Deliverable Phase 2 – Climate Risk Assessment

Applying the CLIMAAX Framework to County Louth, Ireland

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Abbreviations and acronyms

Abbreviation / acronym	Description
AA	Appropriate Assessment
AFA	Area for Further Assessment (flood risk planning designation)
AICBRN	All-Island Climate and Biodiversity Research Network
AR6	Sixth Assessment Report IPCC
CARO	Climate Action Regional Office
CDP	County Development Plan
CDS	Climate Data Store
CFRAM	Catchment Flood Risk Assessment and Management
CINEA	European Climate, Infrastructure and Environment Executive Agency
CLIMAAX	Climate Risk Assessment Framework project (EU Horizon Europe initiative)
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRA	Climate Risk Assessment
CSO	Central Statistics Office (Ireland)
DkIT	Dundalk Institute of Technology
EURO-CORDEX	European branch of CORDEX regional climate modelling initiative
FRS	Flood Relief Scheme
GCM	Global Climate Model
GEV	Generalised Extreme Value (statistical distribution)
GIS	Geographic Information System
GHS-POP	Global Human Settlement Population dataset
HSE	Health Service Executive
LACAP	Local Authority Climate Action Plan
LAP	Local Authority Plan
LCAP	Louth Climate Action Plan
LCAS	Local Climate Adaptation Strategy
LCDA	Low Carbon Development Act
LCDP	Louth County Development Plan
LCC	Louth County Council
LECP	Local Economic and Community Plan
LUISA	Land Use-based Integrated Sustainability Assessment model
MRFS	Mid-Range Future Scenario (OPW flood scenarios)

NAF	National Adaptation Framework
NCAC	National Climate Action Charter
NCCRA	National Climate Change Risk Assessment
NIFM	National Indicative Fluvial Map
OPW	Office of Public Works
OSI	Ordnance Survey Ireland
PPN	Public Participation Network
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
RPI	Risk Priority Index
SEA	Strategic Environmental Assessment
SSP	Shared Socioeconomic Pathway

Executive summary

This deliverable presents the outcomes of Phase 2 of the Climate Risk Assessment (CRA) for County Louth, developed using the CLIMAAX methodological framework[1]. Phase 1 of the assessment utilised EU-wide datasets to identify three priority climate hazards for the county, flooding (coastal and river), heavy rainfall, and windstorms, based on historical impacts, projected future severity, and initial stakeholder validation. Phase 1 also identified significant limitations, including the absence of local-level data, limited socio-economic vulnerability information, and the need for broader community input. Phase 2 was developed to address these gaps by refining and deepening the initial findings through the integration of local datasets, site-specific analysis, and structured stakeholder engagement.

The main actions undertaken during Phase 2 include a comprehensive stakeholder engagement process conducted throughout November 2025, led by the Louth Climate Action Team in collaboration with Grant Thornton Ireland and M-CO. This process comprised community drop-in sessions held across four locations in County Louth (Ardee, Dundalk, Cooley, and Drogheda), a dedicated engagement meeting with elected representatives of Louth County Council (LCC), technical workshops with council staff and subject matter experts, an online survey distributed through the Public Participation Network (PNN), and the collection of post-storm incident reports following Storm Chandra in January 2026[2]. Local data and spatial analysis were also integrated into the assessment to refine the understanding of hazard exposure and vulnerability at a community level. The three core CLIMAAX principles (social justice, equity, and inclusivity; quality, rigour, and transparency; and the precautionary approach), were applied throughout the assessment process.

The Phase 2 assessment confirms that flooding, heavy rainfall, and windstorms remain the most pressing climate risks for County Louth, consistent with Phase 1 findings. Stakeholder engagement provided strong validation of these risks while also revealing important local detail not captured in the initial analysis. Recurring flooding pressures were identified along river systems and in urban centres, particularly in Dundalk, Drogheda, and the Cooley Peninsula. Drainage and wastewater infrastructure was found to be operating at or beyond capacity during heavy rainfall events, and transport network vulnerabilities were highlighted, with access routes becoming impassable during flood and storm events. Evidence of informal community resilience was also documented, including local support networks and voluntary maintenance of drainage infrastructure, demonstrating a readiness for more structured adaptation support. The engagement process further highlighted governance and coordination challenges, including fragmented responsibilities across agencies and difficulties in communicating climate risk uncertainties without undermining the urgency for action.

Climate risks in County Louth are already materialising and are projected to intensify, particularly for flooding and heavy rainfall. The integration of local data and stakeholder engagement has significantly enhanced the accuracy and relevance of the assessment compared to the EU-level analysis conducted in Phase 1. Vulnerability is unevenly distributed across the county, with certain communities, infrastructure systems, and geographic areas, such as Dundalk and Drogheda, facing substantially higher levels of risk. The outputs of this phase provide a strengthened

[1] CLIMAAX CRA Handbook — CLIMAAX CRA Handbook
[2] Storm Names - Met Éireann - The Irish Meteorological Service

evidence base to inform the next Louth County Development Plan (LCDP)[3] and support infrastructure investment decisions.

