Deliverable Phase 2 – Climate Risk Assessment

Tipperary County Council (TCC)

Ireland, Tipperary

DRAFT Version 1.0 | June 2026

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

Funded by
the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101093864. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Document Information

Deliverable Title	Phase 2 – Climate Risk Assessment
Brief Description	This report presents Phase 2 of the CLIMAAX Climate Risk Assessment for Tipperary County Council, delivering a detailed, locally informed analysis of priority climate hazards, their impacts on infrastructure, services, and communities, and a structured evaluation of risk severity, urgency, and resilience to support future adaptation planning.
Project name	CLIMAAX TIPPERARY
Country	Ireland
Region/Municipality	County Tipperary
Leading Institution	Tipperary County Council
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Deliverable submission date	26/06/2026
Final version delivery date	26/06/2026
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Version	Date	Change editors	Changes
1.0	26/06/2026	TCC	Deliverable submitted

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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
CRM	Climate Risk Management
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 report presents Phase 2 of the Climate Risk Assessment (CRA) for Tipperary County Council (TCC), delivered under the CLIMAAX project. It builds directly on the outputs of Phase 1, which identified a broad set of climate hazards and established a high-level assessment methodology using European-scale datasets and initial stakeholder engagement. Phase 2 responds to the need for a more detailed, locally relevant and decision-focused understanding of climate risk. It provides a comprehensive assessment of how key climate hazards affect the county's infrastructure, services and communities, and establishes a structured basis for prioritising risks and informing future action. The reader gains a clear and complete overview of the nature, scale and spatial distribution of climate risks in County Tipperary, and how these risks can be addressed within the local authority service delivery context.

Phase 2 involved a series of structured analytical and engagement activities aligned with the CLIMAAX framework. Priority hazards were refined from Phase 1 to focus on river flooding, heavy rainfall, wind, snow and heatwaves. Higher-resolution national and local datasets were integrated to improve the accuracy and relevance of the analysis, replacing or supplementing the European-scale datasets used previously. Locally tailored risk workflows were developed for each hazard, incorporating hazard, exposure and vulnerability components. A Social Vulnerability Index was applied to assess population sensitivity and adaptive capacity, enabling a more comprehensive understanding of risk beyond physical impacts. Stakeholder engagement was undertaken with internal departments, advisory bodies and the corporate risk function to inform, validate and contextualise the analysis. A structured Key Risk Assessment was carried out, evaluating each hazard in terms of severity, urgency and resilience capacity in line with CLIMAAX and national methodologies.

The results provide a detailed, place-based understanding of climate risk across County Tipperary. The assessment identifies spatial "hotspots" where risks are concentrated due to the interaction of hazard, exposure and vulnerability, particularly within urban centres, along river corridors and across critical transport networks. River flooding, heavy rainfall and wind are confirmed as the most significant and immediate risks, with substantial impacts on infrastructure, service delivery and community resilience. These hazards are already affecting the county and are projected to intensify under future climate conditions. Heatwaves are identified as an emerging risk, with increasing frequency and implications for vulnerable populations, particularly in relation to health and social vulnerability. Snow is identified as a lower-priority risk in the long term due to declining frequency, although it remains relevant due to its potential to cause short-term disruption, particularly in rural areas. The assessment demonstrates that climate risk is driven not only by hazard intensity, but by the distribution of assets and vulnerability of communities. It also establishes a transparent and consistent framework for risk prioritisation, aligned with national and European approaches, providing a robust evidence base for decision-making.

The key conclusions from Phase 2 highlight that climate risks in County Tipperary and TCC service delivery are both significant and increasing, requiring structured and coordinated responses. River flooding, heavy rainfall and wind pose immediate challenges to infrastructure, services and operational continuity, while heatwaves represent an emerging risk that requires early attention. The integration of local data and targeted analysis has significantly enhanced the relevance and usability of the assessment for local authority decision-making. TCC has a strong foundation of

resilience through existing governance arrangements, emergency response systems, partnerships with other service areas and planning frameworks; however, further integration of climate risk into policy, investment and operational processes is required to strengthen long-term resilience. The use of a systematic, evidence-based approach to risk prioritisation provides a clear and defensible basis for action.

Phase 3 will build on these findings by translating prioritised risks into increased risk awareness and practical climate risk management actions. This will include the identification of suitable adaptation measures, the integration of climate risk into policy and planning frameworks, strengthening institutional capacity and establishing monitoring and evaluation mechanisms to support ongoing risk management and continuous improvement.

1 Introduction

Tipperary County Council (TCC) received funding in spring 2025 to carry out a Climate Risk Assessment (CRA). 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 outputs of Climaax will not replace existing climate risk frameworks in place as they relate to TCC service delivery, however, will significantly increase awareness, capacity and the development of stronger climate risk awareness and response frameworks. The Tipperary CLIMAAX project will run until December 2026, and the area of focus for this project is County Tipperary. (Figure 1-1) This report is the second of three publications to be produced as part of the CLIMAAX project.

1.1 Background

County Tipperary is located in the southern region of Ireland and is 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 Ireland's largest inland county, with a population of 167,661 (CSO, 2022) and is the geographical location of this 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 regard 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 (TCC, 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 (TCC, 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 temperatures increasing by 0.7°C and the climate becoming 7% wetter when compared to the 1961-1990 and 1991-2020 time 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 (see Appendix 7.1 for details of services delivered), damage to public and private assets, loss of critical services, e.g., power and communication, damage to the environment, and threats to public health.

TCC is itself a large organisation (approx. 1300 staff, 300 vehicles, 5,200 social housing units and many civic buildings, assets and properties across the region) and in its role as a Local Authority, provides essential services (Appendix 1) such as housing (including social housing and Housing Assistance Payment), road maintenance, planning, environmental protection, fire services, libraries, recreation, and waste management . TCC manages a budget of approximately €234m across eight service divisions in Tipperary. The Council comprises an Elected Council of 40 Councillors with a permanent Executive. The direct and indirect responsibilities of local authorities in Ireland for climate action (both mitigation and adaptation) is set out in the Appendix 7.1).

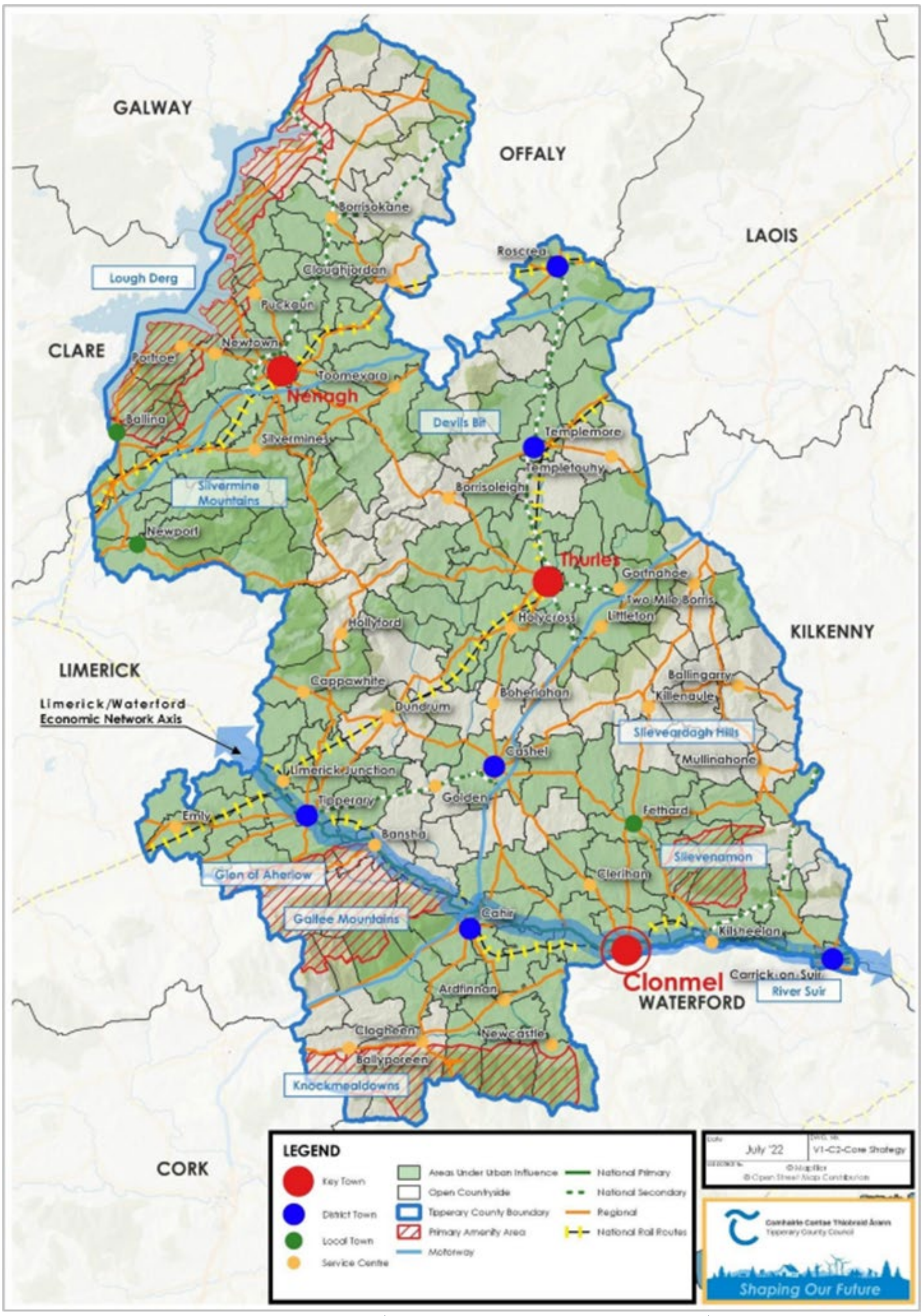

Figure 1-1: Map of County Tipperary (Tipperary County Council, 2022)

1.2 Main objectives of the project

The objective of Phase 2 is to build on the findings from Phase 1 and conduct a more comprehensive regional assessment of the key climate risks identified in Phase 1, and how these will impact County Tipperary and the services delivered by TCC. The key climate risks brought to Phase 2 include: river flooding, wind, heavy rainfall, snow and heatwaves. After further assessing these climate risks, using local climate data, more refined risks and impacts, including spatial distribution, to Tipperary and the services provided by TCC will be identified.

In addition, the outcomes and insights of this Phase will be used to inform Phase 3, which will assess and identify suitable measures that can be implemented to help address the adverse impacts of the climate risks listed in Phase 1 and 2. Phase 3 will also detail potential adaptation measures, emergency response plans and management practices that can be implemented and monitored to track progress on climate resilience in Tipperary and TCC.

The outcomes of the CLIMAAX project will help TCC understand which assets are most exposed to climate change, as well as assessing the wider impacts climate change has and will continue to have on the services delivered by TCC. These insights will allow TCC to incorporate the risks posed from climate change into their existing policies, risk management process, financial planning and daily operations – minimising potential financial loss, reputational damage and high costs.

In addition to enhancing Tipperary's resilience to climate change this project will also act as a pilot for the other 31 local authorities in Ireland. The guidelines to support local authorities undertake their Climate Action Plans are currently being updated, therefore there is an opportunity for the CLIMAAX methodologies and learnings from this project to inform this process. This will allow other local authorities across Ireland to benefit from CLIMAAX, helping to create a more uniform approach to assessing and managing climate risks and ensure that CLIMAAX aligns and complements the existing approach to climate risks within local authorities in Ireland.

TCC is a member of the EU Missions for Climate Adaptation and has participated in two of its climate adaptation flagship projects, CLIMAAX and Pathways2Resilience. The learnings from these projects have enhanced the knowledge base around climate change adaptation in TCC and have strengthened the existing local adaptation framework in the form of a Stage 1 CRA completed for TCC in 2023.

1.3 Project team

Tipperary County Council's Climate Action Office, supported by KPMG Ireland, is delivering the CLIMAAX project. From the outset, stakeholder engagement has been a central element in the development and delivery of the CRA. A wide range of internal and external stakeholders were engaged throughout Phases 1 and 2 of the project.

Key internal stakeholders across TCC departments, including members of the cross-departmental Climate Action Team and corporate risk stakeholders. In addition, relevant external stakeholders, such as the Environmental Protection Agency (EPA) and the Climate Action Regional Office (CARO), were engaged to provide sectoral and regional insights. This collaborative approach enabled the CRA to reflect a comprehensive understanding of how climate change is impacting the county, with specific consideration given to risks and impacts relevant to individual departments, sectors, and corporate governance functions.

1.4 Outline of the document's structure

This document is structured in line with the CLIMAAX Phase 2 framework and provides a logical progression from context to analysis and evaluation.

Section 1: Introduction - Sets out the project background, objectives, governance context and stakeholder involvement.

Section 2: Climate Risk Assessment – Phase 2 - Presents the core methodology and results, including scoping, risk exploration, regionalized risk analysis and key risk assessment, as well as monitoring and the Phase 3 work plan.

Section 3: Conclusions - Summarises the main findings and key insights from the Phase 2 assessment.

Section 4: Progress Evaluation - Reviews project progress against key performance indicators and milestones.

Sections 5–7: Supporting Information - Provide supporting documentation, references and appendices to ensure transparency and support the analysis.

2 Climate risk assessment – Phase 2

2.1 Scoping

The main goal of CLIMAAX is to identify, assess and address current and future climate risks for County Tipperary and the adaptation response of TCC. 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 methodologies and ensure local authority CRAs are fit for purpose in terms of its inter-dependence with sectoral adaptation plans such as, agriculture, health, emergency services, transport, etc.

2.1.1 Objectives

The objective of the Phase 2 CRA is to provide a clear, in-depth assessment of current and future climate-related risks caused by river flooding, wind, heavy rainfall, snow and heatwaves, and how they impact County Tipperary and TCC services. Building on the outcomes from Phase 1 this CRA will conduct a more comprehensive climate risk assessment for the five climate hazards. The CRA will look at three-time horizons, short-, medium- and long-term, and the varying impacts and severity these climate hazards are expected to have on Tipperary and TCC's own services, now and in the future.

The climate hazards (river flooding, wind, heavy rainfall, snow and heatwaves) will be assessed, with each risk identified being assigned a level of severity and urgency rating, as well as identifying potential measures to build capacity and ability to respond to the respective risks.

The findings of the CRA will be used to inform future planning and development within the county and will feed into and influence key local authority policies, budgets, reports and management plans, including assessing the systematic integration of climate change risks into Tipperary County Council's corporate risk register.

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

- **Technical Expertise:** Although TCC has 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 has 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 Application of Principles

The Phase 2 CRA has been developed in line with the core principles of the CLIMAAX Framework to ensure the analysis is robust, inclusive, and transparent.

Social justice, equity and inclusivity: Social justice, equity and inclusivity have been embedded throughout the CRA through the development and application of a Social Vulnerability Index. This index identifies communities and population groups that may be disproportionately affected by climate-related hazards due to socio-economic, demographic and health factors. This ensures that climate risks are assessed not only in physical terms, but also in relation to vulnerability and adaptive capacity, supporting more equitable prioritisation of risks and targeted adaptation measures.

Quality, rigour and transparency: The CRA is underpinned by a strong emphasis on quality, rigour and transparency. National-level datasets and authoritative sources have been used where possible to ensure consistency and credibility. The assessment methodology, assumptions and findings have been clearly documented and disseminated to internal and external stakeholders throughout Phases 1 and 2, supporting transparency and shared understanding of climate risks.

Precautionary approach: A precautionary approach has been applied to avoid underestimating future climate risks. Climate projections have, where possible, been based on high-emissions scenarios (RCP8.5) to support robust long-term planning. In addition, a range of probabilities and return periods has been assessed where data allows, particularly for river flooding, to reflect uncertainty and variability in future climate hazards.

2.1.3 Context

Service Areas: Local authorities in Ireland deliver a wide range of community and sectoral services that underpin economic development, community wellbeing, environmental management and spatial planning. These services include housing, planning and building, roads and transport, water services, environment, and emergency management, alongside community, heritage, libraries, and economic supports (see Appendix Table 7-1). Collectively, these functions define the operational scope through which local authorities influence climate risk and resilience. For the CLIMAAX assessment in Tipperary, this structure provides a practical framework for mapping climate hazards, vulnerabilities, and adaptation responses across service delivery.

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 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 is 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.

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: Local authorities play a central role in climate action and therefore managing risks, operating across a range of responsibilities that extend beyond their direct operations and rely on cooperation with other sectors and government organisations. The LACAP framework defines four complementary roles that clarify how local authorities deliver, enable, and lead climate action (Figure 2-1). First, they hold full accountability for emissions reduction and resilience within their own assets, services, and operations, areas under direct control and measurable performance. Second, they influence wider society through regulatory powers, service provision, and investment decisions, shaping outcomes across sectors, businesses, and communities. Third, they co-ordinate and facilitate place-based action by convening stakeholders, enabling partnerships, and supporting collaborative initiatives that require collective delivery. Finally, they act as advocates, setting direction through awareness raising, engagement, and capacity building to support long-term behavioural change.

TCC manage risks through an internal Risk Management Framework related to the Corporate Plan 2024-2029. Organisational and Operational Risk Registers exist which contains the significant risks that could likely prevent the achievement of the 25 Strategic Organisational Objectives set out in Corporate Plan. It’s expected that the outputs of Phase 3 will present additional recommendations of suitable adaptation measures that will enhance climate resilience in TCC and County Tipperary further.

