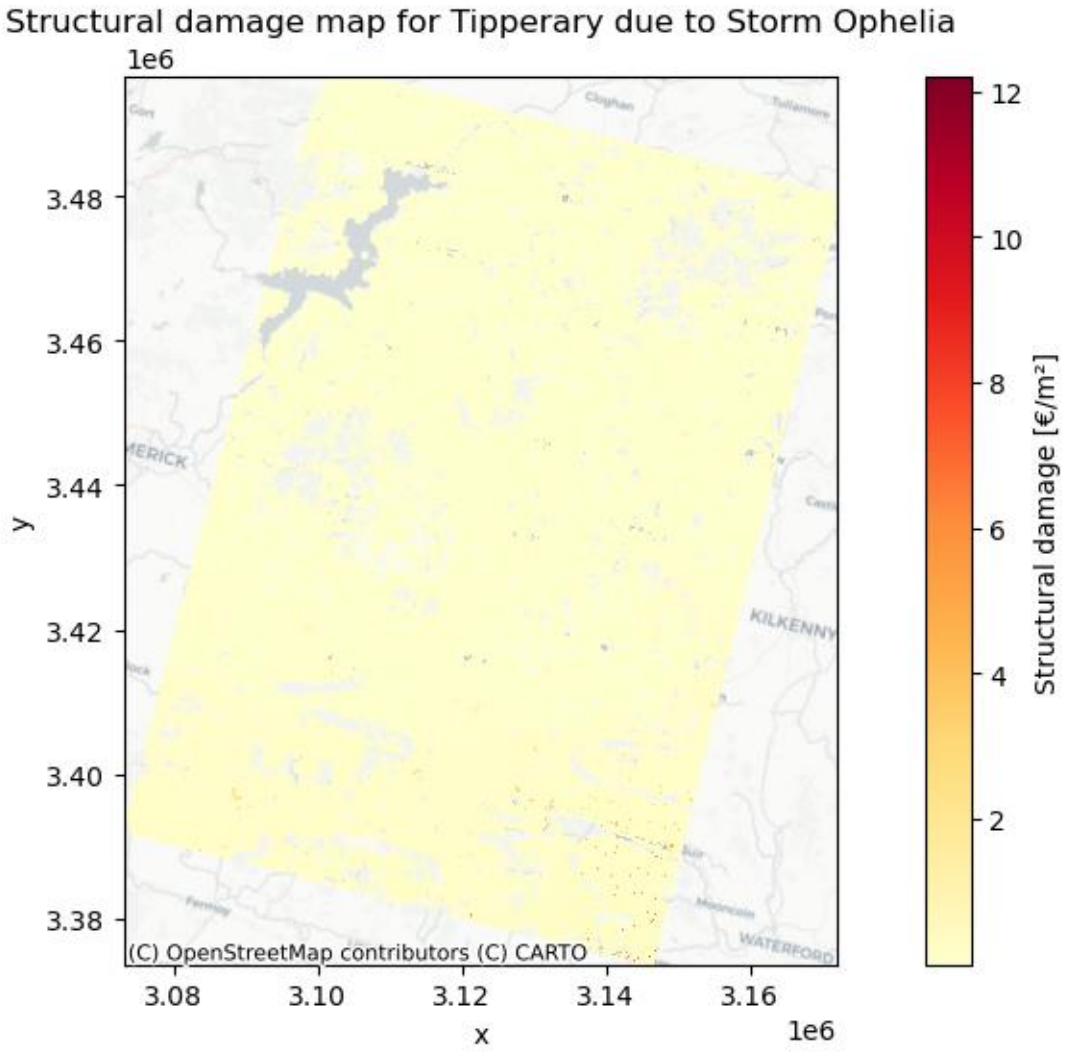

Figure 2-4: The potential structural damage from wind storms for the Tipperary region based on the standard vulnerability curves within the Risk_assessment_STORMS notebook associated with Storm Ophelia. The map shows the damage in Euros per metre based on land use type, with the light-yellow showing areas of pasture land use and the associated economic damage. See the Jupyter Workbook in the supporting material for larger image.

2.3.3 Workflow #3: Heavy Rainfall

To assess the current and future changes in heavy rainfall hazard for County Tipperary, the hazard assessment for heavy rainfall (Notebook: EXTREME_PRECIPITATION_Hazard_Assessment) was applied to the Tipperary region using the data outlined in Table 2.5.

Table 2.5: Data overview workflow #3 Heavy Rainfall for the EXTREME_PRECIPITATION_Hazard_Assessment notebook.

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
EURO-CORDEX **Climate Projections**	N/A	N/A	N/A

2.3.3.1 Hazard assessment

The hazard assessment for the 24 hour duration showed that there is a projected increase in the amount of rainfall associated with each return period for a RCP8.5 scenario (2041-2070) (Figure 2-5). For instance, rainfall associated with the 1 in 100-year event increased from 67 mm to 74 mm. The existing 100-year event is project to become the 61-year event.

Figure 2-5: Mean 24-hour precipitation for County Tipperary for the historical and future (2041-2070) time periods for the RCP8.5 scenario.

The spatial distribution of precipitation shows that the highest levels of precipitation are associated with the south of the region, however, the future change in precipitation (Figure 2-6) shows an increase in magnitude for the south-west of the region, and a slight decrease in the east. The hazard assessment shows that Tipperary is currently exposed to this hazard, and the severity/frequency of this hazard will increase in the future.