Phase 3 will build on these insights by translating the findings of Phase 2 into actionable adaptation strategies, including the development of targeted measures for priority risks, the design of implementation pathways and governance structures, and continued stakeholder engagement to support co-design of locally relevant solutions.

1 Introduction

1.1 Background

County Louth is a coastal county in the North-East of Ireland, covering 826 km² along the Irish Sea coast between Counties Meath and Down. With a population of 139,703 (CSO Census 2022), it is Ireland's smallest county by area but has the second-highest population density (169 persons/km²) outside of Dublin, reflecting its role as a strategic gateway between the Republic of Ireland and Northern Ireland.[4]

The county is characterised by dense urban settlement concentrated in two principal towns: Dundalk (population 43,112), the county town and administrative centre, and the Louth portion of Drogheda (20,257), a regional hub straddling the County Meath border. Together, these two settlements account for 45% of the county's population, with Ardee (5,294), Dunleer (1,837), and thirteen smaller settlements hosting a further 10%. The remaining 45% of residents live in dispersed rural areas across an agricultural landscape, including historic villages, coastal fishing communities (Carlingford, Clogherhead, Annagassan), and the Cooley Peninsula uplands.[5]

Coastal exposure is extreme: 51% of the county's population resides within 5 km of the coast, positioning the majority of residents in zones vulnerable to coastal flooding, storm surge, and sea-level rise. Dundalk sits on a low-lying coastal plain at the head of Dundalk Bay, while Drogheda occupies the lowest gradient of the River Boyne valley adjacent to the Boyne estuary. Both towns are intersected by tidal rivers (Castletown River in Dundalk, River Boyne in Drogheda), creating compound flood risk from fluvial, pluvial, and coastal sources.

County Louth's economy is anchored by manufacturing, logistics, and services, reflecting its position along the Dublin-Belfast Economic Corridor[6]. Drogheda Port handles bulk freight and construction materials, supporting regional supply chains.[7] Dundalk hosts significant pharmaceutical manufacturing such as MSD[8], food processing, and retail distribution centres. The county depends on infrastructure networks (road, rail, port, power and wastewater) that are increasingly exposed to climate hazards.

[3] Louth County Development Plan 2021-2027 - Louth County Council
[4] https://data.cso.ie/
[5] https://www.cso.ie/en/releasesandpublications/ep/p-cp2tc/cp2pdm/pd/
[6] Invest | Louth County Council | Dublin Belfast Economic Corridor
[7] DROGHEDA Port - Ports Directory
[8] MSD Ireland announces acquisition of WuXi Vaccines' Dundalk site - MSD Ireland

1.2 Main objectives of the project

The overall objective of Phase 2 of the CLIMAAX project for County Louth is to refine and deepen the understanding of climate risks across the county by building on the outputs of Phase 1 and integrating localised evidence into the assessment. Phase 1 established a baseline understanding of the county's climate risk profile using EU-wide datasets provided through the CLIMAAX Handbook Toolkit, identifying flooding (coastal and river), heavy rainfall, and windstorms as the three priority hazards. While this initial assessment provided a valuable high-level screening, it also highlighted the need for more detailed, locally grounded analysis to capture the specific ways in which these risks affect communities, infrastructure, and services across the county.

Phase 2 addresses this need by enhancing the understanding of exposure and vulnerability through the integration of local datasets and structured stakeholder engagement. EU-wide datasets were coupled with more detailed Irish sources to improve local accuracy for County Louth. Met Éireann and Office of Public Works (OPW) observations were used to better reflect observed storm conditions, while local authority zoning data replaced LUISA[9] data to enable settlement-level damage analysis. These datasets were further supported by stakeholder inputs, ensuring the outputs reflect local planning context and priorities.

Local datasets consisted mostly of rainfall, floods and wind data available from Met Éireann, along with building classification. The assessment draws on data from LCC and the OPW, including planning documents, flood risk mapping, emergency management records, and post-storm incident reports, alongside qualitative evidence gathered through community drop-in sessions, technical workshops, elected representative engagement, and an online survey distributed through the PNN. This combination of quantitative and qualitative evidence enables a more complete and locally relevant picture of climate risk than was achievable through EU-level data alone.