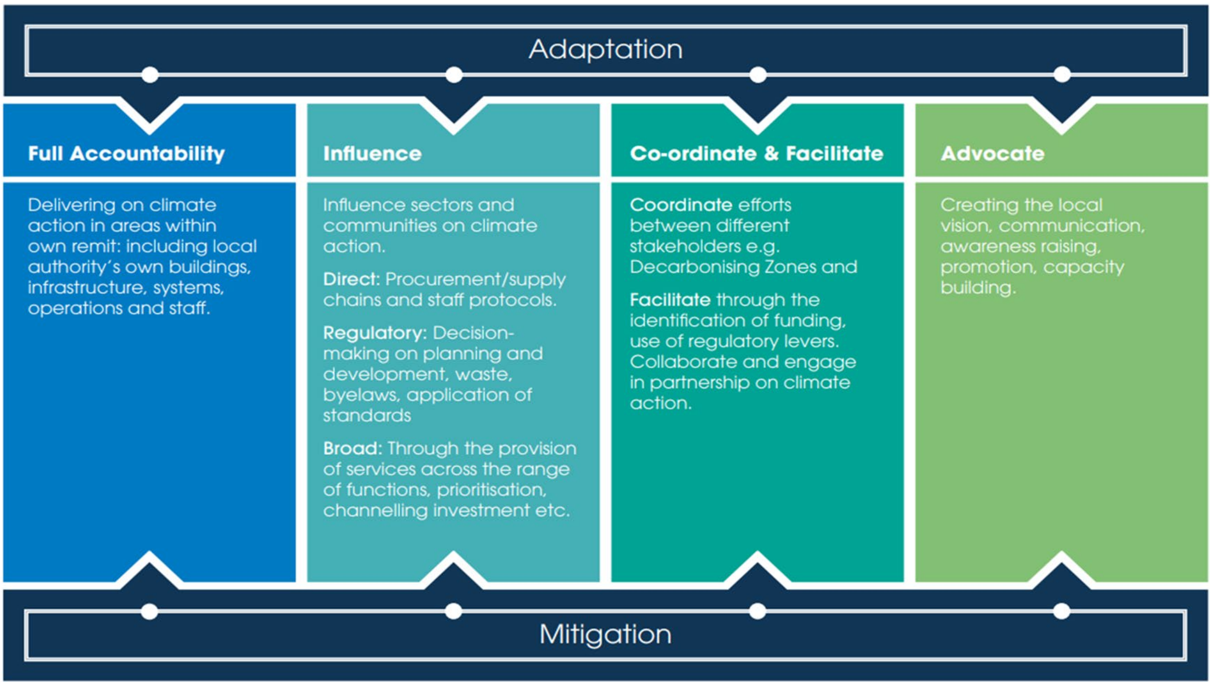

Figure 2-1: The local authority scope on climate action (Local Authority Climate Action Plan Guidelines, 2023)

2.1.4 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. 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 2-2), 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, comprises 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.

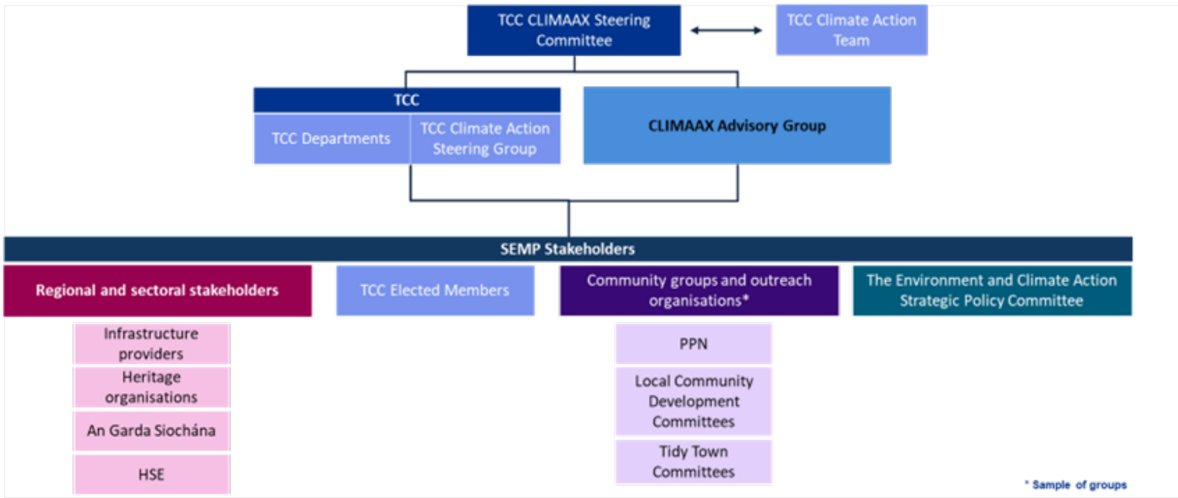

Figure 2-2: Stakeholder Engagement and Management Plan Stakeholder Groups

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 Strategic Policy 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 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. The CLIMAAX Tipperary project was outlined in the Climate Action Annual Progress Report 2025, endorsed by both the SPC and the elected representatives and made available to the general public.

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.

2.1.5 Stakeholder Engagement

Stakeholder engagement in Phase 2 was implemented in line with the Stakeholder Engagement and Management Plan (SEMP). Engagement activities were designed to ensure that the assessment was informed by local knowledge, operational experience and sectoral expertise.

Activities undertaken during Phase 2 included a targeted data-gathering workshop with local authority staff and representative bodies, two meetings of the CLIMAAX Advisory Group to review and validate the risk assessment approach and emerging findings, a dedicated meeting with the Tipperary County Council corporate risk function to discuss approaches to integrating climate risk into existing risk management practices, and regular bi-weekly Climate Action Team meetings to oversee and manage delivery of Phase 2. Collectively, these activities supported all stages of Phase 2, including refined risk analysis, key risk assessment and validation of results.

Participants represented a broad range of stakeholder groups, reflecting the multi-risk and cross-sectoral nature of the assessment. These included:

- Internal stakeholders from across local authority departments, coordinated through the CLIMAAX Steering Committee and Climate Action Team;
- Members of the CLIMAAX Advisory Group, comprising national and regional bodies providing scientific, technical and policy expertise; and
- Regional and sectoral stakeholders, including infrastructure, environmental and emergency management organisations.

During Phase 2, stakeholder engagement has become more focused on the internal, institutional approach to managing climate risk. This shift reflects both the work already underway with communities and the specific purpose of the CLIMAAX assessment at this stage. The cross-departmental Climate Action Team is actively engaged with communities through a range of ongoing initiatives, supported by existing public information, including the published Local Authority Climate Action Plan, which is already helping to raise awareness and understanding of climate action across the county. In contrast, Phase 2 of CLIMAAX has focused on understanding how climate risks affect the local authority itself, including how risks are managed within services, decision-making processes and corporate risk frameworks. This type of work requires technical and organisational knowledge that is best addressed through engagement with internal teams and expert stakeholders rather than through community-based activities. In addition, the spatial risk analysis produced as part of Phase 2 includes sensitive information related to local authority assets and services, which is more appropriate for internal use at this stage. For these reasons, engagement has prioritised internal stakeholders and advisory bodies, while continuing to complement existing community-focused climate action work rather than duplicating it.

This focus on institutional engagement also reflects the increasingly technical nature of the Phase 2 assessment. As the work moves into detailed climate data, spatial analysis and structured risk scoring, discussions can become complex at an early stage. To gain meaningful value from engagement at this level, participants need a shared understanding of the underlying concepts, assumptions and limitations of the analysis. Where this understanding is not in place, engagement risks becoming either overly simplified or difficult for stakeholders to contribute to in a meaningful way. For this reason, Phase 2 engagement has been deliberately focused on internal teams and expert stakeholders who have the capacity to interpret and apply technical outputs, enabling more constructive discussion, clearer feedback and more effective use of stakeholder input. This approach supports informed decision-making and helps ensure that the results of the assessment can be appropriately embedded within local authority risk management and governance processes.

2.2 Risk Exploration

2.2.1 Screen Risks

The hazard selection from Phase 1 has been refined in Phase 2 to prioritise those risks most relevant to the current local authority context. The rationale for inclusion (and removal) of each hazard is summarised below:

- **River flooding:** Included due to significant existing impacts and high exposure, particularly in settlements along major rivers (e.g. River Suir), with risks to infrastructure, environment, and public safety.
- **Wind**: Included as a nationally significant and frequent hazard, with county-wide exposure to Atlantic storm systems and risks driven by disruption to critical infrastructure and services.
- **Heavy rainfall:** Included due to its role as a key driver of surface water and river flooding, particularly in urban areas with drainage constraints and rapid runoff.
- **Heatwaves**: Included as an emerging hazard, with increasing frequency and severity projected under climate change, particularly impacting vulnerable populations
- **Snow**: Included due to low-frequency but high-impact events, requiring continued preparedness despite limited projected change.
- **Droughts**: Included in Phase 1 due to the importance of agriculture and water resource sensitivity but removed from Phase 2 focus as other risks are currently more material for the local authority. Furthermore, there is little additional local data that can be used within the analysis to further refine the Phase 1 workflow.
- **Fire (wildfire):** Included in Phase 1 as a potential future risk linked to vegetation and ecosystem vulnerability but removed from Phase 2 focus due to lower current relevance relative to other hazards. Furthermore, there is little additional local data that can be used within the analysis to further refine the Phase 1 workflow.

Overall, the refined hazard set ensures that Phase 2 focuses on priority risks for Tipperary County Council while maintaining awareness of lower-priority or emerging hazards identified in Phase 1.

2.2.2 Choose Scenario

The scenario development approach follows the CLIMAAX framework and combines future climate projections with socio-economic change to assess evolving climate risk in County Tipperary.

Future climate conditions were selected based on the CLIMAAX workflows and aligned with national practice, using Representative Concentration Pathways (RCPs), in particular the high-emissions scenario (RCP8.5), to provide a conservative and risk-based assessment of future impacts. This approach is consistent with Ireland's National Climate Change Risk Assessment (NCCRA) and reflects the need to capture upper-bound risk for long-term planning.

Non-climatic drivers were identified through a structured review of the Tipperary County Development Plan, supplemented by socio-economic evidence and stakeholder insights, to capture the key factors influencing future risk. The analysis considered development patterns (e.g. settlement hierarchy, zoning, infrastructure provision), demographic change (including population growth and ageing), and economic activity (particularly rural and agricultural dependencies), all of which influence how exposure and vulnerability evolve over time. These drivers were systematically classified according to their role in shaping exposure (distribution and scale of assets) and vulnerability (sensitivity and adaptive capacity of communities and systems), consistent with the CLIMAAX risk framework.

The outputs of this step are summarised in Table 2-1 and Table 2-2. Table 2-1 identifies the key drivers influencing the location, scale and distribution of exposed assets, while Table 2-2 outlines the socio-economic and infrastructural factors that influence vulnerability, including demographic structure, housing quality, service access and economic dependency. Together, these tables provide the basis for combining socio-economic development with future climate conditions within the risk assessment.

Table 2-1: Future changes in exposure for County Tipperary

Category	Driver		Current Pattern	Future Exposure	
Planning	Settlement growth	Development focused in towns, villages, and rural areas	Mix of towns + dispersed rural housing	↑	Increasing as population grows
Housing	New homes	More housing adds more assets at risk	Concentrated in settlements, spread in rural areas	↑	Increasing with housing delivery targets and densification policies
Land Use	Zoning of land	Land designated for housing and jobs guides where exposure occurs	Focused on zoned areas in settlements	↑	Expanding as more land is zoned
Infrastructure	Water, wastewater, roads	Development happens where services exist	Clustered in serviced areas	↑	Growing demand as development increases
Rural Pattern	One-off housing	Houses spread across rural areas	Wide, dispersed exposure	↑	Continuing under rural housing policy
Environment	Protected sites	Development near rivers, habitats and heritage areas	Overlap between assets and sensitive areas	↑	Ongoing interaction as pressure grows
Transport	Road network	Assets rely on road access, especially in rural areas	Extensive rural road network	↑	Greater reliance with growth
Economy	Enterprise land	Land for businesses adds non-residential exposure	Near towns and transport routes	↑	Increasing with economic growth
TCC Assets	Service Delivery	Requirement to provide services across the region	Clustered in serviced areas	↑	Increase due to increased population/demand

Table 2-2: Future changes in vulnerability for County Tipperary

Category	Driver		Current Pattern	Future Vulnerability	
Population	Age profile	Older people and very young more affected by disruption	Higher older population in rural areas	↑	Increasing ageing population
Housing	Housing quality	Older or poorly maintained homes are more vulnerable	Mix of older rural housing and newer stock	↑	Gradual improvement, but legacy issues remain
Transport	Car dependence	Reliance on private cars increases vulnerability if access is disrupted	High dependence in rural areas	↑	Likely to remain high
Infrastructure	Service capacity	Limited water/wastewater capacity reduces resilience to stress	Constraints in smaller settlements	↑	Gradual upgrades, but uneven
Health	Access to healthcare	Distance and service availability affects vulnerability	Centralised services, rural access challenges	↔	Incremental improvement expected
Connectivity	Access to services	Distance to healthcare, shops and services affects ability to respond	Rural areas have limited access	↔	Some improvement, but rural gaps remain
Land Use	Agricultural reliance	Dependence on farming increases sensitivity to disruption	Strong rural/agri-based economy	↔	Likely to remain stable
TCC Responsibilities	Service Delivery	Requirement to provide services across the region	Services delivered in urban and rural settings	↑	Increase in demand due to increased population and infrastructure

The future socio-economic developments include population growth, an ageing population, expansion of the built environment, and changes in economic activity and land use. In Tipperary, a significant proportion of the population lives in rural areas, and key sectors such as agriculture, construction and retail play an important role in the local economy, influencing both exposure and sensitivity to climate risks. Population growth and development are expected to increase the number of assets exposed to climate hazards, including residential and commercial buildings, transport infrastructure, water services and energy systems. At the same time, demographic changes, particularly an ageing population, are expected to increase vulnerability, as certain groups may be less able to prepare for, respond to and recover from extreme events. Broader planning and development trends, including policies under the National Planning Framework, such as urban densification and continued development in rural areas, will also shape how exposure evolves in the future.

The assessment considers multiple time horizons to capture short-, medium- and long-term risks. The short-term aligns broadly with the current planning cycle of five years, and reflects existing exposure and vulnerability conditions, where climate signals are relatively limited but important for establishing a baseline. The medium-term focuses on mid-century conditions (e.g. 2041–2070), which are commonly used in the CLIMAAX workflows and where climate impacts become more pronounced, with long term equating to the end of the century.

2.3 Regionalized Risk Analysis

In Phase 2, the selected CLIMAAX risk workflows were refined to reflect the local context of County Tipperary and the operational needs of TCC more accurately. While Phase 1 applied the common CLIMAAX methodology using European-scale datasets, Phase 2 focused on improving the spatial and decision-making relevance of the assessment by integrating higher-resolution Irish national and local datasets. This refinement was designed to ensure that the assessment captured the geography, settlement pattern, infrastructure profile and socio-economic characteristics of Tipperary more effectively. In practice, this meant replacing or supplementing European datasets with locally relevant hazard, exposure and vulnerability information.

Across all five hazards, future changes in exposure and vulnerability were also informed by local planning and socio-economic evidence, including settlement growth, housing delivery, infrastructure demand, ageing, rurality, housing quality and access to services. This ensured that the Phase 2 assessment did not only refine the hazard workflows technically but also embedded them in the local development and service context of County Tipperary.

2.3.1 River Flooding

The CLIMAAX River Flooding workflow was substantially refined across the hazard, exposure and vulnerability components to improve local relevance and decision usefulness.

Hazard: The hazard assessment was based on OPW CFRAM flood mapping developed through Ireland's Catchment Flood Risk Assessment and Management Programme. CFRAM provides detailed flood hazard and risk mapping for Areas for Further Assessment, underpinned by hydraulic modelling, surveyed channel and floodplain data, and locally calibrated information on flood behaviour. In practical terms, this represents a significantly higher-resolution and more locally robust evidence base than the broad-scale datasets used in Phase 1. As a result, flood extents and probabilities can be represented at community scale, rather than as broad regional patterns. This contrasts with the WRI Aqueduct dataset, which is a global river flood model designed primarily for strategic screening and scenario comparison at coarse spatial resolution. While Aqueduct is useful for identifying broad trends in future river flood hazard, it is less suitable for local authority-scale assessment because it cannot capture local topography, channel conditions, floodplain behaviour, or interactions with the built environment in the same level of detail as CFRAM. For County Tipperary, the use of OPW CFRAM therefore provided a more appropriate and defensible basis for identifying the location and severity of fluvial flood exposure in settlements and along key transport corridors.

Exposure: Exposure was assessed using the road network provided by Tipperary County Council, OpenStreetMap building footprints, and Council workplace location data. This enabled the analysis to identify where transport infrastructure, buildings and Council services intersect with flood-prone areas.

Vulnerability: Vulnerability was incorporated through road classification and the application of JRC damage curves for roads and buildings. This allowed the assessment to move beyond simple exposure mapping towards a more decision-relevant understanding of potential consequences, including the proportion of road assets and buildings likely to be affected under different flood scenarios.

Table 2-3: Data overview for river flooding analysis

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
OPW CFRAM	*JRC Damage Curves*	- *TCC Road Schedule* - *OpenStreetMap Buildings*	*Number/proportion of assets damaged*

2.3.1.1 Hazard Assessment

For the river flooding hazard assessment, urban boundaries were obtained for eight study areas based on Central Statistics Office (CSO) Census 2022[1] analysis to provide a consistent spatial unit for analysis. OPW CFRAM fluvial flood extent and depth mapping was intersected with these urban boundaries to calculate the proportion of each settlement area exposed to flooding under current conditions and future scenarios. An example of the OPW CFRAM Flood Depth data is shown in Figure 2-3.The analysis was undertaken for a range of Annual Exceedance Probabilities (AEPs), allowing comparison of how flood extents and depths vary with event probability and how it changes between the current baseline and the Mid-Range Future Scenario (MRFS).

The Mid-Range Future Scenario (MRFS) represents an indicative medium-term climate change future used by the Office of Public Works (OPW) to assess how fluvial flood hazard may evolve beyond present-day conditions, based on a “typical” or central estimate of projected climate change impacts rather than an extreme outcome. Within the NCCRA, the OPW’s future flooding scenarios were explicitly aligned with RCPs to provide an approximate temporal harmonisation, with the MRFS broadly corresponding to mid-century conditions under a moderate emissions pathway (RCP4.5, 2050). This alignment was achieved by linking the MRFS allowances for increased precipitation to projected changes in winter precipitation around the medium-term

[1] Census 2022 Urban Boundaries and Built Up Areas - CSO - Central Statistics Office

period, 2041–2070. In this assessment, MRFS flood depths derived from OPW CFRAM mapping are used to quantify changes in the proportion of each urban area exposed to river flooding across a range of AEPs, providing a consistent basis for comparing current and future hazard conditions. The results indicate that, for most settlements, the MRFS leads to modest but systematic increases in flooded area relative to the current scenario, particularly for more frequent and moderate events (e.g. 10% and 1% AEP), highlighting a gradual intensification of river flood hazard in the medium term rather than an abrupt step change.