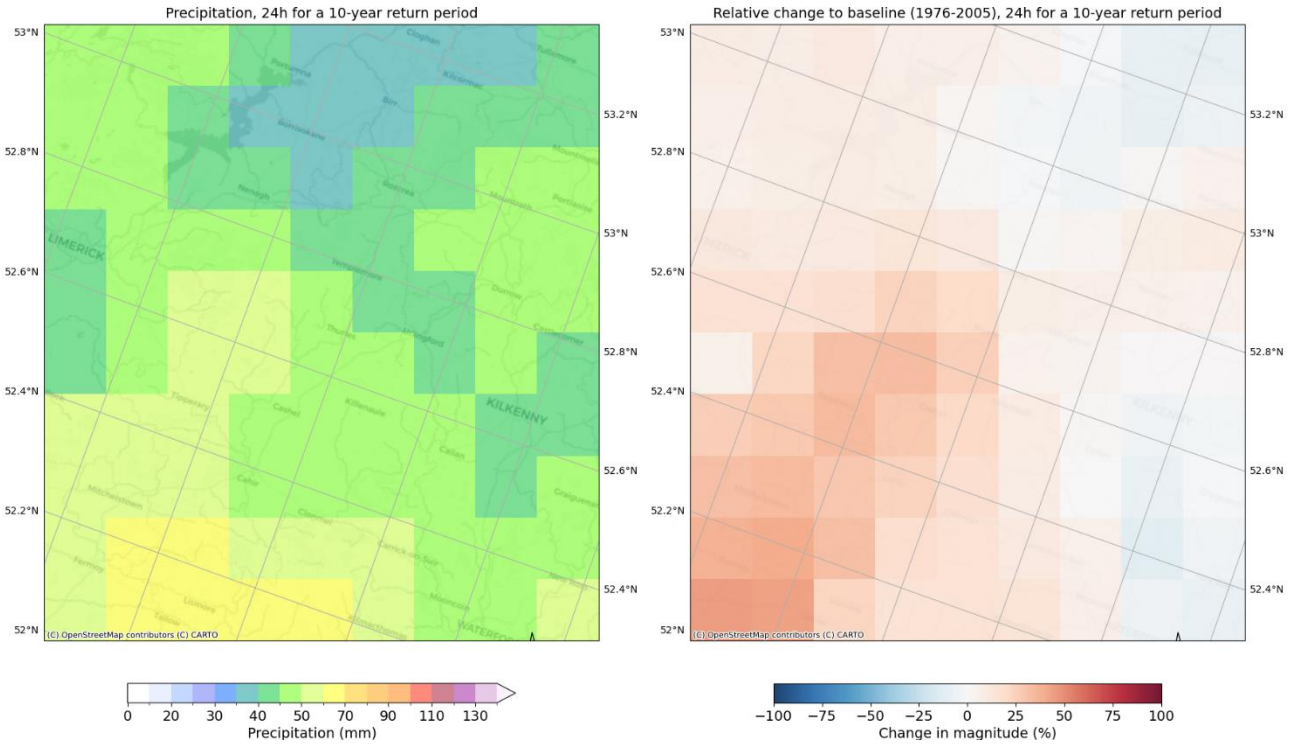

Figure 2-6: The spatial distribution of the change in 24-hour precipitation for County Tipperary for the historical and future (2041-2070) time periods for the RCP8.5 scenario and a 10 year event.

The main risk associated with heavy rainfall is pluvial flooding, where the local topography and drainage is key to understanding the risk fully. Phase 2 should focus on evolving this workflow to include local conditions within the spatial assessment.

2.3.4 Workflow #4: Heatwaves

Two workflows were applied to assess urban heatwaves for Tipperary region. The hazard workflow (*Notebook: heatwave_hazard_assessment_xclim*) was used as this could be tailored to the Irish definition of heatwaves. The risk workflow (*Notebook: heatwave_risk_assessment*) was used to allow for the assessment of vulnerability to determine overall levels of risk. The data used for each workflow are shown in Table 2.6.

Table 2.6 Data overview workflow #4: Heatwave for the hazard (heatwave_hazard_assessment_xclim) and risk (heatwave_risk_assessment) workflows.

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Daily maximum and daily minimum air temperature at 2 m height from the EURO-CORDEX dataset	N/A	N/A	N/A
Copernicus Heatwave Days based on Euro-COREDX	*WorldPop Population for <5 years and >65 years.*	*Population*	Heatwave Risk Matrix

2.3.4.1 Hazard assessment

The hazard workflow (*Notebook: heatwave_hazard_assessment_xclim*) was used with the Irish heatwave definition applied which is 5 or more days of >25°C. The urban area of Thurles was chosen to demonstrate the risks as it is one of the main towns in County Tipperary. The workflow shows that in the baseline period, only one heatwave was recorded (2003), with multiple heatwaves projected to occur between 2050 and 2070 in RCP8.5, and only one in RCP4.5.

Using the EuroHEAT hazard data based on the health-related EU-wide definition, which is for the summer period of June to August, heat waves were defined as days in which the maximum apparent temperature (Tappmax) exceeds the threshold (90th percentile of Tappmax for each month) and the minimum temperature (Tmin) exceeds its threshold (90th percentile of Tmin for each month) for at least two days. For Ireland, this shows that in RCP8.5 there is an increase in the occurrence of heatwaves by 2046-2075, with the relative heatwave occurrence change shown in Figure 2-8, which shows a north-south gradient, with the southern areas of the country projected to have the largest increases in the heatwave hazard.

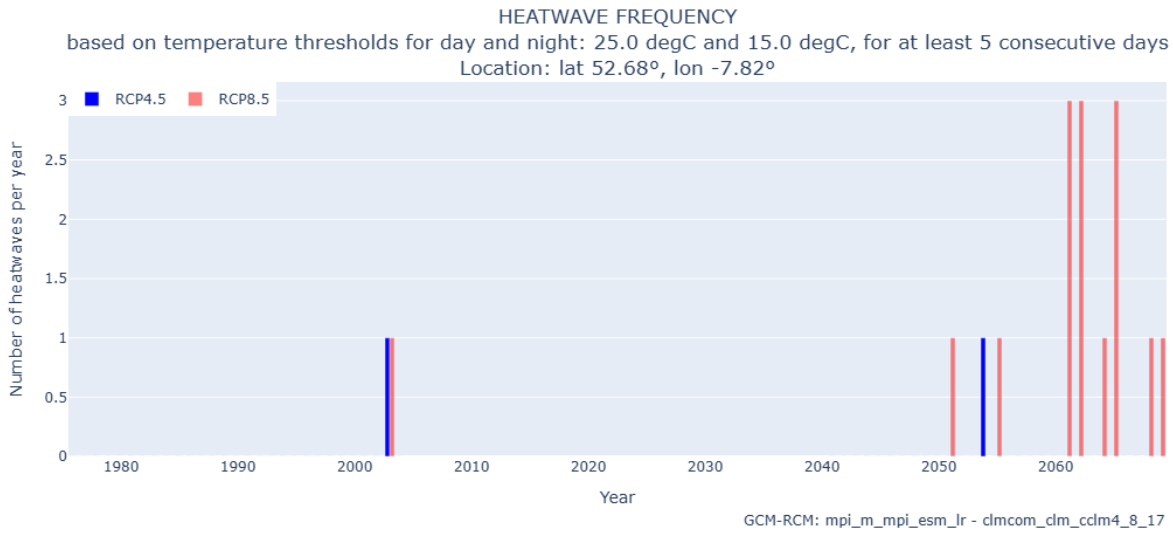

Figure 2-7: The heatwave frequency for Thurles, Tipperary. The assessment uses the Irish definition of heatwaves of 5 days or more of >25°C.

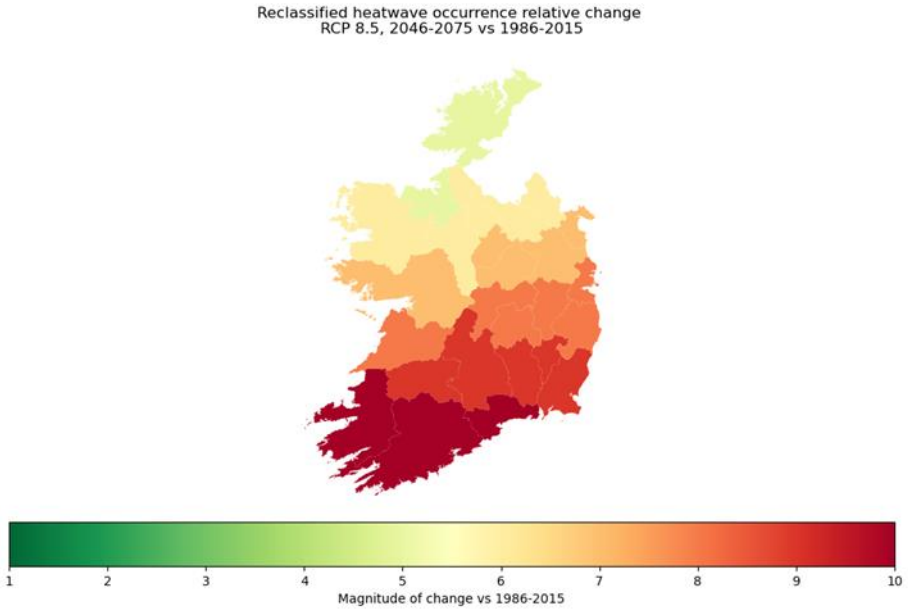

Figure 2-8: Classification of the relative heatwave hazard for Ireland for 2046-2075 compared to the baseline period of 1986-2015.