The significance of Phase 2 to County Louth is considerable. The assessment provides the evidence base required to inform the development of the next LCDP, presenting a direct opportunity to embed climate risk considerations into the county's strategic planning direction, land-use policies, and infrastructure investment priorities. It also strengthens the evidence underpinning the Louth Climate Action Plan (LCAP) 2024–2029[10] and the Local Economic and Community Plan (LECP)[11], ensuring that climate resilience is integrated across the county's long-term spatial, economic, and social planning frameworks. For communities across the county, the assessment validates and quantifies the climate risks that residents, businesses, and local organisations are already experiencing, providing a formal evidence base to support advocacy for adaptation measures and resource allocation.

The use of the CLIMAAX Handbook and its associated workflows has been central to the delivery of Phase 2. The Handbook provides a standardised, step-by-step methodology for climate risk assessment that ensures consistency, transparency, and comparability with other European regions participating in the CLIMAAX programme. This structured approach has enabled the

[9] JRC Data Catalogue - Collection - European Commission
[10] Climate Action Plan - Louth County Council
[11] Dublin City Local Economic and Community Plan | Dublin City Council

project team to apply a recognised and peer-reviewed framework while tailoring the analysis to the specific conditions and priorities of County Louth. The Handbook's multi-hazard workflow structure has also facilitated the systematic assessment of exposure, vulnerability, and risk across the three priority hazards, ensuring that each is analysed using a consistent and rigorous methodology. In Phase 2, the benefit of the CLIMAAX Handbook has been particularly evident in the integration of local data into the standardised workflows, allowing the assessment to move from the broad EU-level screening conducted in Phase 1 to a more refined and locally calibrated analysis.

Phase 2 also seeks to include more detailed local data on asset locations, infrastructure condition, the absence of nationally downscaled climate projections for certain hazard variables, and the need for stronger community and stakeholder input to ground-truth the quantitative findings. While not all these gaps have been fully resolved, particularly those relating to data availability and resolution, the stakeholder engagement process has provided critical qualitative evidence to supplement the available datasets. Community-reported experiences, location-specific observations, and local knowledge of vulnerable areas and populations have enriched the assessment and ensured that it reflects the lived reality of climate risk in County Louth, not solely the outputs of modelled projections.

1.3 Project team

The CLIMAAX project for County Louth is delivered through a collaboration between Louth County Council, Grant Thornton Ireland, and M-CO.

LCC provides local leadership, stakeholder coordination, and alignment with policy and planning frameworks. Grant Thornton Ireland leads the technical delivery of the climate risk assessment, supported by specialist expertise from M-CO in stakeholder engagement and climate adaptation.

The combined team brings expertise in climate risk modelling, GIS analysis, policy development, and stakeholder engagement, ensuring that the outputs are both technically robust and locally relevant.

1.4 Outline of the document’s structure

This document follows the CLIMAAX Phase 2 deliverable structure.

Section 2 presents the Phase 2 climate risk assessment, including scoping, stakeholder engagement, and detailed risk analysis. The scoping section outlines how Phase 1 findings have been refined, including enhanced stakeholder input and improved data integration.

Subsequent sections detail the risk exploration and regionalised risk analysis, focusing on the three priority hazards identified: flooding, heavy rainfall, and windstorms.

The document concludes with key findings, reflections on the assessment process, and a work plan for Phase 3, which will focus on the development of targeted adaptation strategies.

2 Climate risk assessment – phase 2

2.1 Scoping

2.1.1 Objectives

The objective of the Phase 2 CRA is to refine and deepen the understanding of climate risks in County Louth by building on the baseline established in Phase 1. Where Phase 1 provided a high-level identification and quantification of priority hazards using EU-wide datasets, Phase 2 moves beyond this initial screening to produce a more detailed, locally grounded, and community-informed assessment of how these risks manifest across the county.

The purpose of Phase 2 is threefold. First, it seeks to integrate local data and site-specific evidence into the risk assessment, addressing the data gaps identified in Phase 1 and producing a more granular understanding of exposure and vulnerability at a sub-county level. Second, it aims to capture stakeholder perspectives, lived experience, and local knowledge through a structured engagement process, ensuring that the assessment reflects the realities of climate risk as experienced by communities, elected representatives, and technical experts across County Louth. Third, it provides a strengthened evidence base to directly inform policy and decision-making at both local and regional level.

The expected outcomes of Phase 2 include a validated set of priority climate risks for the county, a detailed understanding of how these risks are distributed across geographic areas and population groups, and an evidence base that is suitable for integration into planning and policy processes. In particular, the outputs of this phase are intended to directly inform the development of the next LCDP which presents a critical opportunity to embed climate risk evidence into the county's strategic direction, land-use policies, and infrastructure investment priorities. The assessment will also support future iterations of the LCAP 2024–2029 and the LECP, ensuring that climate resilience is integrated into long-term spatial, economic, and social planning for the county. Beyond these local planning instruments, the outcomes contribute to Ireland's obligations under the National Adaptation Framework (NAF)[12] and the Low Carbon Development Act (LCDA) 2021[13], and provide a model for how the CLIMAAX Framework can be applied at a local authority level in an Irish context.