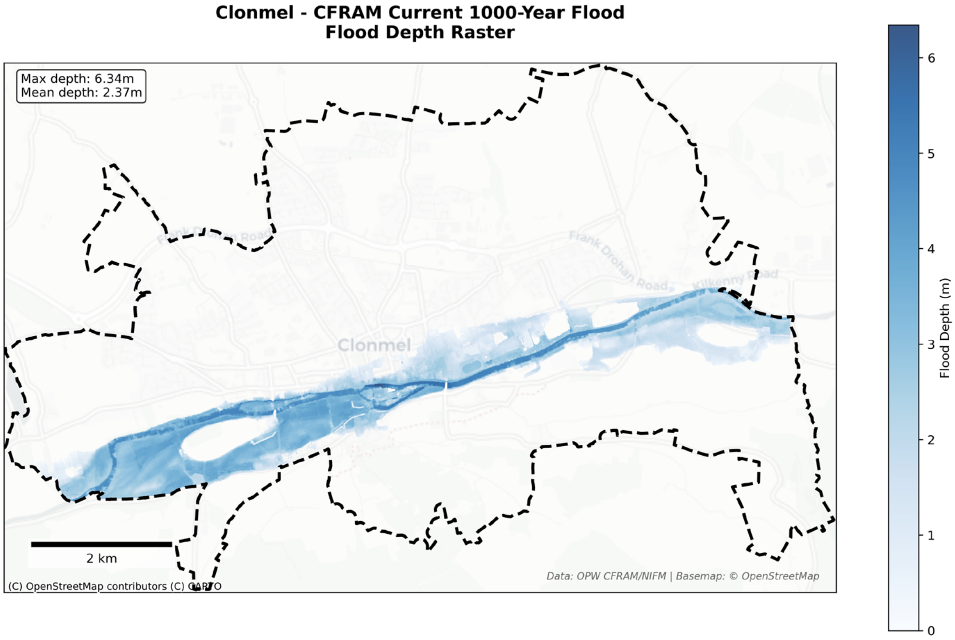

Figure 2-3: An example of the flood depth data for Clonmel for the 0.1% AEP for the current period.

Table 2-4: A summary of the change in area flooded for each urban area for the current and Mid-Range Future Scenario.

Urban Area	*Area Flooded (%)*					
	Current			*MRFS*		
	10% AEP	*1% AEP*	*0.1% AEP*	*10% AEP*	*1% AEP*	*0.1% AEP*
Borrisokane	3.4	4.1	4.5	4.1	4.4	5.1
Carrick-on-Suir	59.4	59.4	62.9	63.0	63.1	63.2
Clonmel	22.0	24.3	27.3	-	-	-
Nenagh	83.6	83.9	84.6	84.3	84.6	84.8
Newport	50.9	51.1	51.0	51.2	51.5	51.6
Templemore	68.0	69.9	73.0	-	-	-
Thurles	51.7	56.4	57.3	55.1	57.4	57.4
Tipperary	30.4	30.9	31.0	31.0	33.3	33.9

2.3.1.2 Risk Assessment

The river flooding risk assessment builds on the hazard analysis by explicitly integrating exposure and vulnerability to assess potential impacts on key assets within each urban area. Roads and buildings were identified as the primary receptors due to their importance for service delivery, accessibility and community functioning. Flood depth information derived from OPW CFRAM mapping was intersected with road networks and building footprints to quantify the degree of inundation affecting each asset. Potential damage was then estimated using Joint Research Centre (JRC) depth–damage functions, enabling a consistent and comparable assessment of the likely consequences of river flooding across settlements and scenarios (Figure 2-4). This approach allows the analysis to move beyond flood extent alone and towards a more decision-relevant understanding of risk, reflecting both the severity of flooding and the sensitivity of exposed infrastructure.

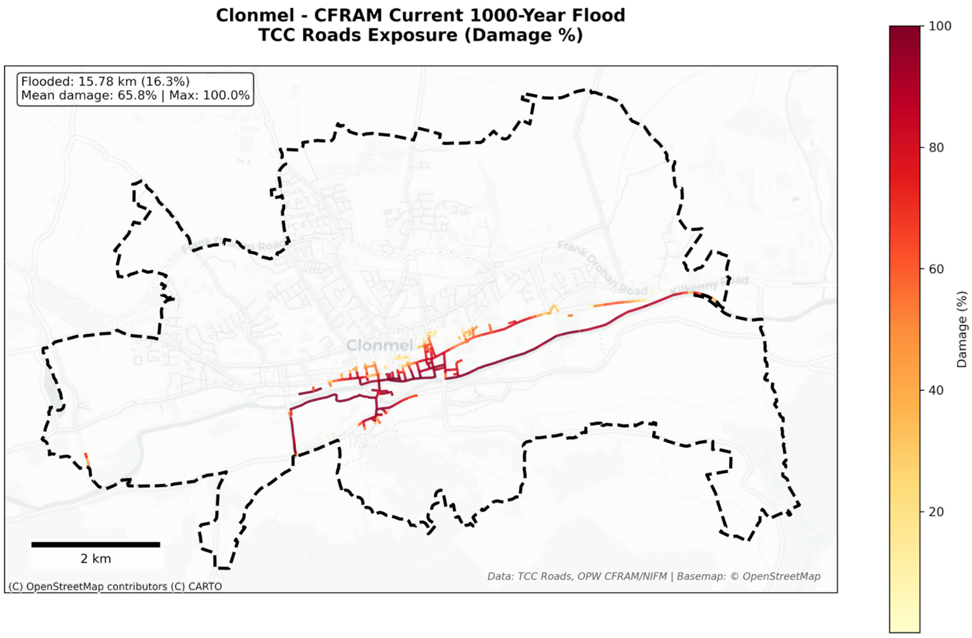

Figure 2-4: River flooding damage assessment for roads in Clonmel under the current 0.1% AEP (1-in-1,000-year) event, showing the spatial distribution of inundated road segments and the estimated percentage damage derived from flood depths and JRC depth–damage functions.

2.3.1.2.1 Roads

The results show that river flooding under the current 0.1% AEP (1-in-1,000-year) event affects a relatively small proportion of Tipperary's overall road network within most urban areas, but with notable variation by settlement and road classification. Flood impacts are concentrated primarily on local roads, particularly local primary, secondary and tertiary roads, reflecting their proximity to rivers and floodplains and their greater spatial extent within urban areas. The highest proportions of flooded road length were observed in Templemore, Carrick-on-Suir and Clonmel (Figure 2-4), where sections of the local road network experience comparatively elevated exposure, while impacts on national primary and national secondary roads are consistently limited across all settlements. In several towns, including Newport, Borrisokane and Tipperary, flooded road lengths are minimal or negligible, indicating lower current fluvial risk to transport connectivity. Overall, the pattern highlights that river flooding risk to roads is highly localised and disproportionately affects lower-order roads that are critical for local access rather than strategic national routes.

The road length-weighted average damage results indicate that, where road segments are inundated under the current 0.1% AEP (RP1000) event, the severity of damage is often high, particularly on local and regional roads, with several urban areas showing length-weighted averages in the “severe” (>50%) category (Figure 2-5). In Clonmel, the flooded portions of the network are dominated by high average damage across multiple classes, including regional (70.6%), local primary (64.9%), local secondary (83.3%) and local tertiary (66.9%), while national primary roads show lower, but still material, average damage (21.0%). In Templemore, damage to affected routes is similarly concentrated in the higher categories, with national secondary (54.3%), local primary (51.4%) and local tertiary (65.6%) all falling within the severe band, although local secondary is lower (28.0%). Carrick-on-Suir shows a mixed pattern: where flooding occurs, averages are moderate to high for national primary (38.6%) and local primary (37.9%) but remain severe on local secondary (63.0%). By contrast, Nenagh has lower length-weighted average damages where inundation occurs (e.g., regional 16.9% and local primary 12.7%), consistent with more limited depth impacts on the segments affected. Overall, the pattern reinforces that the RP1000 event can translate into disproportionately high consequences on lower-order roads where they intersect deeper floodwater, even when the overall proportion of road length inundated is relatively small, reflecting the use of flood depth information with JRC depth–damage functions to quantify damage severity.

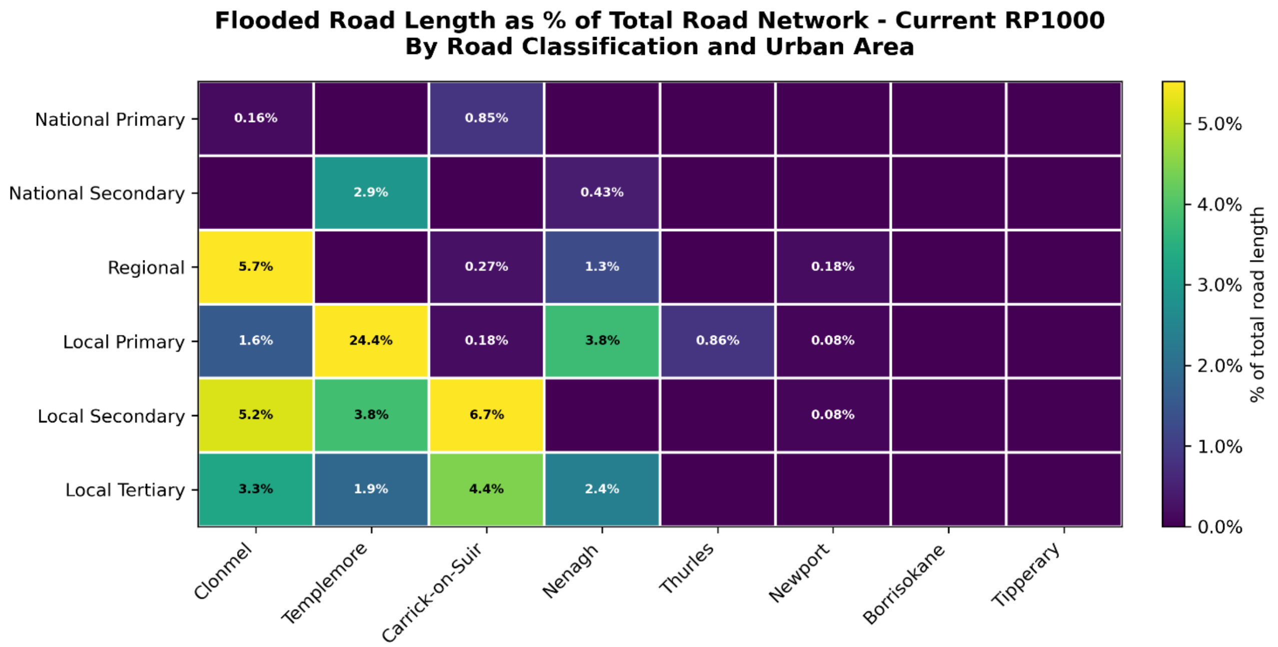

***Figure 2-5**: The road damage by road hierarchy due to river flooding for the urban areas in County Tipperary due to a 1-in-a 1000-year flood event for the current period.*

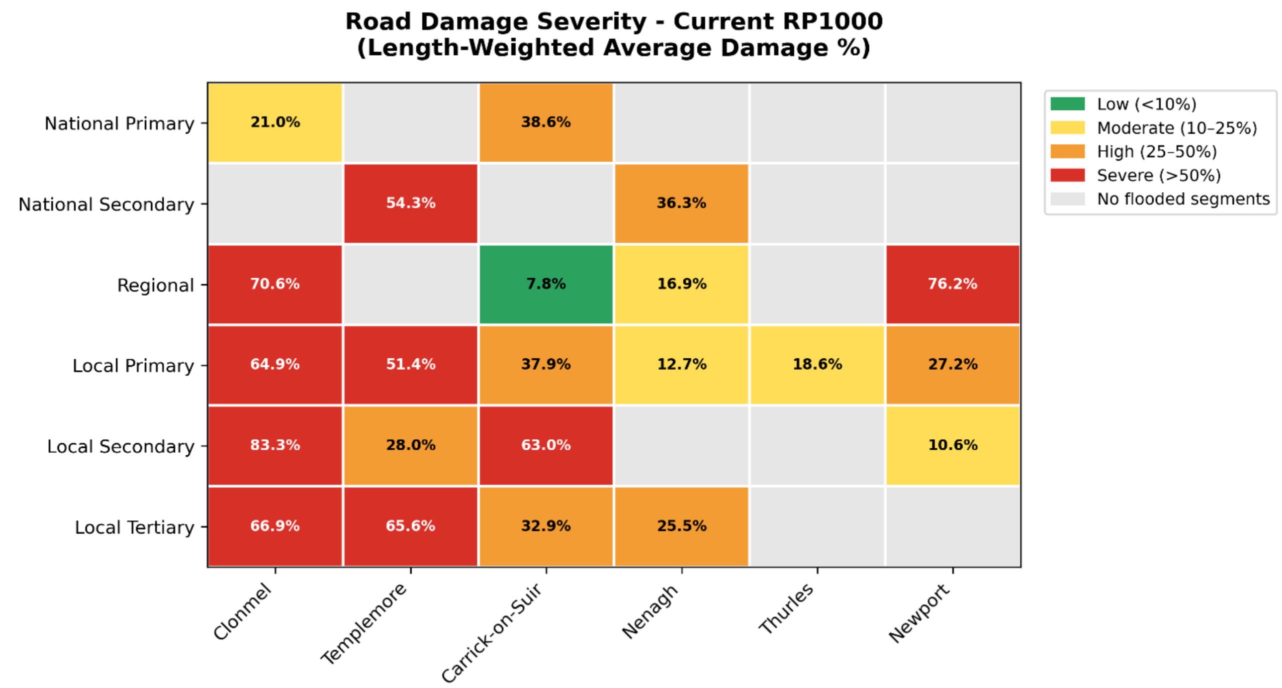

Figure 2-6: Length-weighted average road damage severity for the current 0.1% AEP (1-in-1,000-year) river flood event, showing the estimated percentage damage to flooded road segments by road classification and urban area, derived from OPW CFRAM flood depths using JRC depth–damage functions. Tipperary is not shown as there are no road segments flooded in the current period.

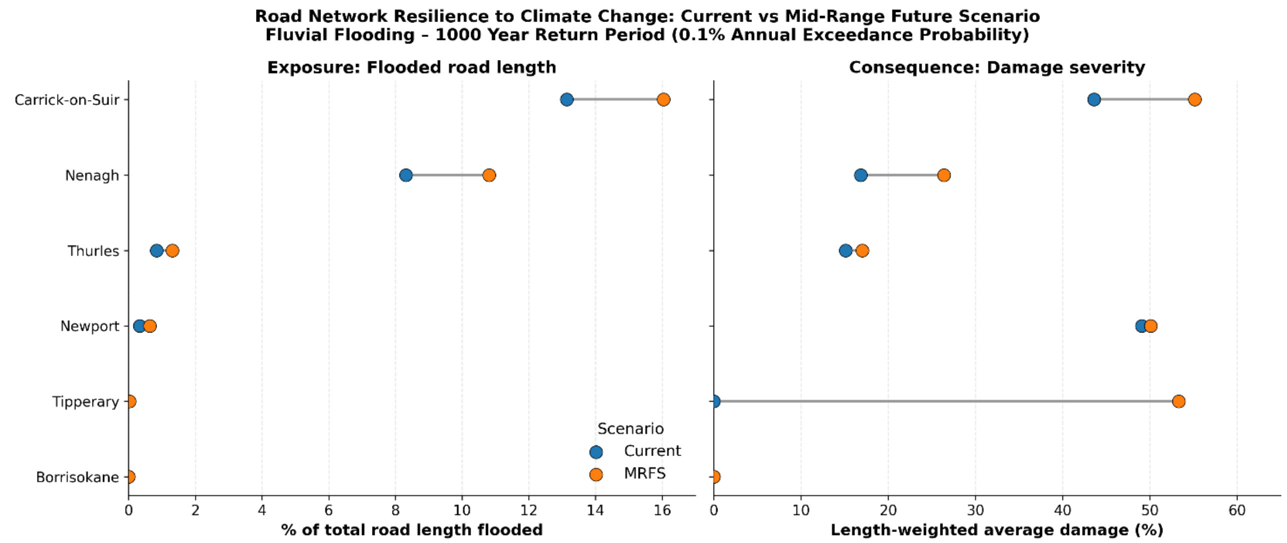

Figure 2-7: Comparison of current and mid-range future (MRFS) river flooding impacts on urban road networks for the 1-in-1,000-year (0.1% AEP) event, showing changes in the proportion of road length flooded (exposure) and the average severity of damage on flooded road sections (consequence); Clonmel and Templemore are not shown due to the absence of MRFS flood projection data.

Climate change is expected to increase the pressure on local road networks from river flooding, both by expanding the extent of flooding and by increasing the severity of damage where flooding occurs. This is illustrated by the comparison between current conditions and the Mid-Range Future Scenario (MRFS) for the 1-in-1,000-year fluvial flood event shown in Figure 2-6. The figure focuses on urban areas where consistent current and MRFS data are available; Clonmel and Templemore are excluded due to the absence of MRFS flood projections, preventing a like-for-like comparison.

The results indicate that under MRFS, several areas experience a clear increase in the proportion of the road network exposed to flooding, alongside higher damage levels on flooded road sections. This is most evident in Carrick-on-Suir and Nenagh, where climate-driven changes result in both a larger share of roads being inundated and more severe impacts on those roads. These locations therefore show a compounding climate risk, where increased flood extent and increased flood severity act together to reduce transport resilience.

Other settlements, such as Thurles and Newport, show more modest changes under MRFS, suggesting a gradual intensification of flood impacts rather than a step change. In contrast, Borrisokane remains unaffected in both scenarios, reflecting the absence of mapped fluvial flood impacts on the urban road network. Tipperary continues to show very limited flood extent, but the MRFS introduces damage to a small number of road segments, indicating that even minor increases in flood exposure under climate change can lead to disproportionately high localised impacts.

Overall, Figure 2-7 demonstrates that climate change is likely to exacerbate existing spatial patterns of road flooding risk, with the greatest impacts occurring in towns already exposed under current conditions. The analysis highlights the importance of considering not only where flooding may expand in the future, but also how the severity of damage to critical local roads may increase, with implications for access, emergency response and service continuity under more extreme flood events.

2.3.1.2.2 Buildings

River flooding poses a significant risk to the built environment, and climate change is expected to increase both the number of buildings affected and the severity of damage during extreme flood events. This is illustrated by the building damage results for the 1-in-1,000-year (0.1% AEP) fluvial flood event, shown for current conditions and compared with the Mid-Range Future Scenario (MRFS) in Figure 2-7 and Figure 2-8.

Figure 2-7 shows the distribution of building damage under current conditions, grouped by damage severity bands across urban areas. The results indicate that flood impacts on buildings are highly uneven across the county. In towns such as Clonmel, Carrick-on-Suir, Nenagh and Templemore, a substantial number of buildings fall within the moderate to high damage bands, reflecting both the scale of exposure within floodplains and the depth of flooding experienced in these areas. In contrast, settlements such as Borrisokane, Newport and Tipperary show far fewer affected buildings, with impacts generally limited to lower damage bands. This highlights that current building flood risk is strongly location-specific and closely linked to settlement patterns along major river corridors.