Both workflows show that heatwaves are currently relatively rare for the Tipperary region, however by mid-century they can be considered an emerging hazard due to climate change, with RCP8.5 showing the highest levels of the hazard.

2.3.4.2 Risk Assessment

Following the risk assessment workflow (*Notebook: heatwave_risk_assessment*), the vulnerability to heatwaves is based on those <5 years of age, and those >65 years of age based on population data for 2020. Figure 2-9 shows that the highest levels of vulnerability are found in Dublin, which is the region with the largest absolute numbers of people. Tipperary has very low levels of vulnerability. Combining the hazard and vulnerability data shows that for Ireland (Figure 2-10), Dublin has the highest relative risk by 2046-2075 in an RCP8.5 scenario, with Tipperary considered a medium risk nationally.

The heatwave risk assessment shows that heatwaves are an emerging risk for the region, however, the workflow assumes a static population and demographics. Phase 2 should focus on the change in vulnerability associated with both an increasing and ageing population across the region to more accurately assess future risks associated with heatwaves.

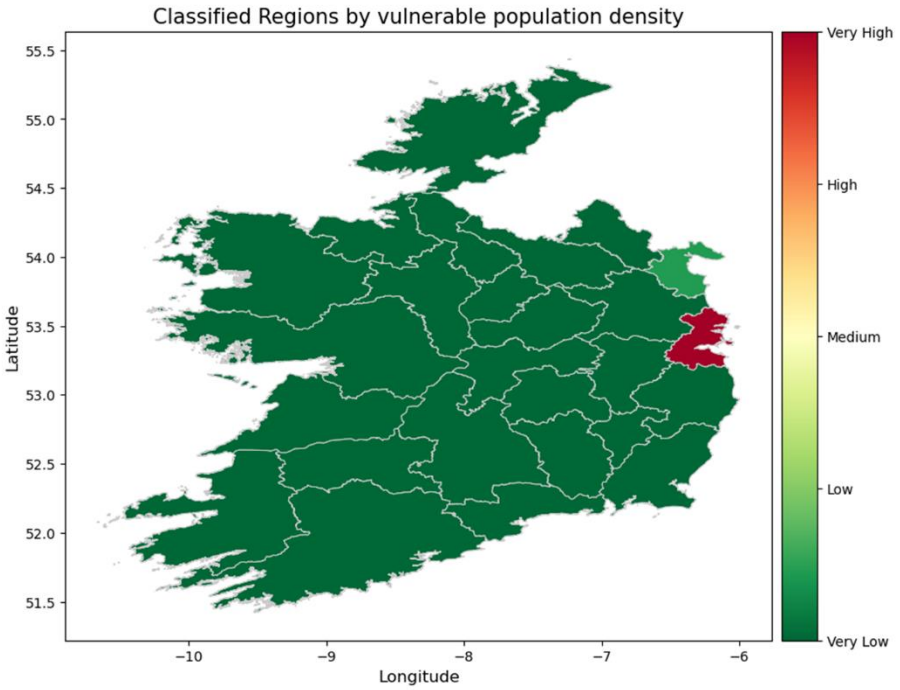

Figure 2-9: The relative vulnerability of the population to heatwaves based on those <5 years of age, and those over 65 years of age for Ireland.

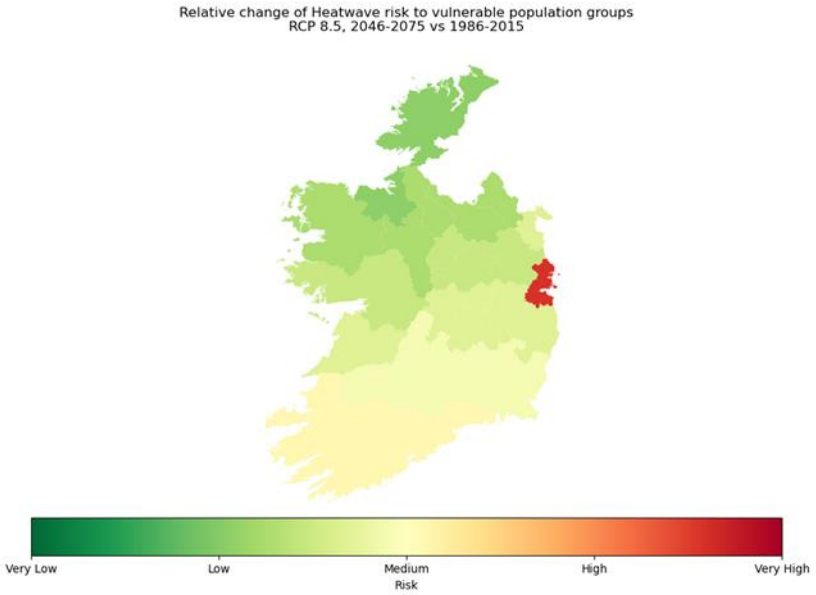

Figure 2-10: The relative heatwave risk for Ireland for 2046-2075 in a RCP8.5 scenario based on combining the hazard and vulnerability indices.

2.3.5 Workflow #5: Droughts

Drought was assessed using the relative drought hazard workflow (*Notebook: Hazard_assessment_RELATIVE_DROUGHT*) and the risk assessment workflow (*Notebook: Risk_assessment_RELATIVE_DROUGHT*). The results of these two workflows were combined to allow visualisation of the results via the visualisation workflow (*Notebook: Risk_visualization_RELATIVE_DROUGHT*).

Table 2.7 Data overview workflow #5: Droughts for the Hazard_assessment_RELATIVE_DROUGHT and Risk_assessment_RELATIVE_DROUGHT notebooks.

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Ensemble average from ISIMIP 3b bias-adjusted atmospheric climate	*CLIMAAX Dataset: droughtrisk_sample_nuts3*	*CLIMAAX Dataset: droughtrisk_sample_nuts3*	NUTS3 Relative Drought Index

2.3.5.1 Hazard assessment

The drought hazard was assessed using the workflow *(Notebook: Hazard_assessment_RELATIVE_DROUGHT) and* is represented by the WASP (Weighted Anomaly Standardized Precipitation) Index. The WASP Index quantifies precipitation anomalies by standardising deviation from average historical rainfall to assess droughts and wet conditions. An increase in the WASP Index typically indicates that precipitation levels are above the long-term average, which suggests wetter conditions that are less likely to lead to a drought. Conversely, a decrease in the WASP Index would suggest drier conditions and a higher likelihood of drought. For the Midland region, the baseline period has median WASP Index of -0.014 indicate that the region experienced precipitation levels slightly below to its long-term average, suggesting minimal deviation from typical conditions for the Midland region over the historic period. For SSP5-8.5, this decreases slightly to -0.019 for 2071 -2100, showing. All of the NUTS3 regions within the Midland NUTS2 region a decreasing WASP with time in the RCP8.5 scenario, representing an increasing severity of drought hazard.