The Phase 2 assessment has operated within several limitations and boundaries. In terms of data availability, the assessment has been largely dependent on datasets accessible from Louth County Council, Met Eireann, and the OPW. The data sets obtained include planning documents, emergency management records, post-storm incident reports, and OPW flood risk data such as Catchment Flood Risk Assessment and Management (CFRAM) maps[14]. While these sources provide a valuable foundation, detailed spatial data on asset locations and critical infrastructure functions remain incomplete, and socio-economic vulnerability data at a sub-county level is limited. The absence of nationally downscaled climate projections for key variables such as localised sea level rise, extreme wind speeds, and drought frequency continues to constrain the precision of certain aspects of the assessment.

[12] National Adaptation Framework (NAF)
[13] Climate Action and Low Carbon Development (Amendment) Act 2021 – No. 32 of 2021 – Houses of the Oireachtas
[14] CFRAM Programme

Stakeholder engagement, while extensive, also presented challenges. Attendance at community drop-in sessions varied across locations, and some vulnerable populations, including non-English speakers, people with disabilities, and homeless individuals, may have been underrepresented despite efforts to design inclusive engagement formats. Communicating the inherent uncertainties in climate projections without undermining the urgency for action required careful framing, and balancing the level of detail needed for technical stakeholders with accessibility for the general public necessitated the development of multiple communication products. The engagement process also highlighted the challenge of managing expectations, as some participants sought immediate action on known problems rather than the longer-term evidence-building that a CRA process delivers.

These limitations have been partially addressed through the stakeholder engagement process itself, which provided qualitative and locally grounded evidence to supplement the quantitative datasets. Community-reported experiences of past climate events, location-specific observations on infrastructure vulnerabilities, and local knowledge of vulnerable areas and populations have enriched the assessment beyond what the available quantitative data alone could provide. Where gaps remain, they have been clearly documented and will inform the scope of Phase 3, which will focus on translating the assessment findings into targeted adaptation measures and identifying where further data collection or analysis is required.

2.1.2 Context

LCC has taken a proactive and structured approach to assessing and managing climate hazards, impacts, and risks. Since signing the National Climate Action Charter (NCAC) in 2019[15], climate action has been embedded as a core priority, with the LCAP 2024–2029 providing a clear roadmap for delivering national climate goals at a local level. The Louth Climate Adaptation Strategy (LCAS) 2019–2024[16] established a risk register covering critical operational areas including infrastructure, land use, waste systems, business continuity, and community health, and this register has continued to inform planning and adaptation decisions throughout Phase 2.

The CRA builds on this foundation by deepening the understanding of how climate risks manifest at a local level. Where Phase 1 relied on EU-wide datasets to identify and quantify priority hazards, Phase 2 integrates locally sourced data, stakeholder engagement, and site-specific evidence to produce a more granular and contextually relevant assessment. A key development during Phase 1 was the publication of the National Climate Change Risk Assessment (NCCRA) in 2025[17], which reinforced the need for detailed local-level climate risk assessments and highlighted gaps in understanding how socio-economic and health factors influence vulnerability. The Phase 2 assessment has been informed by these national findings and seeks to address these gaps within the Louth context.

The Local Authority Climate Action Plan (LACAP)[18] is developed in compliance with the NCAC and the LCDA 2021, which requires local authorities to prepare climate action plans. LCC is also subject to obligations under the European Strategic Environmental Assessment (SEA) Directive

[15] Local Authority Climate Action Charter - CARO
[16] Climate Change Adaptation Strategy - Louth County Council
[17] National Climate Change Risk Assessment Main Report | Environmental Protection Agency
[18] Local Authority Climate Action Plans (LA CAPs) - CARO

and Appropriate Assessment (AA) requirements under the Habitats Directive[19]. The CRA is supported by the EU under CLIMAAX, funded through Horizon Europe[20], which provides access to the CLIMAAX Handbook Toolkit for multi-risk climate assessments.

A critical development in Phase 2 is the role of the CRA in informing the next LCDP. The current LCDP 2021–2027 is nearing completion, and the CRA presents a direct opportunity to embed climate risk evidence into the next plan's strategic direction, land-use policies, and infrastructure investment decisions. The outcomes of the Phase 2 assessment will also support future iterations of the LECP, ensuring that climate resilience is integrated into long-term spatial and socio-economic planning for the county.