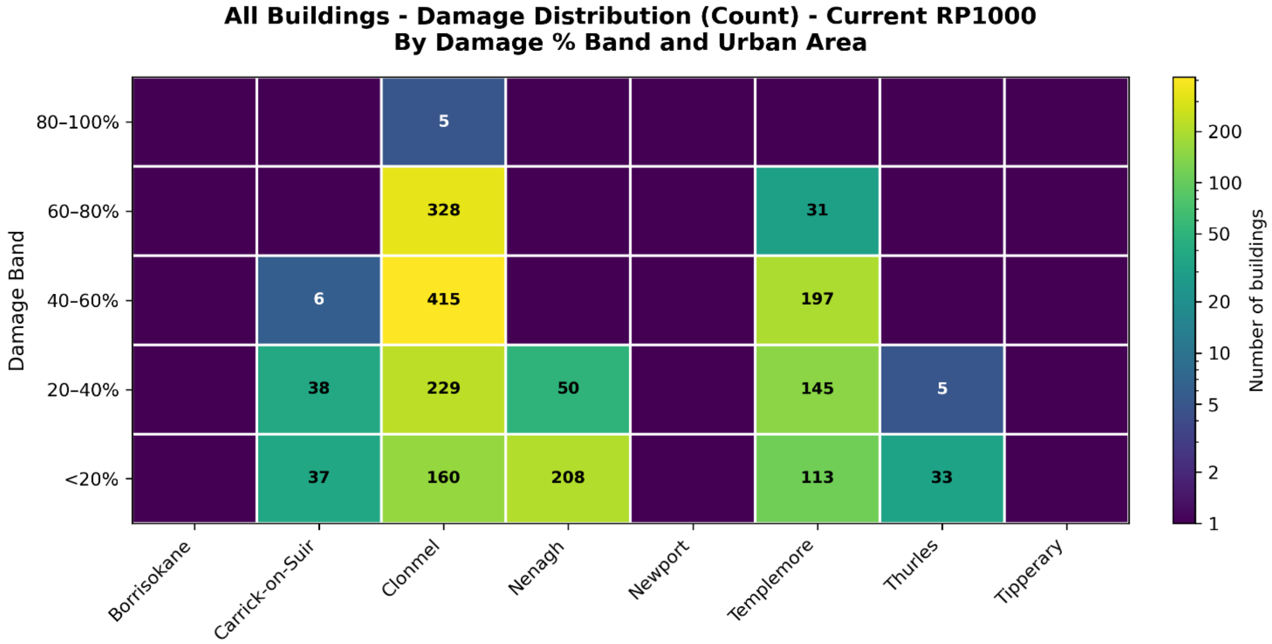

Figure 2-8: Distribution of building damage under current conditions for the 1-in-1,000-year (0.1% AEP) river flood event, showing the number of buildings in each urban area by damage severity band.

The influence of climate change is more clearly demonstrated in Figure 2-9, which compares current conditions with MRFS in terms of both exposure (the percentage of buildings flooded) and consequence (average damage severity to flooded buildings). The results show that, for several settlements, MRFS leads to an increase in the proportion of the building stock affected by the extreme flood event, alongside higher average damage levels where flooding occurs. This pattern is most evident in Carrick-on-Suir and Nenagh, where climate change results in both a greater number of buildings being flooded and more severe damage to those buildings. These locations therefore face a compounding climate risk, with increased flood extent and increased flood severity acting together to reduce building resilience.

Other settlements, including Thurles and Newport, show more modest changes under MRFS, suggesting a gradual intensification of building flood risk rather than a step change. Borrisokane and Tipperary continue to exhibit very limited exposure, although the MRFS results indicate that even small increases in flood extent can translate into meaningful damage for the few buildings affected. As with the roads analysis, Clonmel and Templemore are excluded from the current-to-MRFS comparison due to the absence of MRFS building projections, meaning a consistent assessment of climate change impacts was not possible for these locations.

Overall, the building damage results demonstrate that climate change is likely to amplify existing patterns of flood risk to the built environment, with the most pronounced impacts occurring in towns that are already exposed under current conditions. The findings underline the importance of targeting adaptation measures towards settlements with both high building exposure and increasing damage severity, particularly where residential and mixed-use areas intersect with fluvial floodplains.

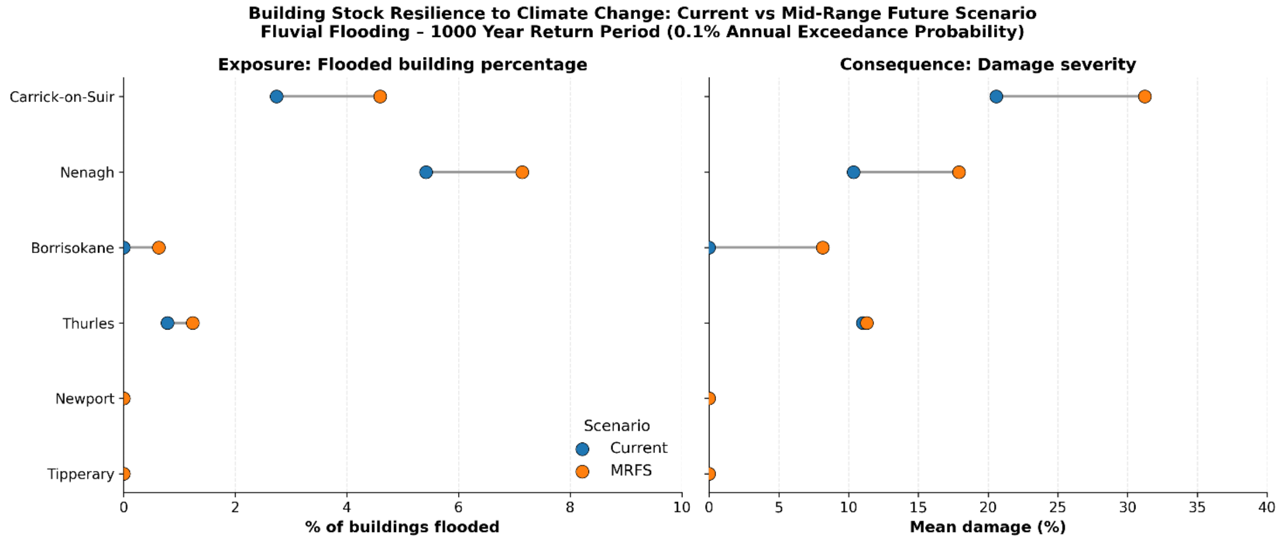

Figure 2-9: Comparison of current conditions and the Mid-Range Future Scenario (MRFS) for building flood impacts under the 1-in-1,000-year (0.1% AEP) event, showing changes in the proportion of buildings flooded (exposure) and the average severity of damage to flooded buildings (consequence); Clonmel and Templemore are excluded due to the absence of MRFS flood projection data.

2.3.2 Heavy Rainfall

In Phase 1, heavy rainfall, and potential surface water flood risk was assessed using climate hazard indicators. While this provided a useful initial overview, the results did not identify where surface water is likely to flow or collect during heavy rainfall detail to support decisions on where and how adaptation measures should be targeted. To address this gap, a Digital Elevation Model (DEM)-based approach was used in Phase 2 to improve the spatial detail of the analysis.

For heavy rainfall in Phase 2, the approach was adapted using a simple local surface water modelling approach to better represent the potential consequences of intense rainfall events in the county. Hazard data were drawn from the Phase 1 Heavy Rainfall assessment to derive the magnitude of a 1 in 100-year rainfall event, based on Euro-CORDEX projections, and combined with LiDAR derived Digital Elevation Models.

Surface water was allowed to flow downhill and pool in low-lying areas using terrain analysis tools such as WhiteboxTools, which were applied to the Digital Elevation Model to identify flow directions, flow accumulation paths, and local depressions. This process produced maps showing where surface water flooding is most likely to occur during heavy rainfall. The outputs provide indicative flood extents and relative depth patterns, intended to highlight areas of higher surface water flood susceptibility rather than provide exact predictions.

Exposure was then assessed using the road network and buildings, reflecting the significance of heavy rainfall for transport disruption, drainage exceedance and localised impacts on property and infrastructure. Vulnerability was incorporated through JRC damage curves, enabling the assessment to move beyond identifying potentially affected assets towards estimating indicative consequences for roads and buildings. This approach reflects the fact that heavy rainfall is a key driver of local disruption in Tipperary, particularly where drainage systems, topography and the built environment interact to increase surface water and local flood impacts.

Table 2-5: Data overview for heavy rainfall analysis

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Digital Elevation Models EURO-CORDEX	JRC Damage Curves	• OpenStreetMap Buildings • TCC Road Schedule	*Number/proportion of assets damaged*

2.3.2.1 Hazard assessment

Two rainfall amounts, 67 mm and 74 mm, were applied across the study areas. These values reflect the Phase 1 estimates for a 1 in 100-year rainfall event currently and in an RCP8.5 mid-century future and were chosen to represent heavy rainfall conditions. Rainfall was assumed to fall evenly across the area, with any excess water flowing over the ground surface once local drainage and infiltration are exceeded. Six locations were analysed chosen due to the availability of suitable DEM data (Cahir, Carrick-on-Suir, Cashel, Clonmel, Thurles, and Tipperary).

Surface water was allowed to flow downhill and pool in low-lying areas, producing maps that show where surface water flooding is most likely to occur. These maps provide indicative flood extents and relative depth, rather than exact predictions, it does not include detailed drainage networks, sewer capacity, or building-level impacts. However, it provides a much clearer picture of where surface water flood hazards are concentrated, helping to inform the assessment of exposure, vulnerability, and the identification of priority areas.

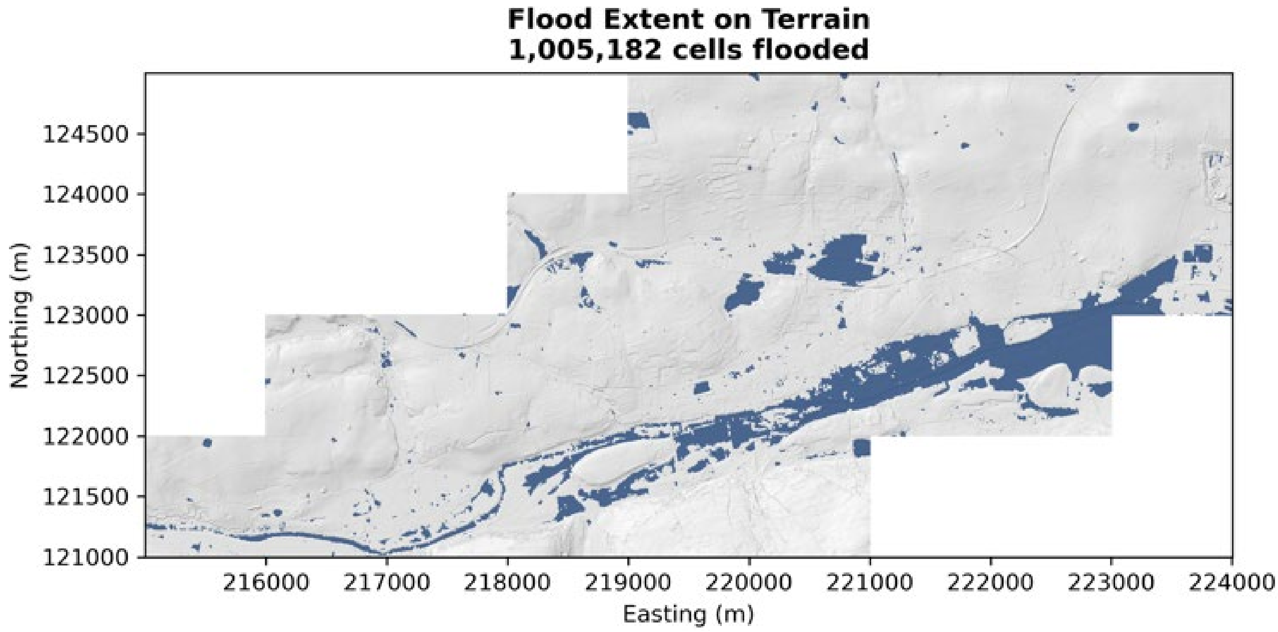

Figure 2-10: An example of the surface water flooding extent as derived from a 1:100 year return period event RCP8.5 2050 (74 mm of rainfall) for Clonmel.

2.3.2.2 Risk assessment

The surface water flooding risk assessment builds on the hazard analysis by explicitly integrating exposure and vulnerability to assess potential impacts on key assets within each urban area. Roads and buildings were identified as the primary receptors due to their importance for service delivery, accessibility and community functioning. Flood depth information derived from surface water flooding analysis described above and intersected with road networks. Potential damage was then estimated using JRC depth–damage functions, enabling a consistent and comparable assessment of the likely consequences of flooding across settlements and scenarios (Figure 2-11).

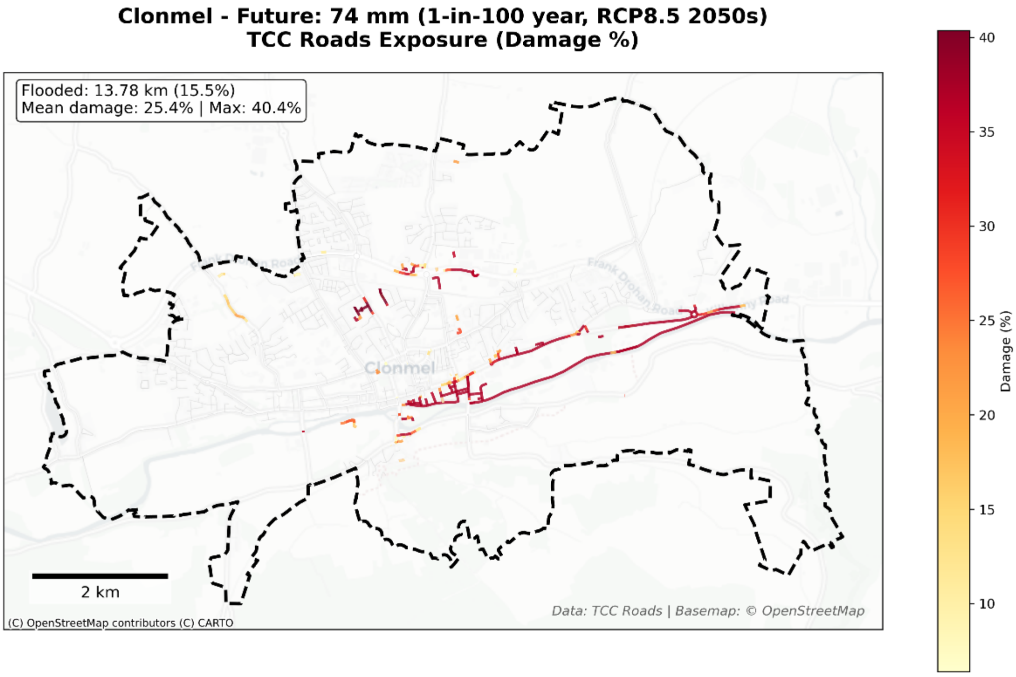

Figure 2-11: Surface water flooding damage assessment for roads in Clonmel under 1-in-100-year event in RCP8.5 by mid-century, showing the spatial distribution of inundated road segments and the estimated percentage damage derived from flood depths and JRC depth–damage functions.

2.3.2.2.1 Roads

The surface water flooding assessment for a 1-in-100 year rainfall event (74 mm, RCP8.5 2050s) indicates notable future impacts across the road network, with flooding concentrated on local and regional roads. Local Secondary and Local Tertiary roads experience the greatest flooded lengths, particularly in Clonmel and Thurles, reflecting their higher exposure and sensitivity. Regional roads also show consistent flooding, while impacts on National Primary and Secondary roads are comparatively limited. Spatially, Clonmel exhibits the highest overall flooded road length across most classifications. These results highlight surface water flood risk to local transport infrastructure, with implications for accessibility, emergency response and maintenance under future climate conditions. In comparison to the current period 1-100 year rainfall event (67 mm) the modelling shows no increase in the extent of flooding, however, an increase in flood depth, and therefore damage is identified.

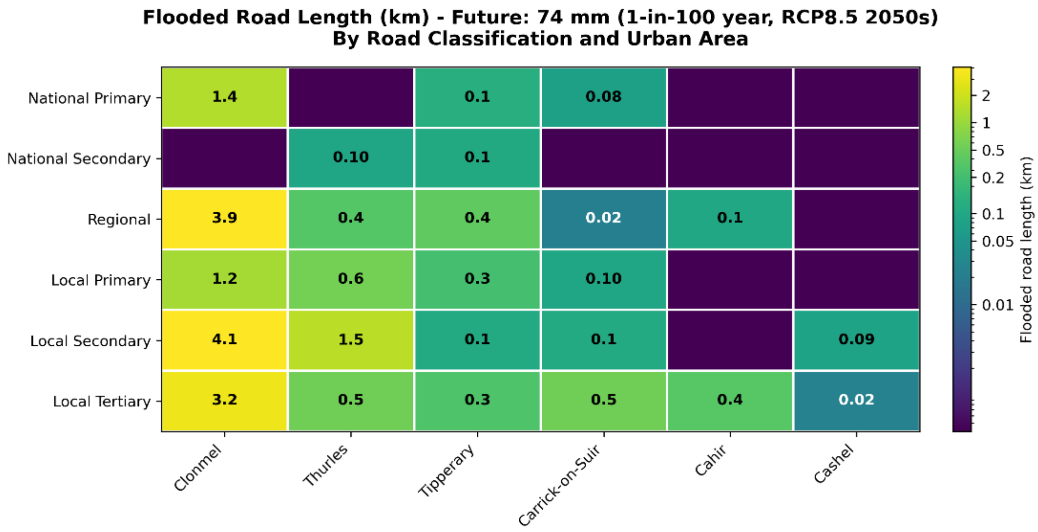

Figure 2-12: The flood road length by road hierarchy due to surface water flooding for the urban areas in County Tipperary due to a 1 in a 100-year rainfall event in RCP8.5 by mid-century.

2.3.3 Heatwaves

For **heatwaves**, the workflow was tailored to reflect both the emerging nature of the hazard in Ireland and the specific social dimensions of risk in Tipperary. Hazard data were derived from TRANSLATE climate indicators (O'Brien et al., 2024), including variables related to heatwave occurrence and summer temperature extremes. Exposure was assessed primarily through population data from Census 2022, recognising that heat risk in this context is primarily people-centred rather than asset-centred. Vulnerability was represented using an updated Social Vulnerability Index, based on Fitton et al. (2021) and refreshed using Census 2022 data. In Phase 2, this index was recalibrated to reflect relative vulnerability within the Tipperary local authority area, rather than against a national baseline, making it more appropriate for local prioritisation. This was particularly important for heatwaves, where risk is shaped not only by rising temperatures but also by age profile, health sensitivity, housing conditions, rural isolation and access to services. The refined approach therefore allowed the assessment to capture both the physical climate signal and the distribution of vulnerable populations across the county.