2.3.5.2 Risk assessment

The results of the drought risk assessment *(Notebook: Risk_assessment_RELATIVE_DROUGHT)* show that within the NUTS2 region, Dublin has the highest level of relative risk, followed by the Midland region (Figure 2-11). These results are relative to the regions assessed (NUTS3 regions) and therefore should not be considered as absolute risk level, i.e., an increase in relative risk does not mean an increase in absolute risk. The workflow used standardised data for exposure and vulnerability, however, to obtain a better understanding of drought risk, a more through examination of the exposures and vulnerabilities will be required.

Figure 2-11: The relative change in the WASP index for the Dublin, Mid-East, and Midland NUTS3 regions for the historic SSP1-26, SSP3-7.0, and SSP5-8.5 scenarios for the mid-century and end-of-century time periods.. County Tipperary is located with the Midlands region.

2.3.6 Workflow #6: Fire

For the fire hazard, the Fire Weather Index (FWI) workflows were utilised to assess the hazard *(Notebook: FWI_Hazard_Assessment) and risk (Notebook: FWI_Hazard_Assessment)* using the data shown in Table 2.8.

Table 2.8 Data overview workflow #6: Fire for the FWI_Hazard_Assessment and FWI_Risk_Assessment notebooks.

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
• **Fire danger indicators for Europe from 1970 to 2098 derived from climate projections** • ***Potential burnable land proportion***	• Wildland Urban Interface • *Protected Areas* • *Ecosystem Irreplaceability Index* • *Population Density* • *Ecosystem Restoration Cost Index*	N/A	N/A

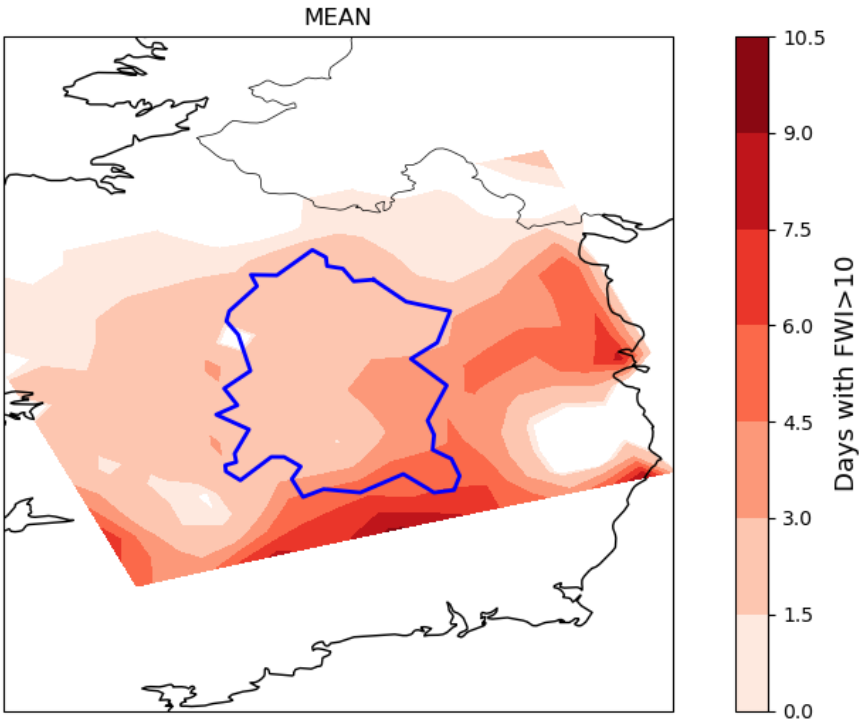

Figure 2-12: The number of days with a Fire Weather Index >10 (mean of ensemble) for RCP8.5 mid-century. Area outlined is the Midlands NUTS3 region within which County Tipperary is located.

2.3.6.1 Hazard assessment

In Ireland, there are five fire danger categories ranging from Very Low to Extreme. These values were selected by Met Éireann to ensure that extreme conditions would appear on 2-3% of days in each month across the 35-year period for which the fire model was run. A High fire danger level

corresponds to a Fire Weather Index (FWI) value over 10, while the Extreme category is identified by a value exceeding 18. The hazard workflow threshold was adjusted to align with the High Fire Danger category. For the historic period, there were approximately 1 to 2 days across the Midland region with a FWI >10. For the mid-century, this increases to a maximum of 6 days within FWI >10 for some parts of the region in an RCP8.5 scenario**Error! Reference source not found.**. The hazard assessment shows that there is an increasing occurrence of High Fire Danger days in the future.

2.3.6.2 Risk assessment

The Irish FWI thresholds are relatively low in comparison to the standard European thresholds, i.e., >10 for a High Fire Danger in Ireland, whereas in Europe, >21.3 is considered high. The risk workflow (*Notebook: FWI_Risk_Assessment*) showed no overall fire danger for the region due to the low levels of the climatic drivers of the hazard. However, when considering other fire danger components, the region has a very high proportion of burnable vegetation. Furthermore, in terms of vulnerability, there are locations within the Midlands region with large areas of environmental protection, and therefore high ecosystem irreplaceability and ecosystem restoration costs. Therefore, Phase 2 should develop the FWI hazard assessment to further determine if fire is a hazard for the region, and increase the information associated with exposure and vulnerability of ecosystems and habitats to wildfire.

2.3.7 Workflow #7: Snow

To assess the current and future changes in the snow hazard for County Tipperary, the hazard assessment (*Notebook: Hazard_assessment_SNOW_BLIZZARDS*) and risk assessment (*Notebook: Risk_assessment_SNOW*_BLIZZARDS) was applied to the Tipperary region using the data outlined in Table 2.9.

Table 2.9 Data overview workflow #7 Snow for the Hazard_assessment_SNOW_BLIZZARDS and Risk_assessment_SNOW_BLIZZARDS notebooks.