The sectors identified in Phase 1 as most relevant to the climate risk assessment remain unchanged in Phase 2: water services and management, transport and infrastructure, health and social services, community, tourism, and biodiversity. Phase 1 established how each of these sectors is affected by climate change, from the strain that intense rainfall and storms place on water and drainage infrastructure, to the disruption of transport networks, the pressures on health services in rural and isolated areas, and the threats to coastal tourism, heritage sites, and fragile ecosystems such as Carlingford Lough, the Cooley Mountains, and the Boyne, Dee, and Glyde estuaries. Phase 2 has confirmed and deepened this understanding through stakeholder engagement, which identified specific local pressures including drainage and wastewater systems operating at or beyond capacity, recurring flooding in settlements and along transport corridors, and disproportionate impacts on vulnerable populations such as elderly residents, low-income households, and geographically isolated communities.

In terms of data availability, Phase 2 has been shaped by the datasets accessible from LCC and the OPW. These include LCC planning documents, the LACAP, the LCAS, emergency management records, and post-storm incident reports, alongside OPW flood risk data including CFRAM maps and flood relief scheme documentation. While these sources provide a valuable evidence base, they also present limitations. Detailed spatial data on asset locations and critical infrastructure functions remains incomplete, and socio-economic vulnerability data at a sub-county level is limited. The absence of nationally downscaled climate projections for key variables such as sea level rise, extreme wind, and drought continues to constrain the precision of certain aspects of the assessment. These data limitations have been partially addressed through the stakeholder engagement process, which provided qualitative and locally grounded evidence to supplement the quantitative datasets.

Existing cross-border cooperation provides a foundation for this coordination. The Shared Island Fund and the PEACE PLUS Programme (2021–2027)[21] support sustainable development in areas such as biodiversity, coastal and marine management, and water quality across Northern Ireland and the border counties. The All-Island Climate and Biodiversity Research Network (AICBRN)[22] facilitates research collaboration on climate and biodiversity issues across both jurisdictions. These initiatives provide opportunities to align climate risk assessment and adaptation planning

[19] Strategic Environmental Assessment (SEA) - Environment
[20] Horizon Europe - Research and innovation - European Commission
[21] PEACEPLUS | SEUPB
[22] AICBRN – All-Island Climate and Biodiversity Research Network

across administrative boundaries, and the outcomes of the CLIMAAX project for County Louth can contribute to and benefit from these broader efforts.

Possible adaptation interventions for the priority climate risks were identified in Phase 1 across each relevant sector. These included integrated catchment-based planning and the expansion of sustainable drainage systems for water services, reinforcement of roads and bridges in flood-prone areas for transport infrastructure, the establishment of community support centres and mobile healthcare provision for health and social services, the protection of heritage sites and diversification of tourism, and the restoration of coastal dunes, wetlands, and ecological corridors for biodiversity. Phase 2 stakeholder engagement has reinforced and expanded these interventions through community-led suggestions, including increased maintenance of drainage infrastructure, expanded nature-based solutions such as mixed native tree planting and restored wetland capacity, improved emergency preparedness and communication, and a stronger focus on prevention rather than response. These community-identified measures will be further developed and prioritised in Phase 3.

2.1.3 Participation and risk ownership

Stakeholder Involvement Process in Phase 2

Phase 2 of the CLIMAAX project for County Louth involved a comprehensive stakeholder engagement process conducted throughout November 2025. The engagement strategy was designed to gather perceptions of climate risks, lived experience and community-led ideas relating to climate adaptation across the county. These engagement activities were led by the Louth Climate Action Team in collaboration with Grant Thornton Ireland and M-CO.

The stakeholder involvement process comprised multiple engagement formats across different stakeholder groups. These were:

1. **Community group engagement** - drop-in sessions held at four locations across County Louth.
2. **Elected representative meeting** - an engagement meeting took place with the members of Louth County Council.
3. **Technical and expert engagement** - workshops were held with council staff and technical experts.
4. **Online survey** – this was distributed through the Louth PPN.
5. **Post-storm incident reporting** - following Storm Chandra in January 2026.

Risk Ownership Organisation in County Louth

Louth County Council holds the primary responsibility for climate risk identification, assessment, and adaptation planning at the local level, as mandated by the NCAC and the LCDA. Specific responsibilities include:

- **Risk Identification and Assessment** - The Climate Action Team leads the development of climate risk assessments, including the current CLIMAAX project, building on the LCAS and the LCAP.

- **Adaptation Planning** - The council is responsible for integrating climate risk considerations into strategic planning documents, including the LCDP and the LECP.
- **Service Delivery and Infrastructure** - Different council departments manage specific risk areas including:
    - Roads Department: road infrastructure resilience and maintenance.
    - Planning Department: land-use planning and development control in risk areas.
    - Environment Services: environmental protection and biodiversity.
    - Emergency Services: emergency response coordination.

Shared Responsibilities with National Agencies

Several climate risks require coordinated action between the council and national agencies such as the OPW for flood relief schemes, Uisce Eireann for public water supply, Inland Fisheries for river management and the Health Service Executive (HSE) and Civil defence to support emergency response during extreme weather events particularly for vulnerable groups.