Table 2-6 Data overview for heatwave analysis

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
TRANSLATE (Heatwaves, Days above 25°C)	*Irish Social Vulnerability to Environmental Hazards Index (ISVEHI)*	*Population (CSO Census 2022)*	*Vulnerable Population*

2.3.3.1 Hazard assessment

Future projections indicate that heatwaves will become a more prominent and consequential climate hazard for County Tipperary, shifting from a relatively rare phenomenon at present to an emerging mid-century risk, particularly under high-emissions scenarios. Using Met Éireann's TRANSLATE climate indicators, which underpin both the National Climate Change Risk Assessment and the CLIMAAX Phase 2 analysis, heatwave hazard in Tipperary is characterised by two complementary metrics: the annual number of summer days (days with maximum temperature > 25°C) and the annual occurrence of heatwave events, defined in Ireland as periods of at least five consecutive days exceeding 25°C). For current conditions, Tipperary experiences approximately 3.39 summer days per year and around 0.16 heatwave events per year, confirming that extreme summer heat has historically been infrequent.

By mid-century under RCP8.5, these indicators show a clear and robust increase in heat hazard, with the annual number of summer days projected to rise to approximately 5.7–8.0 days per year and heatwave occurrence increasing to around 0.18–0.30 events per year. This represents not just warmer average summers but a higher likelihood of sustained periods of extreme heat, which are more strongly associated with adverse health outcomes and service disruption than isolated hot days. These projections also align with the Phase 1 Heatwaves Workflow results, which showed an increase in heatwave occurrence by mid-century in RCP8.5.

2.3.3.2 Risk assessment

The social vulnerability index was developed using an indicator-based approach, updated with CSO Census 2022 data and aligned with the Irish Social Vulnerability to Environmental Hazards Index (ISVEHI) methodology (Fitton et al., 2021). Social vulnerability is defined as the sensitivity of populations to hazards and their capacity to prepare for, respond to, and recover from impacts. The assessment was undertaken at Small Area level and aggregated to the Tipperary local authority area, with results expressed relative to the distribution of vulnerability within Tipperary rather than nationally, enabling identification of locally elevated vulnerability. A suite of socio-economic and environmental indicators was selected to represent the key drivers of vulnerability, including age, health, income, housing characteristics, and access to services. Indicators were standardised using z-scores to ensure comparability across variables and to centre results around a mean of zero.

Indicators were grouped into thematic domains and combined into three core dimensions of vulnerability: sensitivity, adaptive capacity, and enhanced exposure (Figure 2-13). Sensitivity reflects intrinsic characteristics that increase susceptibility to harm, such as age and health status; adaptive capacity captures the ability of individuals and communities to prepare for, respond to, and recover from hazard events; and enhanced exposure represents external physical and environmental factors that can amplify impacts, including housing quality and built environment characteristics. These dimensions provide a structured representation of how social and environmental factors interact to shape vulnerability. Equal weighting was applied at each stage due to the absence of a robust evidence base for differential weighting. The dimensions were then aggregated to produce a composite index, enabling the identification of areas with relatively higher or lower vulnerability within Tipperary.

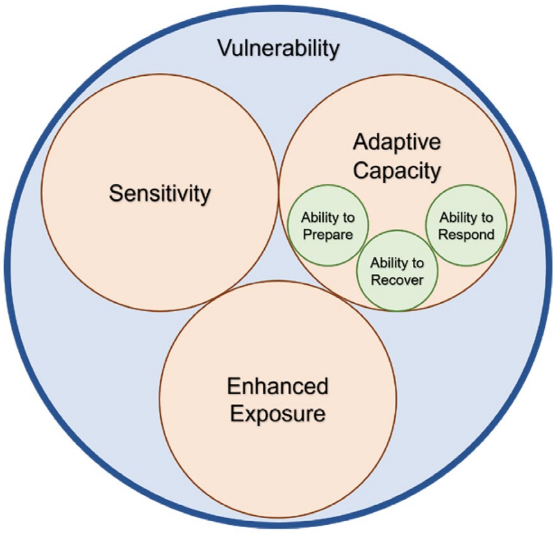

Figure 2-13: Conceptual framework of social vulnerability, illustrating the three core dimensions, sensitivity, adaptive capacity (including ability to prepare, respond, and recover), and enhanced exposure, and their combined contribution to overall vulnerability.

Heatwaves are likely to have the greatest impact in parts of Tipperary where social vulnerability is higher, particularly where people are more sensitive and less able to cope. The results show that several urban areas, including Carrick-on-Suir (Figure 2-14), Nenagh, Roscrea and Tipperary town, contain Small Areas[2] with relatively high or extremely high vulnerability. This is mainly driven by the sensitivity dimension of the index, especially the age and health domains, which identify groups more at risk during periods of extreme heat. Around 28% of Small Areas have high concentrations of younger populations, while 23% have high concentrations of older populations, showing that higher levels of age-related vulnerability are focused in specific areas.

Urban areas show a higher concentration of both younger and older populations compared to non-urban areas, indicating that more age-related sensitivity is more prevalent in urban contexts. However, only a small proportion of areas in both urban (3.3%) and non-urban (2.2%) settings exhibit high levels of both cohorts, confirming that age-related vulnerability is typically driven by distinct demographic profiles rather than co-located populations.

These factors increase the risk of negative health effects during heatwaves. At the same time, lower adaptive capacity, linked to factors such as income, mobility and access to services, reduces the ability of some communities to prepare for and respond to heat. Overall, the results show that heatwave risk in Tipperary is mainly shaped by where more vulnerable populations live and their ability to cope with extreme heat.

[2] Small areas are the smallest spatial unit used to aggregate census data in Ireland.

Social Vulnerability - Carrick-on-Suir

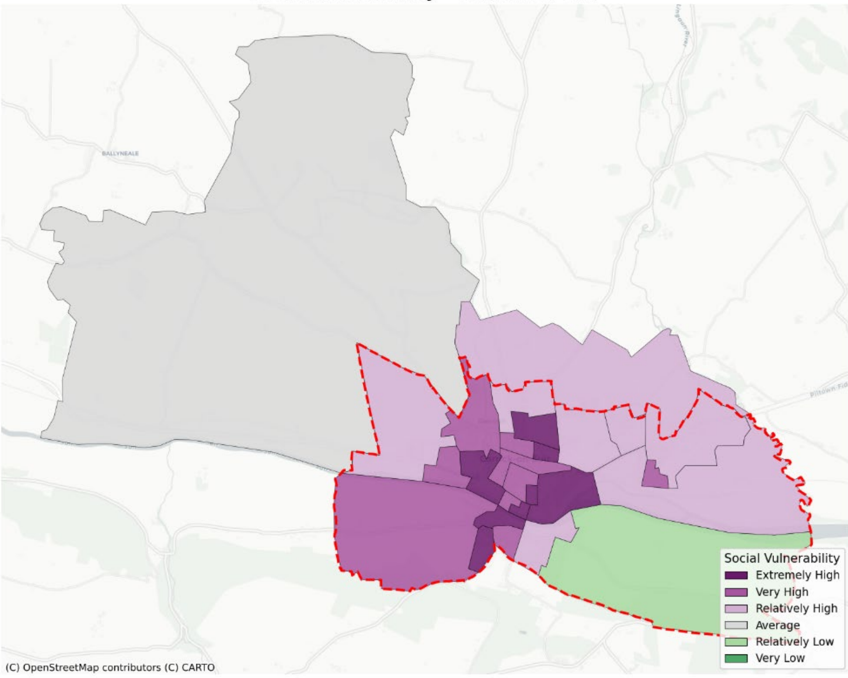

Figure 2-14: An example of Irish Social Vulnerability to Environmental Hazards Index (ISVEHI) for Carrick-on-Suir.

2.3.4 Wind

The regionalized risk assessment for wind relied less on a dedicated local hazard map and more on a structured assessment of vulnerability using local and national evidence. Vulnerability was assessed using the updated Irish Social Vulnerability to Environmental Hazards Index (explained in the previous section), while exposure was interpreted through the population within the county and their respective vulnerability. This was appropriate as the wind hazard affects the whole region, with little spatial variation in the hazard, and because wind risk in Tipperary is not only a function of hazard intensity but also of the county's settlement pattern, reliance on critical networks and the cascading effects that can arise from power outages, fallen trees and transport disruption.

Table 2-7: Data overview for wind analysis

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Mean Wind Speed Projections (Nolan and Flanagan (2020); Nolan, (2024))	*Irish Social Vulnerability to Environmental Hazards Index (ISVEHI)*	*Population (CSO Census 2022)*	*Vulnerable Population*

2.3.4.1 Hazard assessment

Projections for extreme wind speeds in the future are unavailable for Ireland. However, future projections for average wind conditions in Tipperary are expected to change only modestly over the coming decades, with a small overall reduction in mean wind speeds rather than a fundamental shift in windiness. Mean 10 m wind speeds across Ireland are projected to decrease slightly by mid-century, with changes typically on the order of ~1–2% by 2021–2050 and up to ~3–4% by late century under high-emissions scenarios (RCP8.5), relative to the 1981–2010 baseline (Nolan and Flanagan, 2020). These reductions are generally consistent across seasons, although winter changes are smaller and, in some locations, close to zero, reflecting higher uncertainty in seasonal patterns. High-resolution modelling led by Nolan (2024) similarly shows that, while mean wind speeds are projected to decline, the signal is relatively weak compared to temperature or precipitation, and interannual variability remains large; as a result, damaging windstorms are not expected to disappear, even if average conditions become slightly calmer. For Tipperary, this implies that wind will remain a relevant hazard despite the projected small decline in mean wind speed, particularly because disruption is driven more by episodic severe storms rather than by changes in long-term averages.

2.3.4.2 Risk assessment

Wind-related vulnerability in Tipperary is primarily influenced by patterns within the enhanced exposure and adaptive capacity dimensions of the social vulnerability index. Areas with higher vulnerability tend to exhibit characteristics within the housing and built environment domain, including indicators related to building age and non-standard housing types, i.e., mobile homes, which increase susceptibility to wind damage. Approximately 29.1% of Small Areas exhibit high levels of housing characteristics associated with increased exposure, while 17.3% show elevated levels of non-standard housing. In addition, adaptive capacity domains, particularly those relating to income and employment, highlight constraints in the ability to recover from impacts, with 22.8% of areas showing higher levels of unemployment. These factors reduce the capacity of households to absorb and recover from wind-related damage. In contrast to heatwaves, the sensitivity dimension, particularly age and health, plays a more limited role, indicating that wind vulnerability is less strongly driven by population susceptibility and more by exposure and recovery capacity. Overall, the results show that wind-related vulnerability in Tipperary is shaped by the interaction between housing characteristics, environmental exposure and socio-economic capacity.

2.3.5 Snow

For snow, the risk analysis was updated using national climate projection evidence from Nolan (2023), supplemented by the broader Phase 1 CLIMAAX understanding of winter hazard conditions. Hazard indicators included frost days, icing days and projected changes in snowfall-related conditions. Exposure was assessed using population data from Census 2022, while vulnerability was again supported by the updated Irish Social Vulnerability to Environmental Hazards Index. Although snow is projected to decrease as a climate hazard over time, it remains relevant in Tipperary because infrequent but severe events can still create major disruption, particularly for rural communities, transport networks and emergency response. The Phase 2 refinement therefore focused less on expanding a complex local hazard model and more on ensuring that the assessment captured the county's real-world sensitivity to snow-related disruption. This reflects a practical local authority perspective: even if the long-term climatic signal suggests decline, operational risk and preparedness requirements remain important.

Table 2-8: Data overview for snow analysis

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
TRANSLATE (frost days, icing days)	*Irish Social Vulnerability to Environmental Hazards Index (ISVEHI)*	*Population (CSO Census 2022)*	*Vulnerable Population*

2.3.5.1 Hazard assessment

Future projections indicate that snow-related conditions in Tipperary will become markedly less frequent as the climate warms, with the strongest signal being a reduction in the cold-weather "building blocks" that enable snowfall and ice. Using Met Éireann's TRANSLATE indicators as proxies for snow potential, Tipperary currently experiences ~45.7 frost days (fd) per year and ~0.46 icing days (id) per year, but by mid-century under RCP8.5 these are projected to fall to ~26–33 frost days per year and ~0.18–0.41 icing days per year, indicating fewer opportunities for snow/ice formation and persistence. Consistent with this, high-resolution national projections (Nolan, 2024) show substantial decreases in total annual snowfall across Ireland, with ensemble results indicating mean snowfall reductions of ~56% (2041–2071 under SSP585) and ~84% (2071–2100 under SSP585) and notes high certainty in the direction of change (i.e., widespread agreement across ensemble members). In contrast the Phase 1 Workflow for snow assessed future projections for snow for the region to show no change. Taken together, the TRANSLATE-derived declines in frost/ice days and the Nolan (2024) snowfall projections strongly suggest that Tipperary will experience rarer snow events overall, however, infrequent cold outbreaks can still produce disruptive snow/ice episodes even in a declining long-term trend.

2.3.5.2 Risk assessment

Vulnerability to snow and cold weather events in Tipperary is primarily driven by constraints within the adaptive capacity dimension of the index, particularly indicators related to mobility and access to services. Areas with higher vulnerability tend to exhibit characteristics such as reduced access to private transport and longer travel times, which limit the ability of households to access essential services during periods of disruption. Approximately 24.7% of Small Areas show high levels of households without access to a car, while 30.2% exhibit elevated travel times, indicating more limited connectivity. In addition, around 29.8% of areas display characteristics associated with more dispersed or rural settlement patterns, which can further increase exposure to disruption during snow events. These factors highlight the importance of mobility and access in shaping vulnerability, particularly in more rural areas. While sensitivity plays a role, the results indicate that vulnerability to snow is less strongly influenced by demographic characteristics and is instead driven by challenges in connectivity, access and service provision.

2.4 Key Risk Assessment Findings

The Key Risk Assessment step builds on the outputs of the refined risk analysis by evaluating each priority risk in terms of its **severity**, **urgency** and the **capacity to respond**. These dimensions were assessed using the CLIMAAX evaluation dashboard, which provides a structured and transparent way to compare and prioritise risks across hazards. The assessment followed the Key Risk Assessment protocol, ensuring consistency with the CLIMAAX framework and alignment with national and European climate risk assessment practice.

2.4.1 Mode of Engagement for Participation

Engagement for the Key Risk Assessment focused on the validation, interpretation and contextualisation of risk evaluation results, with a strong emphasis on institutional and expert input. This approach built directly on the stakeholder engagement framework set out in Section 2.1.5 and was designed to ensure that the assessment of severity, urgency and response capacity was both analytically sound and operationally credible.

Key engagement activities included targeted meetings with the CLIMAAX Advisory Group and internal local authority stakeholders, which were used to review the proposed severity, urgency and capacity ratings. These discussions ensured that the results accurately reflected local conditions, existing national, regional, and local management arrangements, service responsibilities and practical experience, and that the risk assessment was grounded in how climate impacts are actually managed nationally and locally.

An earlier workshop held in June 2025 further supported this process by capturing detailed input from local authority staff on existing responses to climate-related hazards, operational impacts and service-level experience. This evidence provided essential context for understanding current response capacity and directly informed the assessment of institutional resilience.

Together, these engagement activities ensured that the Key Risk Assessment was informed by a balanced integration of analytical evidence, institutional knowledge and expert judgement. This strengthened the credibility of the assessment and supported a robust, transparent and policy-relevant prioritisation of climate risks, suitable for informing decision making within the local authority.

2.4.2 Gather Outputs from Risk Analysis Step

The Key Risk Assessment draws on a structured hierarchy of outputs generated across Phase 1 and Phase 2 of the CLIMAAX CRA. This ensures that the evaluation of risk severity and risk urgency is grounded in analytical evidence, while maintaining continuity with earlier screening and prioritisation.

Phase 1 outputs provided the baseline evidence for risk evaluation, including hazard screening results, high-level exposure and vulnerability indicators, and qualitative risk narratives derived from European-scale datasets and stakeholder engagement. Phase 1 established the relative importance of climate hazards for County Tipperary, informed the selection of priority risks taken forward into Phase 2, and ensured alignment with national-level assessments such as the National Climate Change Risk Assessment (NCCRA).

Phase 2 Regionalized Risk Analysis outputs provided more detailed and locally relevant evidence and were used in a differentiated way to inform severity and urgency assessments:

- **Hazard outputs** (e.g. flood extents, heatwave indicators and future climate projections) were primarily used to assess how risks are expected to change over time, including increases in frequency, intensity or spatial extent. These outputs were therefore central to assessing urgency, particularly in relation to future escalation and timing of impacts.

- **Exposure outputs** (e.g. spatial intersection of hazards with roads, buildings, population and local authority services) were used to assess the scale and distribution of impacts. Exposure evidence informed both severity (by indicating the number and importance of assets and services affected) and urgency (by highlighting where impacts are already occurring or likely to emerge in the near term).
- **Vulnerability outputs**, including road classifications, depth-damage functions and the Social Vulnerability Index, were used to assess the consequences of impacts once assets or populations are affected. These outputs played a central role in determining severity, by translating hazard and exposure into potential damage, disruption and social impact.

Overall, the Phase 1 baseline and refined Phase 2 analytical outputs provide a transparent and evidence-based foundation for the Key Risk Assessment. Severity is anchored in the magnitude and consequences of impacts for local authority services, assets and communities, while urgency reflects projected change, onset characteristics and the timeframe over which risks are expected to intensify.

2.4.3 Assess Severity

Severity was assigned by translating the quantitative risk analysis into an impact-based judgement that reflects the scale and acceptability of consequences for the local authority context. For each hazard, severity is assessed by considering the magnitude of damage, effects on system functionality, spatial extent and pervasiveness, and the potential for cascading impacts, drawing on the structured consequence framework used in the EU-aligned NCCRA. County Tipperary already has a strong existing evidence base through its LACAP, alongside nationally consistent NCCRA assessments; therefore, an explicit alignment process is undertaken to ensure consistency across assessments and to avoid re-interpreting risks using divergent criteria. The NCCRA consequence dimensions are applied to the local context using Phase 2 hazard, exposure and vulnerability outputs, and the resulting scores are then aligned to the CLIMAAX severity scale (Limited, Moderate, Substantial, Critical) (See Appendix Table 7-2). This approach maintains coherence with national and EU-level evidence while allowing local differentiation, supporting transparent and defensible prioritisation for climate risk management under both current and future (2050) conditions.

River Flooding: River flooding represents a high-severity risk for County Tipperary under current conditions, with severity assessed as '**Critical**'. Historically, river flooding has caused recurrent damage to transport infrastructure, buildings and local communities, particularly in flood-prone settlements such as Clonmel, Nenagh and Thurles. Current risk is driven by a combination of high hazard frequency, significant exposure of roads and buildings, and vulnerability associated with rural accessibility and reliance on critical transport links. Flooding can lead to substantial disruption of system functionality, including loss of road access, impacts on emergency response, and cascading effects across economic activity and public services – all impacting TCC ability to deliver their essential services and to protect their own staff, infrastructure and assets. While systems generally recover, impacts are spatially extensive and recurrent, justifying a Critical severity classification under the CLIMAAX criteria.