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
ECMWF Reanalysis v5 (ERA5)	*N/A*	Population	*N/A*

2.3.7.1 Hazard assessment

The hazard assessment (*Notebook: Hazard_assessment_SNOW_BLIZZARDS)* was undertaken using the default thresholds heavy snowfall & blizzards indicators, however, the time period for the historic and future were altered to 1976-2005, and 2041-2070 respectively. The historic period showed that the annual probability of a snowfall day was below 10% (i.e. greater than a 1 in 10 year event) based on ERA5 data (Figure 2-13)

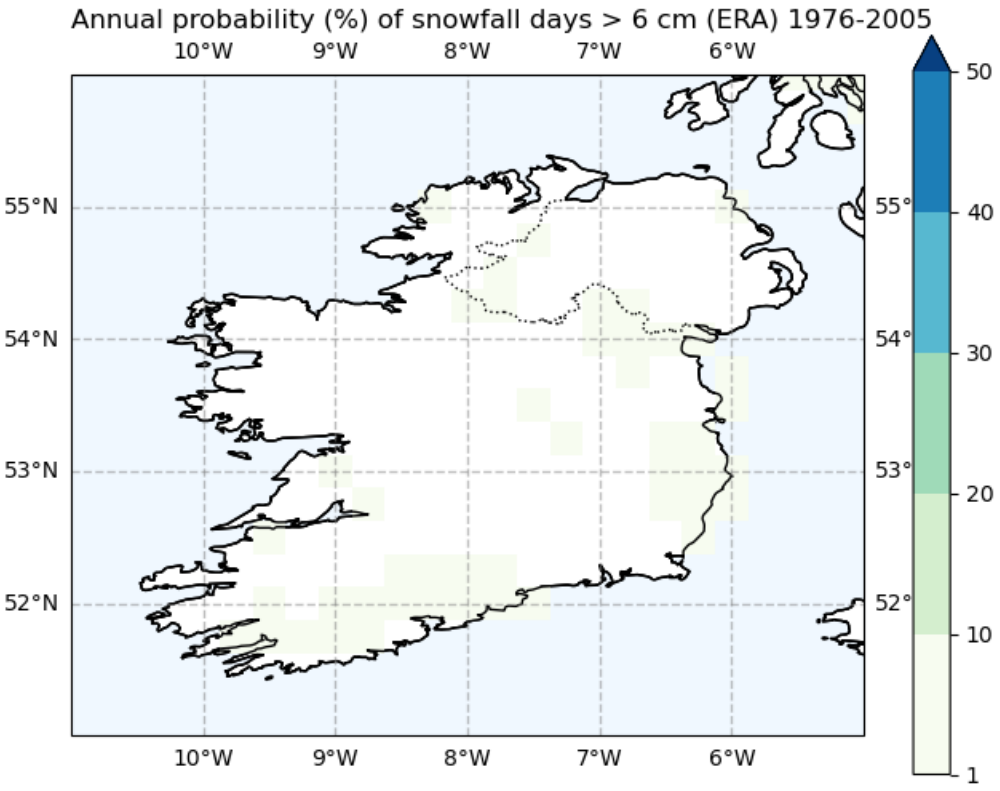

Figure 2-13: The historic (1976-2005) annual probability of snowfall days (>6 cm) based on ERA5 data.

2.3.7.2 Risk Assessment

The risk assessment (Notebook: *Risk_assessment_SNOW_BLIZZARDS*) shows that for the mid-century under an RCP8.5 scenario (Figure 2-14) there will be a limited change in the annual probability of a snowfall day (>6 cm). The exposure data of population density highlights the key urban areas across the region, however, much of the county is rural, which also has a relatively large population that would be potentially more vulnerable to this risk. Phase 2 should focus on the vulnerability aspects of the population to determine with greater certainty that this risk is low for the region.

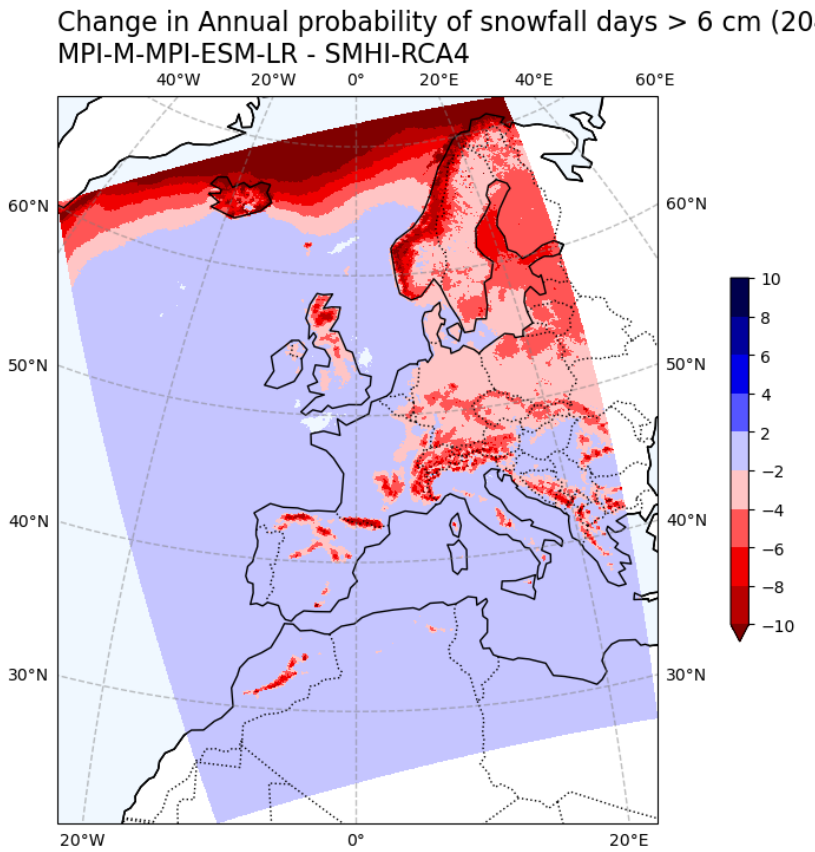

Figure 2-14: The change in annual probability of snowfall days (>6 cm) based on RCP8.5 mid-century (1976-2005 baseline period.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

In Ireland, the National Climate Change Risk Assessment (NCCRA) (Environmental Protection Agency, 2025) used the EU Climate Risk Assessment risk severity criteria adjusted to the Irish geographic, economic, and social contexts. The level of consequence for each risk is based on the following criteria:

- **Damage**: The level of losses or harm caused by the risk. Losses and harm are wide ranging and can include economic damage, impacts on people and livelihoods, and impacts on natural capital, species, habitats, and heritage.
- **System Functionality**: The degree to which the risk affects the system's ability to perform its intended functions. The NCCRA used nine systems that represent nationally important functions across the natural, social, infrastructure, and economic domains that support human activity in Ireland.
- **Extent and Pervasiveness:** The scope of the risk's impact, indicating how geographically widespread the effects are within the system, and the degree to which multiple elements within a system are affected.
- **Cascading Effects**: The potential for the risk to cause secondary impacts to occur as a result of the initial risk event, which can propagate through interconnected systems leading to additional impacts, for example, impacts on water quality/ecology can be exacerbated as a result of water bodies under risk from extreme weather events such as extreme precipitation.

The qualitative Climate Risk Assessment prepared in 2023 as part of the TCC LACAP also assessed the severity of each hazard (except fire which was not assessed), based on the impact of climate

change on the functions and services of the local authority. The functions and services of local authority include community services, housing, environmental management, heritage, libraries and museums, roads and transport and many more. Table 2.10 shows the maximum severity for each hazard for each of the relevant risks identified within the NCCRA for mid-century for an RCP8.5 scenario and the impact rating from the LACAP.

The workflows have identified that for **River Flooding, Wind, Heavy Rainfall** the CLIMAAX workflows suggest a severity consistent with the NCCRA and LACAP, i.e., the region has a relatively high exposure to the hazard, and/or there is a high level of risk.