Representatives of Vulnerable Groups and Exposed Areas

While there was a lack of formal representation of vulnerable groups at the community group sessions, there were multiple references by participants in all locations to their vulnerable and exposed community members such as elderly neighbours and residents of areas known to flood on a regular basis. Participants described how local communities had come together in ad hoc ways to support these groups in the past such as local delivery networks supporting people unable to travel during storms and informal coordination to clear drains, ditches, and culverts after heavy rainfall. These actions demonstrate the ability of local communities to self-organise and suggests a readiness for more structured, supported adaptation initiatives.

Information on Acceptable/Tolerable Risk Levels

The Phase 2 engagement process did not identify any prior formal documentation of acceptable or tolerable risk levels for County Louth. However, several indicators of risk tolerance were noted through the engagement process, which are summarised in Table 2-1 below:

Table 2-1: Implicit Risk Tolerance Indicators

Risk Area	Description
Historical Events as Reference Points	Elected representatives and community members referenced past flood events and Storms Ophelia (2017)[23] and Éowyn (2025)[24] as benchmarks for unacceptable risk levels. The Phase 2 assessment estimates that under future climate scenarios, a Storm Éowyn-equivalent event could cause €287 million in structural damages across County Louth. This level of impact is considered beyond tolerable risk levels.
Infrastructure Design Standards	Existing drainage and flood protection infrastructure was designed to historical standards (for example 50-year or 100-year return periods).

[23] https://www.met.ie/forecasts/storm-names
[24] https://www.met.ie/forecasts/storm-names

	However, stakeholders noted that these standards are increasingly inadequate.
Insurance Availability	Elected representatives raised concerns about flood-risk insurance availability for households in high-risk zones, suggesting that areas where insurance is unavailable or unaffordable represent intolerable risk levels.
Community Expectations	Engagement participants expressed expectations that: a. Roads should remain passable during normal rainfall events b. Homes and businesses should be protected from routine flooding c. Emergency services should be accessible during extreme weather d. Critical infrastructure should remain operational
Regulatory Frameworks	Planning policy and flood risk management guidelines provide implicit risk tolerance thresholds by restricting development in high-risk flood zones. However, some stakeholders noted concerns about enforcement.

The Stakeholder Organigram below illustrates the organisations involved and the responsibilities they hold for climate risk management in County Louth.

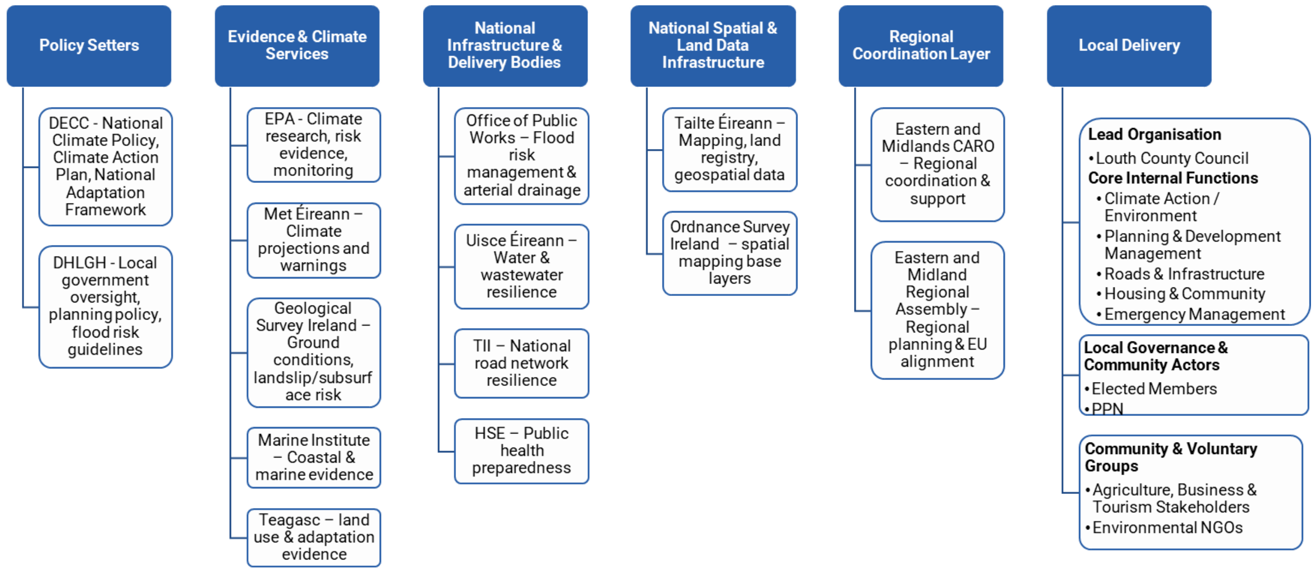

Figure 2-1. Organigram mapping stakeholder responsibilities and how they are interconnected.