Heavy Rainfall (Surface Water Flooding): Heavy rainfall poses a substantial to critical severity risk, with '**Substantial**' severity currently assigned. Historically, intense rainfall events have resulted in surface water flooding, drainage exceedance and short-notice disruption, particularly affecting roads, low-lying urban areas and rural properties. While damage at individual locations is often localised and recoverable, the frequency and geographic spread of impacts means multiple systems can be affected simultaneously, such as disruption and damage to roads and transport, water services, waste management, housing, environment and community services, with drainage exceedance, localised property flooding and increased pressure on operational and maintenance services. Current impacts are typically short-duration but widespread, with potential cascading effects during compound events. This results in a severity level that is below river flooding but still significant in terms of service disruption and cumulative impacts.

Wind: Wind is assessed as a '**Critical**' severity risk under current conditions. Severe wind events have historically caused high levels of damage to infrastructure, particularly electricity and communications networks, transport systems, and the built environment. Wind events can lead to rapid and widespread system disruption, including prolonged power outages, road closures, fallen trees and damage to buildings. The spatial extent of impacts is typically county-wide, and cascading effects are common, affecting emergency response, communications, water services and community safety. Although such events are episodic, their high impact and systemic nature, combined with challenging recovery during severe storms, support a **Critical** severity classification.

Snow: Snow and ice present a '**Substantial**' severity risk under current conditions. Historically, snow events are relatively infrequent but can cause significant disruption when they occur, particularly to the rural road network, emergency response and access to essential services. Impacts are often concentrated in upland and rural areas, where reliance on road connectivity is high. While damage to physical assets is generally limited, system functionality, i.e., the ability to provide local authority services and assets, can be severely affected, especially during prolonged cold spells, with cascading effects for health services, schools and community access. Recovery is typically achievable once conditions improve, supporting a **Substantial** rather than Critical severity classification.

Heatwaves: Heatwaves are currently assessed as a '**Limited**' severity risk, with Limited severity under present-day conditions. Historically, heatwaves have been rare in County Tipperary, and direct impacts on infrastructure and services have been limited. Current impacts are generally localised and manageable, primarily affecting vulnerable populations rather than causing widespread system disruption. While there is potential for health-related impacts and strain on services during heat events, these have not yet translated into significant or systemic disruption at county scale. As a result, severity remains Limited at present, although this assessment recognises that severity is expected to increase in future as heatwaves become more frequent and intense.

2.4.3.1 Future Changes in Severity

Future changes in hazard (Appendix Table 7-3), exposure and vulnerability (Table 2-1 and Table 2-2) are expected to drive an overall increase in risk severity across most hazards, although the direction and scale of change vary by hazard. Projected climate change indicates increases in the frequency and intensity of heavy rainfall and river flooding, which, when combined with planned development, population growth and continued reliance on critical infrastructure, will expand exposure to these hazards over time. At the same time, vulnerability is expected to increase due to demographic trends such as an ageing population, persistent rural accessibility challenges, and growing pressure on infrastructure and services, reducing the ability of some communities to cope with and recover from events. For river flooding and heavy rainfall, these combined changes are expected to reinforce already high impacts, maintaining or elevating severity at Critical levels in future. Wind risk severity remains Critical, with future exposure and vulnerability increases offsetting any uncertainty in projected wind trends, sustaining the potential for widespread and cascading disruption. In contrast, snow severity is expected to remain Substantial or reduce slightly over time, as hazard frequency declines, although increased exposure and vulnerability mean disruptive impacts may still occur when events do happen. Heatwaves show the most pronounced change, with a clear increase in hazard frequency and intensity projected; when combined with growing exposure of vulnerable populations and limited adaptive capacity at present, this leads to a step-change in severity from Limited to Moderate in future, highlighting heat as an emerging risk

2.4.4 Assess Urgency

River Flooding: River flooding is assessed as '**More Action Needed'**, reflecting a risk that is already severe and expected to remain **Critical** into the future. There is no reduction in severity from current to future risk, with severity remaining Critical due to strong evidence of increasing hazard intensity combined with rising exposure and vulnerability. Major impacts are already occurring and are expected to intensify over the near to medium term, meaning action is required now and within the next planning cycle to avoid locking in higher future damages. Climate projections indicate a significant worsening of flood drivers, particularly heavier rainfall and increased catchment response, which will elevate both the frequency and magnitude of events. River flooding is associated with sudden-onset events, often with limited warning, which strongly increases urgency as impacts can escalate rapidly and overwhelm response capacity.

Heavy Rainfall: Heavy rainfall is assessed as '**More Action Needed'**, as risk severity increases from Substantial currently to **Critical** in the future. Major impacts are expected to become more frequent in the short to medium term, particularly during intense rainfall events that exceed drainage capacity, meaning action is needed within the next few years to reduce surface water flooding impacts. Heavy rainfall is expected to worsen significantly in the near future, with strong evidence of increased extreme precipitation. As a sudden-onset hazard, impacts occur rapidly and across wide areas, limiting reaction time and increasing the importance of preparedness and system resilience. While individual rainfall events are short-lived, the risk has the potential to persist through repeated and compounding events, placing cumulative strain on services.

Wind: Wind risk is classified as '**Immediate Action Needed'**, reflecting its **Critical** severity both currently and in future. Major impacts occur during episodic but high-impact storm events, meaning action must be taken in advance of future storms rather than reactively. While future changes in wind hazard carry uncertainty, exposure and vulnerability continue to increase, sustaining high risk levels. Wind is a sudden-onset hazard capable of causing immediate, county-wide disruption to electricity, communications, transport and emergency services, which strongly drives urgency. Wind impacts can also persist beyond the event itself, particularly where outages, blocked routes or infrastructure damage delay recovery. Stakeholder input consistently highlights the cascading and systemic nature of wind impacts, reinforcing the need for immediate action despite uncertainty in hazard trends.

Snow: Snow is assessed under a '**Watching Brief**' urgency rating. Severity is expected to **remain Substantial** or gradually decline over time due to projected reductions in hazard frequency, although disruptive events will still occur intermittently. Major impacts arise during episodic winter events, meaning action focuses on maintaining preparedness rather than implementing major new interventions. Snow is not expected to worsen significantly in the near future, which moderates urgency relative to other hazards. It is a sudden-onset hazard, with immediate transport and access disruption, but established response arrangements reduce escalation risk. While impacts can persist during prolonged cold spells, they are generally time-limited and reversible. Stakeholder perspectives support this classification, noting that existing operational capacity is broadly proportionate, while emphasising the importance of continued monitoring due to rural vulnerability and access challenges.

Heatwave: Heatwaves are assessed as '**More Action Needed'**, reflecting their status as an emerging risk with a clear increase in severity from Limited currently to **Moderate** in future. Major impacts are expected to materialise over the medium term, particularly affecting public health, vulnerable populations and service demand, meaning action is required early to avoid future strain and maladaptation. There is strong evidence that heatwaves will worsen significantly, with increasing frequency and intensity projected. Unlike other hazards, heatwaves are a slow-onset process, developing over days or weeks, which shifts urgency towards anticipatory planning, capacity-building and policy integration rather than emergency response alone. Heat impacts also have the potential to persist, particularly through cumulative health effects and prolonged warm periods. Engagement with health, community and social services highlights that vulnerability is currently under-recognised, reinforcing the need to act now despite lower present-day severity.

2.4.5 Understand Resilience Capacity

2.4.5.1 Approach to assessing resilience capacity

Resilience capacity was assessed as part of the Phase 2 Key Risk Assessment, alongside severity and urgency, in accordance with the CLIMAAX methodology. The assessment examined the ability of the region to respond to and manage climate risks, taking account of measures already in place and the extent to which these reduce risk now and in the future.

The assessment was informed by a structured review of national and local resilience measures (Table 7-5) relevant to the assessed hazards informed by:

- the NCCRA, Sectoral Adaptation Plans, and LACAPs;
- Evidence from statutory plans, emergency management frameworks, and stakeholder engagement; and
- Application of the four resilience dimensions (the "4Rs"): Reliability, Resistance, Recovery & Response, and Redundancy used within in the NCCRA.

The Four Rs of Resilience provide a structured way to assess how well a region can manage climate risks across the full risk cycle. Reliability refers to the ability of institutions, systems and services to function consistently under current and future climate conditions, supported by strong governance, planning, monitoring and early-warning systems. Resistance describes the capacity of physical, natural and spatial systems to withstand climate hazards and limit damage, for example through flood defences, climate-resilient design and risk-informed spatial planning. Recovery and Response capture the ability to prepare for, respond to and recover quickly from climate events, including emergency management arrangements, operational services and community support mechanisms. Redundancy reflects the availability of backup systems, alternative assets and contingency arrangements that allow critical services to continue when primary systems fail. Together, the Four Rs highlight that effective resilience depends not on a single measure, but on a balanced combination of anticipation, protection, response and continuity.

2.4.5.2 Measures in Place

A wide range of climate risk management (CRM) measures are already implemented at both national and local authority levels, contributing to resilience across financial, social, human, physical and natural dimensions. Together, these measures provide a strong foundation for managing current climate risks while supporting longer-term adaptation.

Financial and institutional capacity is supported by national capital programmes, such as flood relief schemes and minor works funding, which provide a stable and long-term financial basis for risk reduction, particularly in relation to flooding and extreme precipitation. At local level, dedicated Climate Action Offices, LACAP governance structures and the integration of climate objectives into corporate and service plans strengthen institutional and financial capacity and ensure that climate risks are embedded in routine decision-making. Emergency response and recovery functions are further underpinned by established funding mechanisms for roads services, civil defence, fire services and Community Support Centres.

Human and social capacity is reinforced through formal governance and engagement structures, including Climate Action Steering Groups, cross-directorate teams and Public Participation Networks, which support awareness, coordination and learning across services and communities. Major Emergency Management arrangements provide a well-established inter-agency framework for preparedness, response and recovery during extreme events. In addition, Community Support Centres enhance social resilience by providing welfare, communications and coordination support during periods of disruption, particularly for vulnerable groups. TCC staff safety responses to climate risk are integrated into operational health and safety plans.

Physical and technical capacity is underpinned by national-scale hazard assessment and monitoring systems, including flood mapping, forecasting and warning services, which support reliable early warning and preparedness. At local level, operational capacity includes severe weather response arrangements, winter service plans, road weather decision-support tools, inspection programmes, and dedicated flood response functions within roads and transport services. The resilience of critical infrastructure is further strengthened through measures such as backup power, network automation and operational redundancy across energy, communications and water services.

Natural and spatial planning capacity is addressed through the embedding of flood risk management within the statutory planning system, including development plan policies, local area plans and national flood risk management guidelines. Spatial planning acts as a key resistance measure by shaping exposure and vulnerability over time, particularly in relation to flood-prone areas, settlement patterns and the siting of infrastructure. Better catchment planning and partnerships are being developed through the Local Authorities Waters programme.

Overall, the region’s resilience capacity reflects a clear and complementary division of roles across governance levels, resulting in a coherent and functional resilience system. At national level, resilience is anchored primarily in reliability and resistance, delivered through statutory planning guidance, national risk assessment and mapping, flood risk management frameworks and large-scale capital investment programmes, which establish a consistent baseline of protection, particularly for flooding and wind. At local authority level, resilience is driven by governance-led reliability and front-line recovery and response, supported by LACAP development plans, climate action offices and cross-service coordination, alongside operational capacities within roads, fire services, civil defence and community support structures. Redundancy is provided at different scales through backup power, alternative facilities and Community Support Centres, enabling service continuity during disruptions. Together, these measures demonstrate a substantial resilience capacity, with national structures reducing risk strategically and local authorities translating policy into spatial control, coordination and on-the-ground response during climate-related events. However, local authorities face significant challenges as a result of the intertwining of functions and responsibilities such as emergency response, power and water supplies with other governmental sectors.

2.4.5.3 Capacity by Hazard

River Flooding: The region has ***substantial*** resilience capacity for river flooding across all Four Rs. Reliability is strong due to well-established flood risk assessment, mapping, forecasting and statutory planning frameworks. Resistance is well developed through flood relief schemes, minor works and flood-risk-informed spatial planning that actively manages exposure. For instance, during Storm Chandra (Jan 2026), flood defences in Clonmel built in 2012, which allow controlled flooding in certain areas, were successful at reducing the areas impacted by the flooding of the River Suir. Recovery and Response capacity is robust, supported by emergency management structures, roads services, civil defence and community support arrangements. Redundancy is present through backup power, alternative facilities and Community Support Centres, though coverage varies locally.

Heavy rainfall: Resilience capacity for extreme precipitation is ***moderate to substantial***, with strengths concentrated in reliability and response. Monitoring, warning systems and planning controls provide a reasonable level of reliability, but resistance measures specific to surface water flooding are more limited and rely largely on drainage capacity and development management. Recovery and Response is well established through severe weather and roads response functions. Redundancy is limited and mostly indirect, drawing on general service continuity arrangements rather than hazard-specific backups.

Wind: The region demonstrates ***moderate*** resilience capacity for wind risk. Reliability is supported by national assessment, warning systems and strong emergency governance. Resistance is relatively limited at local level, with reliance on planning policy rather than widespread physical hardening of assets. Recovery and Response capacity is strong, reflecting well-developed emergency services, utilities coordination and roads clearance operations. Redundancy exists in critical infrastructure and community support systems but is uneven across sectors.

Snow and ice: Resilience capacity for snow and ice is ***moderate***, with an emphasis on operational preparedness. Reliability is supported by winter service plans and road weather decision-support systems. Resistance is limited, with few long-term physical adaptation measures specific to snow and ice. Recovery and Response capacity is strong and well-practised, including gritting, snow clearance and emergency services. Redundancy is provided through backup facilities and welfare supports, enabling short-term service continuity.

Heatwaves: The region currently exhibits ***lower*** resilience capacity for heat risk. Reliability is supported indirectly through general climate governance, health sector coordination and emergency management frameworks, but heat-specific planning remains limited. Resistance measures are underdeveloped, with limited integration of cooling, shading or heat-resilient design at scale. Recovery and Response capacity exists through health and emergency services but is not yet systematically configured around heat impacts. Redundancy specific to heat risk is minimal, indicating a need to progressively strengthen capacity across all Four Rs.

2.4.6 Decide on Risk Priority

Risk prioritisation was informed by a severity–urgency evaluation matrix, which was used to visualise and interpret the relative position of each hazard based on its assessed severity of impact and urgency of action (Figure 2-15). The matrix shows hazards plotted according to current conditions, while directional arrows indicate projected future changes in severity, reflecting anticipated changes in hazard intensity, exposure and vulnerability over time. These arrows illustrate how some risks are expected to move towards higher severity as climate drivers intensify, exposure increases through development, or vulnerability grows due to demographic and socio-economic factors.

Hazards located in the upper-right quadrant of the matrix, characterised by high current or future severity and high urgency, were assigned High Priority, reflecting risks with major impacts, limited response time and a clear need for immediate or near-term intervention (e.g. wind, river flooding and heavy rainfall). Hazards shown moving towards higher severity but with lower immediate urgency were assigned Moderate Priority, recognising emerging or escalating risks where early action can reduce future damages (e.g. heatwaves). Hazards located in the lower-severity and lower-urgency area, and not showing a significant upward shift in severity, were classified as Low Priority, reflecting risks that are either declining or currently well managed, with monitoring and preparedness considered proportionate (e.g. snow).

Resilience capacity was used as a moderating factor alongside the matrix, to reflect the extent to which existing national and local measures reduce residual risk. Where resilience capacity is high or substantial, priority may be moderated even where severity increases; conversely, where capacity is more limited, the projected upward movement in severity reinforces the need for higher priority. The final priority ratings therefore represent a qualitative integration of current and future severity, urgency and resilience capacity, informed by national-level evidence and aligned with the CLIMAAX Key Risk Assessment framework. A summary of the Key Risk Assessment findings is shown in Table 2-9.

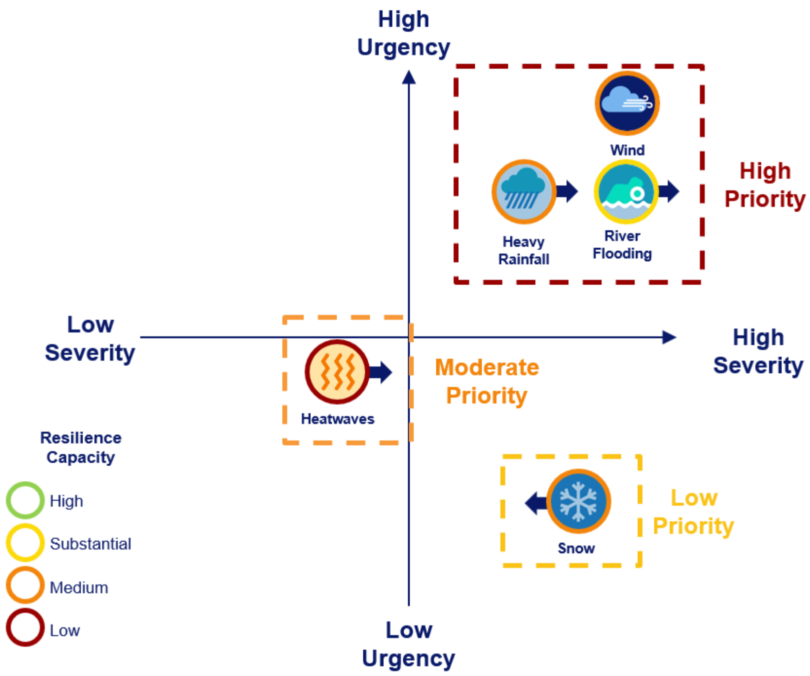

Figure 2-15: Risk prioritisation matrix informed by severity, urgency and resilience capacity. The figure illustrates how climate hazards are prioritised based on their assessed severity and urgency, with colour coding indicating levels of resilience capacity. Arrows show the projected future change in severity, reflecting anticipated changes in hazard intensity, exposure and vulnerability. Hazards moving towards higher severity and urgency are assigned higher priority.

Table 2-9: A summary of the key risk assessment findings for the five hazards.

Risk Workflow	Severity		Urgency	Capacity	Risk Priority
	C	F		Resilience/ CRM	
River flooding					High
Heavy rainfall					High
Wind					High
Snow					Low
Heatwaves					Moderate

Severity	Urgency	Resilience Capacity	Risk Ranking
Critical	Immediate action needed	High	Very high
Substantial	More action needed	Substantial	High
Moderate	Watching brief	Medium	Moderate
Limited	No action needed	Low	Low

2.5 Monitoring and Evaluation

Phase 2 of the climate risk assessment highlighted the importance of spatially explicit analysis in identifying areas of elevated risk. The refined assessment identified urban centres, key transport corridors, and low-lying or flood-prone areas as priority hotspots, where the interaction of hazard, exposure and vulnerability leads to higher risk concentrations. This represents a significant improvement from Phase 1, as the use of higher-resolution datasets enabled more precise, place-based risk identification. A key learning is the critical role of local authority data in enhancing the robustness of the assessment. Datasets such as asset registers, road networks, building information, and census-derived population and social vulnerability data were essential in capturing local exposure and vulnerability.