For **Heatwaves**, the workflow suggests Tipperary has a moderate level of risk, suggesting the severity of this hazard is not as high as assessed by the NCCRA. However, the NCCRA included changes in population and demographics into the assessment, whereas the population remains static in the heatwave risk assessment workflow, potentially explaining this difference in result. The LACAP severity is approximately aligned with the heatwave workflow outcome.

For **Droughts**, the workflow suggest Tipperary will have a minor exposure to droughts in the future, whereas the NCCRA and the LACAP both suggest there substantial and major levels of severity possible. The difference in the severity could be due to the qualitative based assessment of the NCCRA and LACAP to understand the drought hazard whereas the workflow uses a semi-quantitative approach to assess the change in the hazard.

For **Fire**, the workflow shows that the region has relatively low exposure to fire weather compared to Europe. However, the risk workflow shows high vulnerability for environmental assets. The workflow severity is therefore lower than assessed by the NCCRA, potentially due to the national focus of the NCCRA elevating the overall severity level.

For **Snow**, the workflow shows low exposure and low risk, which aligns with the existing evidence base within the NCCRA and LACAP. However, the rural nature of the region, may mean vulnerability is underestimated by the snow workflow.

Table 2.10: The risk severity for each hazard based on the National Climate Change Risk Assessment (NCCRA). For the NCCRA, the maximum severity for each hazard is shown.

Hazard	Severity		
	National (RCP8.5, 2050)	Climate Action Plan	Workflow Outcome
River Flooding	Critical	Major	Aligned with existing evidence
Wind	Critical	Moderate	Aligned with existing evidence
Heavy Rainfall	Critical	Moderate	Aligned with existing evidence
Heatwaves	Critical	Moderate	Less severe than suggested by existing evidence
Droughts	Substantial	Major	Less severe than suggested by existing evidence
Fire	Substantial	-	Less severe than suggested by existing evidence

Snow	Limited	Minor	Aligned with existing evidence

2.4.2 Urgency

All of the workflows show that Tipperary is exposed to all of the hazards already, with an increase in the hazard and/or risk projected in the future, except for the snow hazard. This is also recognised in the NCCRA (Environmental Protection Agency, 2025), which identified the decision urgency for each of the hazards.

The hazards of river flooding, wind, and heavy rainfall were all given a decision urgency of 'More Action Needed' which requires action in the next five years to manage the current and future change in the hazard/risks. This urgency is required, as the risks could result in a high level of impact on the country in a relatively short timeframe and may increase to Catastrophic level of impact by late century (2100) if no action is taken. This national level of urgency for the hazards will also be applicable to Tipperary.

For heatwaves, droughts, fire, and snow, the current level of the risks associated with these hazards is currently manageable at the national level and at a local authority level over the next 5 years. However, there is uncertainty associated with future changes in the hazard, exposure, and/or vulnerability, therefore future levels of risk, and therefore the appropriate adaptation measures to take are yet to be established. Consequently, these hazards were given an urgency of 'Further Investigation' within the NCCRA which requires the development of additional information to determine level of future risk and/or the timing of this change in risk. This national level of urgency for the hazards will also be applicable to Tipperary.

Table 2.11: The urgency for each hazard based on the National Climate Change Risk Assessment (NCCRA). For the NCCRA, the maximum urgency for each hazard is shown.

Hazard	Urgency (NCCRA)
River Flooding	More action needed
Wind	More action needed
Heavy Rainfall	More action needed
Heatwaves	Further Investigation
Droughts	Further Investigation
Fire	Further Investigation
Snow	Further Investigation

2.4.3 Capacity of the Local Authority

As shown through the analysis above, the Tipperary region is already exposed to all seven hazards (from the CLIMAAX Toolbox). Consequently, measures are in place to actively manage the current level of risks including a detailed document that sets out the Councils response to Severe Weather Emergencies or Severe Weather Plan (currently under review), as well as within TCC's LACAP.

The Department of Housing, Local Government and Heritage is designated as the Lead Government Department responsible for coordinating a 'whole-of-Government' response to high impact severe

weather emergencies under the Strategic Emergency Management Framework (SEM), supporting the local authority response. In this role, the National Directorate for Fire & Emergency Management (NDFEM), a section of the Department, works closely with all local authorities in preparation for, and response to, severe weather emergencies. Where weather emergencies are judged to impact public safety at national level the National Emergency Coordination Group (NECG) is activated by the Office of Emergency Planning on request from the Department of Housing, Local Government and Heritage. Met Éireann provides the weather briefings at the NECG, which brings together all Government Departments and relevant agencies and organisations, to support the locally led response and ensure coordination across the "Whole-of-Government" for the duration of the emergency.

Local authorities are designated as the lead agency responsible for coordinating a response to severe weather emergencies. Each local authority has a Severe Weather Assessment Team (SWAT Team) in place which monitors Met Éireann's weather advisories and warnings, activating the necessary coordination structures at local level, when required.

TCC belongs to the Mid-West Major Emergency Management (MEM) region for the purposes of regional level coordination for MEM. This region incorporates County Tipperary, Limerick and Clare. An inter-agency Regional Steering Group is in place for the Mid-West MEM Region with representatives of senior management from each of the Principal Response Agencies (PRAs) i.e. Local Authorities, HSE and AGS. A Regional Working Group on MEM is also in place to support and progress MEM in the Mid-West Region. These regional structures are the vehicle for coordination across the region during high impact severe weather emergencies.

The elements of TCC's own coordination and response structure include the Severe Weather Assessment Team (SWAT Team), Senior Management Team (SMT), Crisis Management Team (CMT) and Individual Section Teams across TCC. The SWAT Team monitors Met Éireann's weather advisories and warnings, activating the necessary coordination structures at local level, when required.

These measures include a Risk Register that is crucial for identifying and managing various risk factors associated with each of the hazards and help coordinate a response. This register enables Tipperary County Council to systematically assess risks, prioritise them, and develop targeted responses. By keeping an up-to-date register, the council can effectively allocate resources and implement strategies to mitigate the identified risks. The council undertakes community engagement initiatives to raise awareness and prepare residents for potential hazard impacts. Educational programmes inform people about the hazards and risks, helping communities to become more resilient when an extreme weather event occurs. The human capacity is bolstered through training programmes for council staff and community leaders, equipping them with essential skills to effectively manage risks associated with extreme weather. On a national level, initiatives such as the Office of Public Works (OPW) Flood Relief Programme support local flood defence projects, helping areas like Tipperary to manage flood risks.

In Ireland, when regions like Tipperary face climate-related events such as flooding or severe weather, national funding is available to assist with recovery. The Humanitarian Assistance Scheme from the Department of Social Protection provides financial aid to affected households, while the Office of Public Works (OPW) offers funding for repairs to flood defences and infrastructure. The Department of Housing, Local Government and Heritage allocates resources for infrastructural repairs, collaborating closely with other entities to ensure a coordinated response. If agriculture is impacted, the Department of Agriculture, Food and the Marine assists farmers in recovering

damaged crops and livestock. Emergency grants or low-interest loans may also be provided to support businesses and public amenities, facilitating swift recovery. These efforts are guided by national Disaster Recovery Frameworks, which promote rapid response and resource provision.