2.1.4 Application of principles

The CLIMAAX Phase 2 climate risk assessment for County Louth was conducted in accordance with the three core principles outlined in the CLIMAAX Framework which are social justice, equity, and inclusivity; quality, rigour, and transparency; and the precautionary approach. This section describes how each principle was integrated into the assessment process.

Social Justice, Equity, and Inclusivity

The principle of social justice, equity, and inclusivity was embedded throughout the Phase 2 assessment to ensure that climate risks and adaptation needs of all community members, particularly vulnerable and marginalised groups, were identified and prioritised. Examples of this are:

Inclusive Engagement Design
The engagement strategy was designed to reach diverse communities across County Louth. Engagement was conducted through multiple channels (in-person sessions, meetings and online surveys) to accommodate different preferences and accessibility needs. The in-person community events were designed as casual drop in sessions in the evening in order to encourage participation. All events met EU accessibility standards.

Vulnerable Group Identification and Representation
The assessment explicitly identified and documented the specific vulnerabilities of priority groups such as elderly residents, low income households, coastal residents and isolated rural communities.

Equity in Risk Assessment
The assessment examined how climate risks are distributed unequally across the population. For example it recognised that climate change does not affect everyone equally and documented how different community groups face heightened risks due to location, lack of resources, limited access to services, or geographic isolation.

Inclusive Adaptation Planning
Community-led ideas and local knowledge were documented and treated as priority data alongside the technical and scientific data. A strong theme emerging from the engagement process was that adaptation requires both local empowerment and system-level change, emphasising the need to support community-led initiatives.

Quality, Rigour, and Transparency
The principle of quality, rigour, and transparency was also applied to ensure that the climate risk assessment is scientifically sound, methodologically robust, and clearly documented.

Methodological Rigour
This approach ensures alignment with a recognised European framework while strengthening local relevance through the integration of Irish datasets. By combining standardised CLIMAAX methodologies with region-specific data inputs, the assessment maintains comparability across regions while improving the accuracy of hazard representation for County Louth.

Data Quality and Validation (commentary with data listed)
Data quality was strengthened through the use of multiple, complementary sources, including EU-wide climate datasets, Met Éireann observational records, OPW CFRAM flood maps, National Indicative Fluvial Map (NIFM)[25] depth rasters, economic damage estimates, and infrastructure data. Quantitative modelling outputs were validated against historical events (e.g., Storm Ophelia 2017, Storm Éowyn 2024 and Storm Chandra[26] 2026 and recent flood events) and supplemented by community-reported experiences, ensuring that results reflect both observed impacts and local knowledge.

Transparency in Process and Findings
The assessment process and findings were documented and communicated transparently. Preliminary findings were presented to stakeholders for feedback and validation, ensuring that the assessment reflects both scientific evidence and local experience.

Precautionary Approach

The precautionary approach was applied throughout the assessment to ensure that uncertainty about future climate risks does not delay action to protect communities and ecosystems. The assessment prioritised analysis of worst-case scenarios to ensure preparedness for severe climate impacts such as:

- The analysis explored Representative Concentration Pathway (RCP) 4.5 and RCP 8.5, with a focus on the RCP 8.5 high-emissions scenario to stress-test Louth's resilience against worst-case climate outcomes.[27]
- By focusing on high-emissions scenarios, the assessment ensures that adaptation planning is robust enough to handle severe climate impacts, even if lower-emissions pathways are ultimately realised.
- The RCP 4.5 moderate-emissions scenario was also analysed to provide a comparative baseline and understand the range of possible futures.

Early Action on Emerging Risks
The assessment identified risks that are projected to worsen significantly in the future, emphasising the need for early action.

[25] NIFM User Guidance Notes - Floodinfo.ie
[26] Storm Names - Met Éireann - The Irish Meteorological Service
[27] Chapter 4: Future Global Climate: Scenario-based Projections and Near-term Information

Addressing Irreversible Impacts

The assessment gave particular attention to risks with potentially irreversible consequences which are outlined in Table 2.2 below:

Table 2-2: Climate risks with irreversible impacts

Risk	Consequence
Coastal Erosion	The assessment identified coastal erosion as a risk that can result in permanent loss of land, infrastructure, and ecosystems.
Ecosystem Degradation	Risks to fragile ecosystems in the Cooley Mountains, Carlingford Lough, and estuaries (Boyne, Dee, Glyde) were identified as potentially irreversible.
Cultural Heritage Loss	Threats to heritage sites such as Monasterboice were documented as risks with irreversible cultural and historical consequences.

2.1.5 Stakeholder engagement

Stakeholder engagement was a principal component of Phase 2 of the CLIMAAX project for County Louth. This section describes the engagement process, participants involved, communication methods, feedback received, and challenges encountered.