Difficulties Encountered

A key difficulty encountered in Phase 2 relates to the framing and consistency of the Key Risk Assessment criteria, particularly when assigning severity, urgency and priority.

Firstly, while hazards provide a useful starting point, they can be broad in their impacts, making it difficult to assign meaningful scores. Framing assessments through specific risk statements (e.g. disruption and damage to buildings due to river flooding) helped to narrow the focus and better capture the interaction of hazard, exposure and vulnerability. This approach also proved more effective during stakeholder engagement, as it aligns more closely with operational and service-level impacts.

Secondly, the severity criteria lacked consistency in structure and content, with some levels omitting key elements such as frequency or duration. In contrast, the NCCRA criteria provide more comprehensive and consistent descriptions across all severity levels and impact dimensions, supporting a more transparent and comparable scoring approach.

Finally, while the concept of “sustain current action” is valuable in recognising where effective measures are already in place, it is not clearly reflected within the urgency categorisation. The current use of “no action needed” may imply that no intervention is required, whereas “sustain current action” more accurately reflects situations where ongoing action is necessary and already being undertaken, creating ambiguity in prioritisation.

Stakeholder Engagement

Stakeholders play a central role in the Monitoring and Evaluation (M&E) of the CRA, ensuring that findings are credible, operationally relevant and embedded within decision-making processes. Engagement with internal stakeholders, particularly the Climate Action Team and corporate risk function, has supported the validation of results, interpretation of risks, and alignment with existing governance structures. Notably, engagement with the corporate risk management function is critical to mainstreaming climate risk into the organisation, enabling the integration of climate risks within the corporate risk register and linking CRA outputs to strategic planning and policy development.

External stakeholders, including advisory bodies and sectoral organisations, have provided technical and policy insight, strengthening the robustness of the assessment and ensuring consistency with national frameworks

Is Learning Ensured?

Learning is embedded within the phased structure of the CLIMAAX process and is actively supported through the progression from Phase 2 to Phase 3. Phase 2 has enabled TCC to develop a clearer understanding of the spatial distribution of climate risks and their implications for local authority assets, while also strengthening institutional knowledge and technical capacity through engagement with internal stakeholders and data integration.

Phase 3 will further enhance this learning by focusing on areas where the Climate Action Team has not yet engaged comprehensively, particularly the approach to integration of climate risk into operational decision-making and planning processes. By translating risk insights into practical adaptation and risk management actions, Phase 3 ensures that learning is not only generated but applied, providing a strong and ongoing basis for organisational learning.

Data Gaps

Key limitations include weak projections of future exposure and vulnerability, particularly in relation to settlement growth and socio-economic change, and a lack of standardised datasets across departments, which constrains integration and comparability. There is also a need to strengthen internal GIS and analytical capacity, including resources for data management, integration and ongoing monitoring. Finally, further development of technical expertise in climate risk assessment is required, alongside continued research on localised and cascading risks. Enhancing cross-departmental knowledge sharing and stakeholder engagement will be critical to embedding climate risk understanding across the organisation.

Outcomes Communication

Noting TCC's full accountability in terms of climate resilience for its own assets and staff, and its broader role in influencing, co-ordinating and advocating for climate resilience through service delivery, the final outcomes of the CLIMAAX project will be communicated primarily through internal organisational channels, led by the Climate Action Team. This will involve a structured programme of workshops and presentations, designed to translate the findings of the CRA into clear, actionable insights for relevant departments and service areas. A key focus of the communication approach is targeted engagement with internal stakeholders, ensuring that those responsible for planning, infrastructure, and service delivery understand the implications of the identified risks and their role in responding to them. These engagements will build on existing activities, for example, health and safety systems, emergency response, spatial planning, social and community resilience, climate proofing of capital projects, resilience across TCC own assets etc and governance structures already in place within the local authority, allowing climate risk outcomes to be embedded within ongoing processes rather than communicated in isolation. Overall, this approach ensures that the outputs of the project are effectively disseminated, understood, and integrated into decision-making across the organisation. TCC is also engaging with the Climaax advisory group, made up of national organisations, with a view to influencing climate risk action and policy development across the 31 local authorities in Ireland.

Monitoring System

At present, there are established systems in place to monitor and respond to acute weather-related risks, including Severe Weather Assessment Teams and defined operational processes. These systems support the local authority in preparing for, responding to, and recovering from extreme weather events, ensuring an effective frontline response to immediate hazards. However, from an organisational risk perspective, there is currently no comprehensive system in place to monitor emerging or changing climate risks over time, particularly in relation to evolving exposure, vulnerability and longer-term impacts. Addressing this gap will be a key focus of Phase 3, which will seek to establish mechanisms for ongoing risk monitoring and integrate climate risk considerations into organisational risk management and decision-making processes.

Efficiency

Efficiency in the CRA process positively contributed to maintaining momentum and focus across Phase 2, enabling the project to progress quickly from high-level screening to more detailed, localised analysis. The use of established CLIMAAX workflows and structured methodologies supported a clear and consistent approach to risk assessment, reducing ambiguity and enabling timely decision-making. In addition, strong internal engagement and targeted data collection helped to streamline the integration of local authority datasets, ensuring that effort was directed towards the most relevant hazards and risk areas. Overall, this efficiency allowed for effective prioritisation, improved coordination, and delivery of actionable outputs within project timelines, while still supporting stakeholder involvement and technical refinement.

2.6 Work Plan Phase 3

Phase 3 will build on the outcomes of the Phase 2 CRA by developing a structured approach to CRM, with a primary focus on how climate risks can be integrated into TCC's existing planning, governance and operational frameworks. The phase will begin with the consolidation and validation of priority risks, including mapping these risks to relevant TCC services, assets and vulnerable populations, and confirming risk ownership across the organisation. Based on this, a set of CRM objectives will be defined, focusing on reducing risk exposure and strengthening resilience, supported where possible by measurable indicators. While a high-level set of potential adaptation and risk management measures will be identified for each priority risk, this will be undertaken at a strategic level only, with limited analysis of individual options, and will primarily serve to illustrate the types of responses required and their alignment with the local authority remit. The core emphasis will instead be on defining practical pathways for integration, including how climate risks and associated responses can be embedded into key policy instruments and processes such as the LACAP, County Development Plan and corporate risk management systems. This will involve identifying appropriate mechanisms, responsibilities and coordination requirements to support integration over time. In parallel, the phase will examine enabling conditions for effective CRM, including data, institutional capacity, financing, governance arrangements and stakeholder engagement. Finally, a monitoring and evaluation framework will be outlined to support ongoing tracking of progress and adaptive management, ensuring that climate risk management and adaptation can be embedded as a continuous and evolving function within TCC.

3 Conclusions Phase 2 - Climate Risk Assessment

Phase 2 of the CRA represents a significant progression from the initial screening undertaken in Phase 1, transitioning from standardised, high-level analysis to a more detailed, spatially explicit and locally tailored assessment of climate risk across County Tipperary and TCC services. This phase reflects a clear shift towards a more decision-focused approach, grounded in local authority needs and aligned with national policy frameworks.

A central achievement of Phase 2 is the integration of higher-resolution national and local datasets, replacing or complementing the European-scale datasets used in Phase 1. This has substantially improved the accuracy, credibility and usefulness of the assessment. The refined analysis clearly demonstrates that climate risk in Tipperary is shaped by the interaction of hazard, exposure and vulnerability, rather than hazard intensity alone. In particular, the assessment has enabled the identification of spatial "hotspots", where risks are concentrated due to overlapping hazards, infrastructure exposure and socio-economic vulnerability. These areas are typically located within urban centres, along river corridors and across critical transport networks, which are essential for service delivery.

The findings confirm that river flooding, heavy rainfall and wind represent the most significant and immediate risks facing TCC. These hazards are already impacting infrastructure, communities and services, and are expected to intensify due to projected climate change, increasing development and a growing asset base. River flooding continues to pose a high-impact, location-specific risk, particularly in settlements with existing exposure to fluvial systems. Heavy rainfall presents a widespread and increasingly frequent risk, often leading to surface water flooding and disruption across multiple sectors simultaneously. Wind remains a critical hazard due to its ability to cause rapid, county-wide disruption and cascading impacts on power, communications and transport networks.

In addition to these immediate risks, Phase 2 identifies heatwaves as an emerging hazard with increasing importance over the medium to long term. While current impacts are limited, future projections indicate rising temperatures and more frequent extreme heat events. The assessment shows that heatwave risk in Tipperary is closely linked to social vulnerability, particularly among older populations, those with health sensitivities and communities with limited adaptive capacity. Conversely, snow and ice are identified as lower-priority risks due to their declining frequency under climate change, although they remain relevant due to their potential to disrupt rural connectivity and emergency response during infrequent but high-impact events.

Phase 2 also highlights that TCC has a strong foundation of resilience, supported by established governance frameworks, emergency response systems and statutory planning processes and its participation in the EU Missions for Climate Adaptation. Existing measures, including flood risk management programmes, emergency planning arrangements and the LACAP, provide a robust basis for managing current climate risks. However, the assessment identifies a number of challenges that remain to be addressed. These include gaps in data availability and consistency, particularly in relation to future exposure and vulnerability; limited integration of datasets and risk information across local authority departments; and the need to further embed climate risk considerations into corporate decision-making, financial planning and operational processes.

Importantly, Phase 2 introduces a structured and transparent framework for risk prioritisation, based on the combined assessment of severity, urgency and resilience capacity. This approach enables a more consistent comparison of risks across hazards and provides a clear basis for identifying priority areas for action. It also aligns with national and European methodologies, supporting policy coherence and strengthening confidence in the assessment outcomes.

In summary, Phase 2 provides a robust, evidence-based understanding of climate risk in County Tipperary and TCC Service delivery, identifying priority hazards, vulnerable assets and high-risk locations. It demonstrates how local data and targeted analysis can significantly enhance the relevance of CRAs for local authority decision-making. The findings establish a strong foundation for Phase 3, which will focus on translating risk insights into practical adaptation awareness and measures, strengthening institutional capacity and exploring how to embed climate risk management within TCC's strategic, spatial and operational frameworks.

4 Progress evaluation

Phase 2 of the CRA represents a significant advancement in the CLIMAAX process for TCC, transitioning from high-level screening in Phase 1 to detailed, place-based analysis and structured risk evaluation. The progress achieved across Phases 1 and 2 demonstrates a clear and coherent development pathway, moving from foundational scoping and hazard identification towards prioritised, evidence-based climate risk insights.

The Key Performance Indicators (KPIs) and Milestones presented in Table 4-1 and Table 4-2 confirm that the majority of activities planned for Phase 2 have been successfully completed. In particular, progress is evident across three core areas:

- **Stakeholder engagement** activities have evolved from broad external engagement in Phase 1 to a more targeted and technically focused approach in Phase 2. This includes the completion of data gathering workshops, validation workshops, and engagement with the Strategic Policy Committee. While planned public meetings were not delivered, this reflects a deliberate methodological shift rather than a delivery gap. As outlined in Section 2.1.5, engagement was prioritised towards internal and expert stakeholders to support the technical nature of Phase 2 outputs and ensure meaningful input into risk analysis and evaluation.
- **Data integration and workflow** development have been fully achieved, with both national and local datasets incorporated into multiple risk workflows. This represents a key milestone in improving the spatial resolution, reliability and decision-relevance of the assessment. The transition from European-scale datasets in Phase 1 to locally calibrated datasets in Phase 2 is a critical achievement and underpins the enhanced quality of the analysis.
- **Risk validation and governance alignment** has been successfully completed through stakeholder workshops and internal engagement processes. These activities ensured that the outputs of the risk assessment are aligned with operational realities, service delivery responsibilities and existing governance structures within TCC.

Overall, the KPI assessment indicates that Phase 2 has met its intended objectives, with deviations (e.g. public meetings) reflecting adaptive project management rather than underperformance.

4.1 Milestones

The project has achieved two key milestones in Phase 2, setting a solid foundation for phase 3 (Table 4.2). The milestones outlined in Table 4.2 demonstrate a logical and structured progression of the project.

- Phase 1 milestones (stakeholder mapping, hazard workflows, and methodology development) provided a strong analytical and governance foundation.
- Phase 2 milestones, including the refined risk analysis and the delivery of the regional/local multi-risk assessment, have been completed, representing the core outputs of this phase.

The timely achievement of these milestones indicates effective project coordination and resource allocation. It also demonstrates that the project has successfully transitioned from methodological development to applied risk assessment, delivering outputs that are directly relevant to local authority decision-making. The remaining milestones, particularly those associated with adaptation strategy development and CLIMAAX-level engagement, are appropriately positioned within Phase 3 and reflect the intended sequencing of the overall project.

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 2025
Stakeholder Engagement: Conduct a Risk Exploration Workshop	Completed as part of Phase 1 – August 2025
Stakeholder Engagement: Conduct a Data Gathering Workshop with TCC	Completed as part of Phase 2 – December 2025
Stakeholder Engagement: Conduct 2 x Public Meetings - Information Gathering	General public meetings not held due to change in approach to stakeholder engagement (see Section 2.1.5)
Workflows: Integrate national climate and hazard data into at least four workflows	Completed as part of Phase 2
Workflows: Integrate local/regional exposure and vulnerability data into at least four workflows	Completed as part of Phase 2
Stakeholder Engagement: Conduct a Risk Severity and Validation Workshops	Completed as part of Phase 2
Stakeholder Engagement: Present at the TCC Environment and Climate Action Strategic Policy Committee – Project Update	Completed as part of 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 2025
M2: Standardised workflows for seven hazards (Phase 1)	Completed as part of Phase 1 – August 2025
M3: Common Methodology - Multi-risk Climate Assessment Deliverable (Phase 1)	Completed as part of Phase 1 – September 2025
M4: Refined risk analysis of hazards (Phase 2)	Completed as part of Phase 2 – March 2026
M5: Refined Regional/Local Multi-Risk Assessment Deliverable (Phase 2)	Completed as part of Phase 2 – June 2026
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

The refined risk analysis outlined in Section 2.3 produces a suite of intermediate and final outputs, including both spatial datasets and tabular results that underpin the interpretation of findings. These outputs support the assessment of hazard, exposure, and vulnerability, and are used to inform the overall risk characterisation. A summary of the outputs generated for each hazard is provided below, with the corresponding spatial and tabular datasets made available via GeoNode and Zenodo to support transparency and reuse. Due to data protection and privacy constraints, certain datasets are provided in aggregated form, and detailed asset-level information is restricted to summary-level reporting.

- **River Flooding:** The river flood risk assessment for the urban areas of Borrisokane, Carrick-on-Suir, Cashel, Clonmel, Nenagh, Newport, Templemore, Thurles, and Tipperary produced a suite of hazard, exposure, and impact datasets across multiple return periods (10-, 100-, and 1000-year events) and climate scenarios (Current, Mid-Range Future Scenario (MRFS), and High-Range Future Scenario (HRFS)). Outputs include flood hazard rasters representing spatial depth distributions, along with tabular summaries of flood extent, depth statistics, and total inundated area in absolute and relative terms. Building exposure datasets are provided for residential, commercial, and combined categories, including aggregated metrics on flooded buildings, depth characteristics, and damage levels by urban area. Road exposure outputs include total and flooded lengths, proportion inundated, and summary depth and damage statistics, with breakdowns by road classification. Spatial datasets are supplied in GeoJSON format.
- **Surface Water Flooding:** The surface water flood analysis for the urban areas of Cahir, Carrick-on-Suir, Cashel, Clonmel, Thurles, and Tipperary provides a structured set of tabular, vector, and raster datasets describing hazard and exposure. Tabular outputs include aggregated building- and road-level metrics such as flooded counts, lengths, proportions, and associated depth and damage statistics. Road results are disaggregated by functional classification to support comparison within and across urban areas. Vector datasets as GeoJSONs of building, and road segments with key attributes (e.g. flood depth, flood status, damage percentage, segment length), while raster datasets represent continuous flood-depth surfaces.
- **Social Vulnerability (Heatwaves, Wind, and Snow):** The social vulnerability analysis produced a comprehensive set of ISVEHI 2022 outputs at the Small Area scale. Outputs include standardised datasets of all input indicators (22 variables), corresponding Z-scores, and aggregated results at domain, dimension (Sensitivity, Ability to Prepare, Ability to Respond, Ability to Recover, and Enhanced Exposure), and overall vulnerability index levels. Spatial outputs comprise indicator-level maps and dimension maps for each urban area, as well as classified (7-class) overall vulnerability maps, supported by multi-panel comparison figures. At the Local Authority scale, full-extent maps are provided for overall vulnerability and each dimension. Accompanying tabular and geospatial datasets are supplied for both full-area and urban-only subsets, containing indicator values, normalised scores, dimension results, composite indices, and classification outputs.

6 References

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7 Appendix

7.1 Service Areas and Responsibility for Climate Adaptation

Table 7-1: A summary of the key service areas of Tipperary County Council.