In terms of capacity to address the change in these hazards and risks due to climate change, Tipperary County Council has a Climate Action Team, which is committed to advancing local climate initiatives and works in collaboration with the Climate Action Regional Office (CARO). CARO offers guidance and coordination for regional climate strategies, supporting local authorities in creating effective climate adaptation plans and facilitating knowledge sharing across sectors. Tipperary County Council also have a Local Authority Climate Action Plan that includes 13 actions focused solely on adaptation, emphasising the region's commitment to addressing climate risks.

Ireland's capacity for climate adaptation is guided by the Climate Action and Low Carbon Development (Amendment) Act 2021 and supported by national initiatives, such as the NCCRA, the Irish Climate Change Assessment (ICCA), and the National Framework for Climate Services (NCFS). The Climate Action and Low Carbon Development (Amendment) Act 2021 sets policy direction, including the National Adaptation Framework (NAF), advising local governments like Tipperary County Council to develop Local Authority Climate Action Plans. The NCCRA evaluates climate risks at the national scale, informing local authorities about vulnerabilities to tailor effective adaptation strategies. ICCA provides a comprehensive and authoritative assessment of the state of knowledge around all key aspects of climate change, with a central focus on Ireland. This alignment with national strategies ensures a national and consistent understanding the science and risks of climate change to inform adaptation at the regional and local level. The NFCS coordinates collaboration between climate information providers and users and provides high-quality climate data, analysis, and expertise.

2.5 Preliminary Monitoring and Evaluation

Through the assessment of the seven climate hazards through the standard workflows, the first phase of the project highlighted:

- At both the national, e.g., the NCCRA, and regional level, e.g., the TCC LACAP, there is a relatively good sources of information available to inform the screening and prioritisation of climate risks. This is supported by a governance structure that includes a dedicated Climate Action Team at the local authority level, which aids the implementation of the LACAP Adaptation Actions and facilitates stakeholder engagement within TCC and other relevant groups.
- The outcomes of the CLIMAAX workflows generally align with the national understanding of climate risks for the region. However, although the workflows are useful for identifying changes in hazards and risks, as well as some spatial differences across the region, local-level data on hazards, exposure, and vulnerability is necessary for the spatial analysis to be informative for local decision-making.
- Climate data from the NFCS will be incorporated into the workflows for Phase 2, primarily informing the hazard aspect of risk. Understanding current and future changes in exposure and vulnerability will require gathering and processing a variety of information, including extensive stakeholder engagement with both internal and external parties to identify the relevant factors.
- Phase 1 focused on the entire Tipperary region. In Phase 2, with a greater emphasis on exposure and vulnerability data, it may be necessary to concentrate on a few key areas within the region to allow for more detailed analysis. These areas will be identified through a review of the evidence to date and input from stakeholders.

- The introductory workshop with the internal TCC stakeholders raised awareness of the project to a range of functions and services across the local authority. Feedback within the workshop highlighted the implications of climate change on the planning and implementation of emergency response activities, and how the outcomes of the CLIMAAX project could help improve these in the future and in embedding adaptation response in the delivery of other services and functions of the Council.

2.6 Work plan

The work plan for the remaining phases of the project aims to build upon Phase 1's foundational activities, advancing comprehensive **climate risk assessment for Tipperary and the adaptation strategies** and response across county council service delivery (as outlined in the Tipperary County Council Corporate Plan). Phase 2 will focus on refining risk analyses for key hazards, such as river flooding, wind, heavy rainfall, heatwaves, droughts, and fire, identified in the initial risk workflows. At least **four workflows** will be selected with priority given to the hazards with the highest level of risk plus availability of local hazard, exposure, and vulnerability information that could be integrated into the workflows. Stakeholder engagement will be central, with activities, such as data gathering and validation workshops with Tipperary County Council staff and councillors, public meetings for information collection, and risk severity and validation workshops. These will gather diverse insights to inform workflow improvements and policy decisions. Phase 2 will result in refined risk assessments that will support the development of targeted adaptation actions.

Phase 3 will concentrate on developing adaptation strategies and refining risk management plans, leveraging insights gained from Phase 2. Workshops will address existing risk management practices and explore potential adaptation options, aiming to identify actionable strategies for each hazard. Dissemination activities, including public meetings and strategic presentations, will facilitate widespread sharing of project results and support the enhancement of Tipperary's climate resilience. Phase 3 will result in the development of potential adaptation options that can be implemented to enhance resilience across the region.

3 Conclusions Phase 1 - Climate risk assessment

The workflows provide useful information to screen key hazards and identify areas of interest for further analysis in County Tipperary. However, the information produced using standard data has limitations, necessitating additional tailoring to enhance the outputs' usefulness. Addressing these limitations will be crucial in refining the assessments and developing effective adaptation strategies for the various hazards faced by the region. The conclusions for each workflow are as follows:

- **River Flooding:** River flooding poses a significant risk to County Tipperary, with potential economic damages exceeding €4.67 billion, primarily affecting pastural land. To address this in Phase 2, detailed Irish flood hazard data should be utilised to refine vulnerability and exposure assessments. Improving data accuracy will provide a better understanding of potential damages, enabling targeted adaptation strategies to mitigate these risks effectively.
- **Wind:** The assessment of wind hazards, particularly considering events like Storm Ophelia, highlighted substantial economic damage impacting agricultural and rural areas in Tipperary. Current risk assessments may not fully capture the extent and breadth of actual impacts on urban areas, critical infrastructure, agriculture and forestry. Phase 2 should focus on enhancing vulnerability curves to better represent these sectors and incorporate national datasets to evaluate potential future changes in extreme wind events more accurately.

- **Heavy Rainfall:** Heavy rainfall is identified as a growing hazard in Tipperary, with projections showing increased severity and frequency, leading to risks associated with pluvial flooding in urban areas and agricultural operations. Phase 2 requires evolving the workflow to incorporate local topographical and drainage conditions to provide precise spatial risk assessments. Developing better management strategies for pluvial flooding risks will be crucial for the region's adaptation to this hazard.
- **Heatwaves:** Heatwaves are considered an emerging hazard for Tipperary, with future risks expected to increase, although current assessments show low exposure in the region. Phase 2 should integrate dynamic demographic data to assess changes in vulnerability related to population age and growth, improving risk matrices for better forecasting of future impacts and adaptation needs, ensuring Tipperary is prepared for potential heatwave scenarios.
- **Droughts:** The drought hazard assessment for Tipperary suggests minor exposure compared to national assessments that indicate substantial severity. This discrepancy may arise from differences in methodologies. Phase 2 should involve a more thorough examination of exposures and vulnerabilities, aiming to align drought risk assessments with the qualitative national evaluations and enhancing understanding of future drought impacts.
- **Fire:** While fire hazards currently show low climatic drivers, Tipperary has high vulnerability due to environmental factors like burnable vegetation and ecosystem sensitivity. In Phase 2, further development of the fire weather index (FWI) assessment will help determine potential hazard levels. Expanding exposure and vulnerability data to include ecosystem and habitat susceptibility will be vital for comprehensively assessing fire risks in the region.
- **Snow:** The hazard assessment shows that there is a low risk associated with snow for the region due to the relatively low historic likelihood of occurrence. Climate change is likely to reduce the frequency further. However, the risk assessment only considered population density and given the rural nature of much of the region, this may underestimate the impact across the region, and should be further explored in Phase 2 to determine if this requires further refinement.