Service Area	Key Services
Arts and Culture	Arts Grants; Festivals and Events Support; Arts Centre Support.
Business and Economy	Local Enterprise Office Supports; Business Grants; Business Advice Services
Community	Community Grants; Community Development Supports; LCDC-related services, Community Support centres
Electoral Register	Register of Electors Management; Check the Register service
Emergency Services	Fire Service; Civil Defence; Emergency Response Coordination
Environment	Environmental Complaints; Anti-Litter Services; Biodiversity Protection Actions, Climate Action,
Heritage and Architectural Conservation	Protected Structures Management; Conservation Grants; Heritage Awareness
Housing	Social Housing Support; Housing Adaptation Grants; Housing Maintenance
Leisure and Recreation	Sports Facilities Management; Parks and Open Spaces; Recreation Programmes
Libraries	Library Membership; Book Lending; Online Library Services
Planning and Building	Planning Permission Applications; Building Control Notices; Dereliction Management, Active travel, vacancy and dereliction, Town Centre First
Roads and Transport	Road Maintenance; Street Lighting; Road Opening Licences
Tourism	Tourism Development Support; Destination Promotion
Veterinary and Animals	Dog Licensing; Animal Welfare Inspections; Animal Control
Waste Management	Household Waste Information; Recycling Services; MyWaste.ie referrals, Civic Amenity Sites, waste management, circular economy, landfills
Environment and Water Quality	Septic Tank Inspections; Drainage and Flooding Issues; Group Water Schemes, farm inspections
Corporate Affairs	Energy management, Facilities and Property management, Elected Representatives

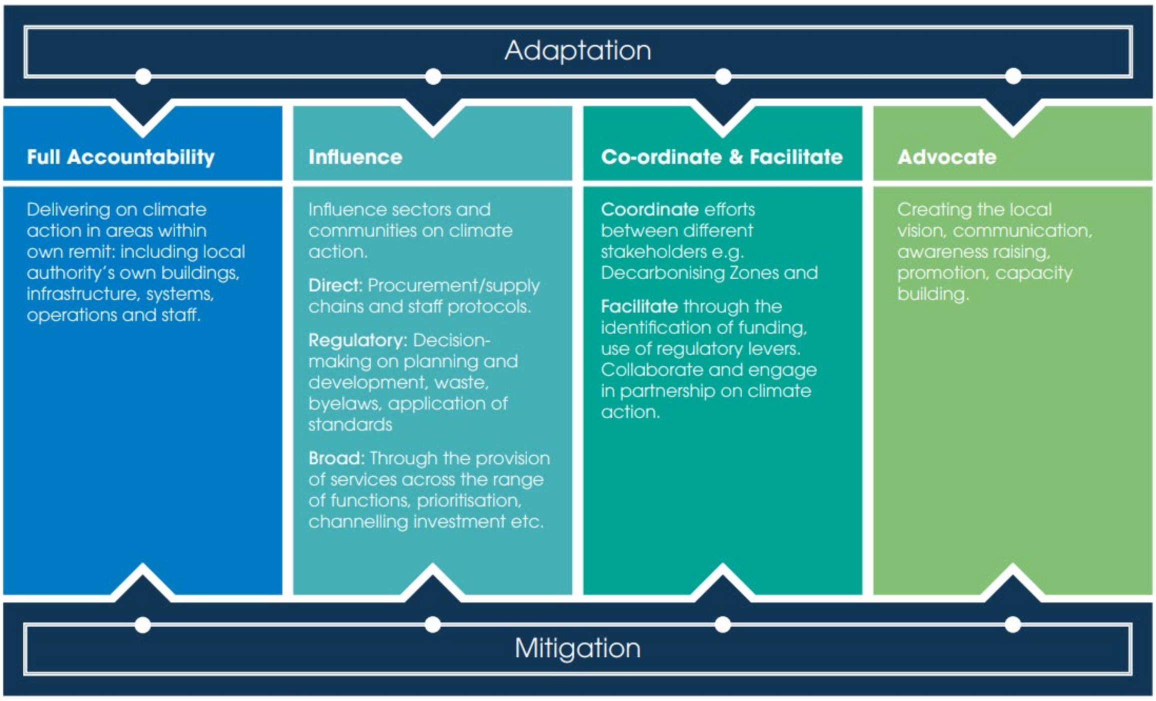

Figure 7-1: Local Authority responsibility for Climate Action

7.2 Severity Alignment

Table 7-2: Alignment of the National Climate Change Risk Assessment (NCCRA) severity criteria and CLIMAAX criteria.

NCCRA					***CLIMAAX***		
Severity	***Damage***	***System Functionality***	***Extent / Pervasiveness***	***Cascading Effects***	***Severity***	***Definition***	***NCCRA Alignment***
Catastrophic	Very large and frequent damage	Irreversible loss	Very large extent or very high pervasiveness	Irreversible cascading effects beyond system	**Critical**	Severe impacts; intolerable outcomes; cascading/systemic effects; critical disruption and life-threatening conditions	Aligned
Critical	Large and frequent losses	Long-term disturbance	Large extent and high pervasiveness	Long-term cascading effects beyond system	**Critical**	Severe, systemic, disruptive outcomes	If **systems are failing or close to failure** and disruption is prolonged and difficult to recover from
					Substantial	Potentially intolerable/systemic impacts	If systems are under severe stress but **still functioning**
Substantial	Substantial losses	Temporary or moderate disturbance	Moderate extent or pervasiveness	Temporary cascading effects beyond system	**Substantial**	High frequency and/or significant impacts threatening system functioning	If impacts **start to affect multiple systems** or strain core services
					Moderate	Tolerable but harmful impacts;	If impacts are **system-specific** and modest/recoverable
Limited	Limited or rare losses	No significant disturbance	Limited extent	No cascading effects beyond system boundaries	**Limited**	Minimal and/or acceptable impacts; low frequency	Aligned

7.3 Future Changes

Table 7-3: A summary of the hazard changes for RCP8.5 2050 used to inform the urgency classification.

Hazard	***Current***	***Future (RCP8.5, 2050)***		
		Description		***Evidence*** *(Based on TRANSLATE unless stated)*
River Flooding	• 175 wet days/year • Very wet days (R30mm): ~1.33 days/year • Max 5-day rainfall (Rx5day): ~67.9 mm	↑	**Increase** in heavy rainfall drivers leading to higher flood likelihood.	• Very wet days: Increases (~1.33 → ~1.7–2.3 days/year) • Max 5-day rainfall: increases (~67.9 → ~73–83 mm)
Heavy Rainfall	• Very wet days (R30mm): ~1.33 days/year • Max 5-day rainfall (Rx5day): ~67.9 mm • Wet days (RR1): ~175 days/year	↑	**Increase** in very wet days and rainfall intensity, winter precipitation rising	• Very wet days increases (~1.7–2.3 days/year) • Max 5-day rainfall increases (~73–83 mm) • Small decrease in wet days • Winter precipitation increases: ~+4–12% increase
Wind	• Limited trend detectable in observed mean wind speeds	↔	The mean annual 10 m wind speed is projected to **decrease**, however there is **high uncertainty**.	• Decrease in mean wind speeds (esp. summer) • A small decrease in extreme wind days
Snow	• Frost days (fd): ~45.7 days/year • Icing days (id): ~0.46 days/year	↓	**Decline** in frost, ice, and snowfall frequency and intensity.	• Frost days decrease (~45.7 → ~26–33 days/year) • Icing days decrease (~0.46 → ~0.18–0.41 days/year) • <10% annual probability of snowfall days (>6 cm) (CLIMAAX Phase 1) • Very rare / negligible (↓70–90%) (Nolan, 2024)
Heatwave	• ~0.16 heatwaves/year • ~3.39 summer days (>25°C)	↑	**Increase** in heatwave frequency and hotter summer temperature extremes.	• Heatwaves increase (~0.16 → ~0.18–0.30 events/year) • Summer days increase (~3.39 → ~5.7–8.0 days/year)

7.4 Urgency Alignment

Table 7-4: Alignment of the National Climate Change Risk Assessment (NCCRA) urgency criteria and CLIMAAX criteria.

CLIMAAX		Aligned NCCRA Category	Rationale
Urgency	**Definition**		
Immediate Action Needed	• Rapid worsening; high probability; • Long adaptation lead times (>10 years)	**More Action Needed**	NCCRA has no “immediate” category; this maps to the strongest “More Action Needed”
More Action Needed	• Significant change observed/projected; • Limited response time; adaptation takes years	**More Action Needed**	Direct alignment
Watching Brief	• Stable conditions; • Region can act quickly if trends worsen	**Watching Brief** *or* **Sustain Current Action**	**Sustain Current Action** if existing measures are effective **Watching Brief** if minimal measures
No Action Needed	• No significant change projected; • hazard unlikely to occur or persist	**Watching Brief**	• No near-term adaptation decision required

7.5 Resilience Capacity

Table 7-5: A summary of the resilience measures that are currently in place at the national and regional level aligned with the four resilience categories.

Measure	Description	Resilience Category	Relevant hazard(s)	Focus
Electricity network automation and remote reconfiguration	Existing automation and remote network reconfiguration capabilities within electricity transmission and distribution systems to reduce outage duration and support rapid restoration.	Reliability	Wind; Flooding	Critical Infrastructure
Underground fibre/cables (where deployed)	Undergrounding referenced as an existing resilience measure in communications/energy context (where already implemented).	Resistance	Wind; Flooding (pluvial)	Critical Infrastructure
Vegetation and tree management along electricity networks	Ongoing vegetation management and tree-cutting regimes to reduce storm-related damage and power outages along electricity networks.	Resistance	Wind	Critical Infrastructure
Drone-based inspection of network assets	Use of drones referenced as an existing inspection capability supporting infrastructure	Recovery & Response	Wind; Flooding (river)	Critical Infrastructure

Measure	Description	Resilience Category	Relevant hazard(s)	Focus
	monitoring and restoration workflows.			
Backup generators at sites (energy/communications)	Generator deployment/availability referenced as an existing backup power measure at critical sites.	Redundancy	Flooding (river, pluvial); Wind; Snow	Critical Infrastructure
Batteries at sites (energy/communications)	Battery backup capability referenced as an existing resilience measure (site-level backup).	Redundancy	Flooding (river, pluvial); Wind; Snow	Critical Infrastructure
“Be Winter Ready” public preparedness campaign	Public information/preparedness campaign referenced as an existing mechanism supporting winter readiness.	Reliability	Snow; Wind	Service Continuity & Emergency Response
Reservoir and river level monitoring (water services operations)	Monitoring of reservoir/river levels referenced as an operational monitoring measure supporting water services management.	Reliability	Flooding (river); Extreme precipitation	Service Continuity & Emergency Response
Road weather decision support (Vaisala RoadDSS)	Operational road weather forecasting / decision-support tool used to inform winter service actions.	Reliability	Snow	Service Continuity & Emergency Response
Winter Service Plans (roads)	Formal winter service planning arrangements used by transport operators/contractors for winter operations.	Reliability	Snow	Service Continuity & Emergency Response
Major Emergency Management (MEM) Framework	National inter-agency emergency management framework supporting coordinated preparedness, response, and recovery for major emergencies, including severe weather events.	Recovery & Response	Flooding; Wind; Snow; Heat	Service Continuity & Emergency Response
Gritting / salting operations	Operational winter maintenance treatment activities (salting/gritting) used during ice/snow events.	Recovery & Response	Snow	Service Continuity & Emergency Response
Severe Weather Group (health sector)	Existing coordination structure referenced as part of severe weather preparedness/response in the health sector context.	Recovery & Response	Heat; Flooding; Snow; Wind	Service Continuity & Emergency Response
Snow clearance / snow ploughing operations	Operational snow clearance activities (including ploughing) undertaken during snow events.	Recovery & Response	Snow	Service Continuity & Emergency Response
Uisce Éireann customer text alert system	Text alert system referenced as an existing customer communication mechanism (incl. during disruptions).	Recovery & Response	Flooding; Wind	Service Continuity & Emergency Response
Uisce Éireann emergency repair works	Emergency repair capability referenced as an existing	Recovery & Response	Flooding (river,	Service Continuity &

Measure	Description	Resilience Category	Relevant hazard(s)	Focus
	operational response function for water services disruptions.		pluvial); Wind	Emergency Response
Catchment Flood Risk Assessment and Management (CFRAM) Programme	Catchment-scale flood risk assessment and management framework/programme referenced as an established national approach.	Reliability	Flooding (river, pluvial)	National-scale information, governance, and risk-management infrastructure
Flood forecasting and warning services	Operational flood forecasting and warning services supporting preparedness, early warning, and emergency response for flood events.	Reliability; Rapidity	Flooding (river, pluvial)	National-scale information, governance, and risk-management infrastructure
Flood Risk Management Plans (FRMPs)	Flood Risk Management Plans referenced as existing plans used for managing flood risk under Floods Directive cycles.	Reliability	Flooding (river, pluvial)	National-scale information, governance, and risk-management infrastructure
OPW Capital Flood Relief Scheme	Capital programme/funding mechanism supporting delivery of flood relief schemes.	Resistance	Flooding (river)	National-scale information, governance, and risk-management infrastructure
OPW flood mapping programmes (NIFM / CFRAM)	National flood hazard mapping and flood extent products produced by OPW as part of multiple programmes (used as baseline evidence for risk identification and planning).	Reliability	Flooding (river)	National-scale information, governance, and risk-management infrastructure
OPW Minor Flood Mitigation Works Scheme	Funding mechanism supporting smaller-scale, local flood mitigation works.	Resistance	Flooding (river, pluvial)	National-scale information, governance, and risk-management infrastructure
Planning System & Flood Risk Management Guidelines (incl. Section 28 guidelines)	Statutory planning guidance used to manage flood risk in spatial planning / development management.	Resistance	Flooding (river, pluvial)	National-scale information, governance, and risk-management infrastructure
Preliminary Flood Risk Assessment (PFRA)	Existing Floods Directive screening process used to identify areas of potentially significant flood risk.	Reliability	Flooding (river, pluvial)	National-scale information, governance, and risk-management infrastructure
Changeover switch installation in designated CSCs (LA-arranged)	For a designated CSC, the local authority arranges installation of an electricity changeover switch (manual transfer switch / changeover panel) enabling	Redundancy	Wind; Snow; Flooding	TCC - Redundancy

Measure	Description	Resilience Category	Relevant hazard(s)	Focus
	generator supply during outages (existing framework requirement).			
Council maintains network of public amenities (potential CSC premises)	The Council "maintains and operates" public amenities including libraries and public swimming pools/leisure centres; CSC guidance identifies sports halls/community centres/town halls/leisure centres as premises types that can be designated as CSCs.	Redundancy	Wind; Snow; Flooding	TCC - Redundancy
Local authority access to transportable generators for CSC activation	Local authorities will have access to transportable generators for CSCs; guidance specifies generator types and that units can be mobilised to CSC sites during outages.	Redundancy	Wind; Snow; Flooding	TCC - Redundancy
Civil Defence capability (vehicles & ambulances; operating bases)	Civil Defence provides support to events and operates out of Clonmel and Nenagh fire stations with a fleet of vehicles and ambulances (existing response support capability).	Recovery & Response	Wind; Snow; Flooding	TCC – Recovery and Response
Interface with Major Emergency Management (MEM) framework	Alignment of climate adaptation planning with emergency management structures to support preparedness and response to severe weather and climate-related events.	Recovery & Response	Flooding; Wind; Snow; Heat	TCC – Recovery and Response
CSC activation procedures (requested by coordination group or self-activated)	CSCs can be activated either (a) at request of a coordination group or (b) self-activated by the community group, with notification to the local authority (existing operating model).	Recovery & Response	Wind; Snow; Flooding	TCC – Recovery and Response
CSC welfare service bundle (food/charging/hygiene/Wi-Fi + information)	CSCs provide welfare services (food/refreshments, device charging, hygiene facilities, Wi-Fi/internet) and can disseminate consistent public information (existing CSC function).	Recovery & Response	Wind; Snow; Flooding	TCC – Recovery and Response
Fire & Rescue Service – 24/7 emergency cover (12 stations)	Fire & Rescue maintains round-the-clock emergency cover and operates from 12 fire stations across the county (existing emergency response capability).	Recovery & Response	Wind; Snow; Flooding	TCC – Recovery and Response
Humanitarian Subgroup (LCG/RCG) to coordinate CSC support	CSC support is coordinated via a Humanitarian Subgroup under the Major Emergency Management coordination structure, with multi-agency membership (LA, HSE, An Garda Síochána, Civil Defence, utilities etc.).	Recovery & Response	Wind; Snow; Flooding	TCC – Recovery and Response

Measure	Description	Resilience Category	Relevant hazard(s)	Focus
Public communications for CSCs (dedicated phone line; leaflet drops; local radio)	In high-impact events, local authority may establish a dedicated phone line and use leaflet drops (via An Post) and local radio where telecoms/broadband are disrupted (existing response option described).	Recovery & Response	Wind; Snow; Flooding	TCC – Recovery and Response
Roads & Transport – Flood Risk Management function	The Tipperary County Council Roads & Transport Section includes Flood Risk Management as an active service responsibility (i.e., an existing operational function).	Recovery & Response	Flooding (river, pluvial); Extreme precipitation	TCC – Recovery and Response
Roads & Transport – Severe Weather Response function	The Roads & Transport Section includes Severe Weather Response as an active service responsibility	Recovery & Response	Wind; Snow; Extreme precipitation; Flooding	TCC – Recovery and Response
County Development Plan (CDP)	Statutory spatial planning framework integrating climate adaptation and mitigation into land-use zoning, development standards, flood risk management and infrastructure planning.	Resistance	Flooding; Heat; Wind; Extreme precipitation	TCC - Resistance
Local Area Plans (LAPs)	Statutory local-scale plans applying climate objectives at settlement level, including flood risk management, compact growth and climate-resilient development patterns.	Resistance	Flooding; Heat; Extreme precipitation	TCC - Resistance
Climate Action Office	Dedicated organisational unit (e.g. Climate Action Coordinator/Officer) responsible for coordinating climate action, supporting policy integration and overseeing reporting and delivery across the authority.	Reliability	Flooding; Heat; Wind; Snow; Extreme precipitation	TCC - Reliability
Local Authority Climate Action Plan (LACAP)	Statutory local authority plan setting out mitigation and adaptation objectives, actions, governance arrangements, monitoring and reporting mechanisms aligned with national climate policy.	Reliability	Flooding; Heat; Wind; Snow; Extreme precipitation	TCC - Reliability
Climate Action Steering Group / Senior Oversight Group	Senior management governance structure providing strategic oversight, direction and accountability for climate action implementation.	Reliability	All hazards	TCC - Reliability
Cross-directorate Climate Action Team	Multi-service internal coordination mechanism to mainstream climate action across planning, housing, roads, environment and corporate services.	Reliability	All hazards	TCC - Reliability

Measure	Description	Resilience Category	Relevant hazard(s)	Focus
Integration of climate objectives into statutory plans and strategies	Requirement to embed climate mitigation and adaptation objectives into corporate plans, service delivery plans and sectoral strategies prepared by the local authority.	Reliability	All hazards	TCC - Reliability
Public Participation Networks (PPNs) and community engagement structures	Formal governance mechanisms enabling community and stakeholder participation in climate planning, decision-making and programme delivery at local level.	Reliability	All hazards	TCC - Reliability
Climate Action Regional Office (CARO) coordination	Regional support and coordination structure providing guidance, consistency and capacity-building support to local authorities on climate action.	Reliability	All hazards	TCC - Reliability
Pre-designated list of Community Support Centres (maintained by local authority)	Each local authority maintains a pre-established list of designated CSCs (including activation contacts) and confirms details annually.	Reliability	Wind; Snow; Flooding	TCC - Reliability
Climate Action Office established (Coordinator/Officer/Community Officer + governance)	A dedicated Climate Action Office was formed (spring 2023) with defined roles (Coordinator, Officer, Community Climate Action Officer) and supporting governance (Steering Group + Climate Action Team) to coordinate and mainstream climate action and monitor/report delivery.	Reliability	Flooding; Extreme precipitation; Heat; Snow; Wind	TCC - Reliability
Climate Adaptation Strategy (2019) used to plan/respond/adapt to extreme weather	A Climate Adaptation Strategy (2019) exists and is described as enabling the Council to plan for, respond to, and adapt to extreme weather events, including thematic coverage of Drainage and Flood Management and business operations.	Reliability	Flooding (river, pluvial); Extreme precipitation; Heat; Snow; Wind	TCC - Reliability