To enhance the effectiveness of risk assessment in Phase 2, it is essential to narrow the scope of geographic areas under consideration. This refinement will allow for more targeted tailoring and improvement of the workflows. By focusing on specific regions within County Tipperary, informed by a thorough review of the existing evidence base and historical impacts, the assessments can be more precise and relevant. Additionally, engaging with stakeholders will be a vital component of this process. Through collaboration with local authorities, community groups, and experts, insights into the unique vulnerabilities and challenges faced by different areas can be gained.

In summary, the climate risk assessment for County Tipperary highlights the varied hazards confronting the region and aims to enhance its climate resilience by understanding the unique social and economic strengths and dependences of the county and thereafter by informing future emergency response, economic and social policy direction, how to manage and source finance and strategic planning decisions. By utilising targeted workflows and refining data in Phase 2, more precise strategies can be developed. Focusing on specific geographical areas and engaging stakeholders will ensure assessments are both relevant and actionable, contributing to building resilience against climate impacts across the region.

4 Progress evaluation and contribution to future phases

4.1 Key Performance Indicators

The key performance indicators for the project (Table 4.1) have been structured to ensure comprehensive stakeholder engagement, integration of data into workflows, and identification of adaptation actions. Phase 1 successfully established the foundation for stakeholder interaction by identifying relevant stakeholders and conducting a Risk Exploration Workshop with Tipperary County Council (TCC). However, further engagement activities are planned for Phase 2, including a Data Gathering Workshop with TCC, two public meetings for information gathering, a Risk Severity and Validation Workshop, and a presentation to the TCC Environment and Climate Action Strategic Policy Committee. Additionally, Phase 2 will focus on integrating national climate and hazard data, as well as local and regional exposure and vulnerability data, into at least four workflows. Looking forward to Phase 3, the planned activities include workshops for existing risk management and adaptation options, alongside public meetings and presentations to disseminate project results, guiding the project towards identifying potential adaptation actions or policy recommendations for each hazard.

4.2 Milestones

The project has reached achieved three key milestones in Phase 1, setting a solid foundation for future phases (Table 4.2). The completion of the Stakeholder Engagement and Management Plan, standardised workflows for seven hazards, and the Common Methodology for Multi-risk Climate Assessment underline the project's early success. Moving into Phase 2, the focus will shift to refining risk analyses for hazards and delivering a refined regional/local multi-risk assessment. This phase will build upon the groundwork laid in Phase 1, enabling more precise and tailored risk assessments. Finally, Phase 3 aims to culminate in the development of adaptation strategies and improved Risk Management Plans.

Table 4.1 Overview of key performance indicators for CLIMAAX TIPPERARY

Key performance indicators	***Progress***
Stakeholder Engagement: Identify relevant stakeholders both internal and external to TCC	Completed as part of Phase 1 – August 2026
Stakeholder Engagement: Conduct a Risk Exploration Workshop	Completed as part of Phase 1 – August 2026
Stakeholder Engagement: Conduct a Data Gathering Workshop with TCC	To be completed in Phase 2
Stakeholder Engagement: Conduct 2 x Public Meetings - Information Gathering	To be completed in Phase 2
Workflows: Integrate national climate and hazard data into at least four workflows	To be completed in Phase 2
Workflows: Integrate local/regional exposure and vulnerability data into at least four workflows	To be completed in Phase 2
Stakeholder Engagement: Conduct a Risk Severity and Validation Workshops	To be completed in Phase 2

Key performance indicators	*Progress*
Stakeholder Engagement: Present at the TCC Environment and Climate Action Strategic Policy Committee – Project Update	To be completed in Phase 2
Stakeholder Engagement: Conduct an Existing Risk Management Workshop	To be completed in Phase 3
Stakeholder Engagement: Conduct an Adaptation Options Workshop	To be completed in Phase 3
Adaptation: Identify at least 2 potential adaptation actions or policy recommendations for each hazard	To be completed in Phase 3
Stakeholder Engagement: Present to Elected Members - Project Update	To be completed in Phase 3
Stakeholder Engagement: Conduct 2 x Public Meetings to disseminate project results	To be completed in Phase 3
Stakeholder Engagement: Present to the TCC Environment and Climate Action Strategic Policy Committee – Project Results	To be completed in Phase 3

Table 4.2 Overview of the milestones for CLIMAAX TIPPERARY

Milestones	*Progress*
M1: Stakeholder Engagement and Management Plan (Phase 1)	Completed as part of Phase 1 – August 2026
M2: Standardised workflows for seven hazards (Phase 1)	Completed as part of Phase 1 – August 2026
M3: Common Methodology - Multi-risk Climate Assessment Deliverable (Phase 1)	Completed as part of Phase 1 – September 2026
M4: Refined risk analysis of hazards (Phase 2)	To be completed in Phase 2
M5: Refined Regional/Local Multi-Risk Assessment Deliverable (Phase 2)	To be completed in Phase 2
M6: Adaptation strategies and improved Risk Management Plans Deliverable (Phase 3)	To be completed in Phase 3
M7: CLIMAAX Workshop (Brussels) (Phase 3)	To be completed in Phase 3

5 Supporting documentation

This section includes key documents that underpin the climate risk project for County Tipperary, detailing strategic planning, stakeholder engagement, and methodological approaches. These resources are vital for guiding future project phases and is available on Zenodo. The supporting material includes:

- **Tipperary County Council: Local Authority Climate Action Plan (PDF):** This document outlines the strategic framework and actions Tipperary County Council is implementing to address climate change, focusing on adaptation and mitigation efforts to enhance the region's resilience and sustainability.
- **Tipperary County Council: Climate Risk Assessment (PDF):** The climate risk assessment provides a detailed analysis of potential climate-related hazards impacting Tipperary, identifying vulnerabilities and evaluating risks to help inform effective adaptation strategies and policy planning.
- **Tipperary County Development Plan (PDF):** The Tipperary County Development Plan outlines the strategic framework and policies for sustainable development and land use in County Tipperary, focusing on economic growth, environmental protection, and community well-being.
- **Tipperary County Council Corporate Plan (PDF):** The Corporate Plan outlines Tipperary County Council's vision for the county, detailing key priorities and explaining the benefits these objectives will bring to our communities over the next five years.
- Risk Exploration Workshop **Presentation (PDF):** This presentation summarises the outcomes of the Risk Exploration Workshop conducted with Tipperary County Council staff, highlighting key insights, stakeholder inputs, and preliminary assessments shaping the ongoing project phases.
- **7 x Hazard Workflow Jupyter Notebooks (PDF):** These documents contain detailed methodologies and analyses for assessing seven key climate hazards affecting Tipperary, using standardised workflows to evaluate risk and inform future climate action planning.

6 References

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