Engagement Approach and Participants

The engagement strategy employed multiple formats to ensure broad participation and gather diverse perspectives on climate risks and adaptation needs.

Community Drop-In Sessions - Four in-person public engagement sessions were held across County Louth in November 2025 in Ardee, Dundalk, Cooley and Drogheda. These sessions were designed as informal drop-in evening events where community members could attend at their convenience, view information materials, and share their experiences and concerns with the project team including information on exposed areas and vulnerable groups.

Elected Representative Meeting - A dedicated stakeholder session was held with County Councillors on November 6, 2025, at a Louth Council Meeting. This session provided elected representatives with an overview of the Phase 1 findings and gathered their perspectives on climate risks, policy priorities, and community concerns.

Online Survey - An online survey was distributed through the PPN to gather feedback from community and voluntary organisations across County Louth. The survey asked respondents to share their experiences of extreme weather events, identify vulnerable areas and groups, and suggest adaptation measures.

Internal/Technical Stakeholder Engagement - Following Storm Chandra in January 2026, Louth County Council technical staff compiled detailed incident reports documenting flooding, road damage, and infrastructure impacts across the county. This internal engagement provided valuable data on current climate risks and infrastructure vulnerabilities.

Communication of project goals and results

Phase 2 goals and findings were communicated using the following mechanisms:

- **Plain-language summary** – A layman's briefing document of Phase 1 findings titled "County Louth's Climate Future: A Guide to Our Key Risks" was prepared for public distribution.
- **Press release** - this was issued to local and regional media highlighting the connection between global climate trends and local impacts in County Louth.
- **Summary article and survey link** - the article and survey were distributed through the PPN newsletter to reach community and voluntary organisations.
- **Detailed briefing document** – this was prepared for internal distribution to Louth County Council staff and elected representatives.

Reception of Results by Participants

The engagement process revealed strong alignment between the quantitative risk assessment findings and community experiences, along with clear calls for action. Participants appreciated the quantitative evidence base provided by the assessment. Community participants strongly validated the identification of flooding, heavy rainfall, and windstorms as priority hazards. Participants also expressed a clear sense of urgency and called for practical action.

Feedback from Participants

The engagement process generated rich feedback across multiple themes as outlined below.

Key Climate Impacts Identified - Participants provided detailed, location-specific feedback on climate impacts. Here are the key points by location:

- **Ardee**: Flooding pressures along river systems, tree safety during wind events, reliance on informal access and support systems.
- **Cooley Peninsula & Carlingford**: Recurrent flooding affecting key infrastructure, risk to housing near rivers, blocked access roads, culvert sizing concerns.
- **Dundalk:** Poor drainage and wastewater overflow, tree management concerns, storm preparedness needs, biodiversity loss linked to increased risks.
- **Drogheda**: Coastal erosion, blocked access routes during flooding, run-off pollution, risk to community infrastructure including allotments and sports grounds.
- **Countywide:** Insurance concerns, future-proofing growth areas, need for integrated sustainable drainage systems, coastal and upland management gaps.

Existing Community Resilience - Participants shared examples of informal adaptation measures already in place such as local delivery networks supporting people unable to travel during storms and informal coordination to clear drains, ditches, and culverts after heavy rainfall.

Suggested Adaptation Actions - Participants proposed a mix of infrastructure, governance, and behaviour-based solutions such as:

1. **Infrastructure Improvements**
    a. Restore or improve drainage systems, culverts, and river management practices.
    b. Increase maintenance schedules for gullies, roadside ditches, and stormwater infrastructure.
2. **Nature-Based Solutions**
    a. Expand nature-based solutions including mixed native tree planting and restored wetland capacity.

   b. Participants frequently framed trees, wetlands, and local stewardship as climate assets, not obstacles.
3. **Governance and Policy**
   a. Introduce clearer policies and local authority empowerment for smaller-scale adaptation works.
   b. Improve emergency preparedness, communication channels, and neighbourhood support planning.
4. **Local Energy and Innovation**
   a. Use hydropower or local energy generation where feasible.
5. **Prevention Focus**
   a. Many comments highlighted the need for a focus on prevention measures, not just response measures.

How Project Outcomes Will Be Further Used by Participants

The engagement process identified multiple ways in which participants intend to use the project outcomes. Below is a summary of the ways they will be used by each participant group:

Louth County Council

1. The outputs provide a critical evidence base that will directly inform the development of the next LCDP and other strategic initiatives, ensuring that climate resilience is embedded at the core of the county's future growth and development plans.
2. The quantitative risk assessment provides evidence to support applications for funding for flood relief schemes, drainage improvements, and other adaptation measures.
3. The assessment informs day-to-day operational decisions by council departments, including roads maintenance, planning applications, and emergency response planning.
4. The assessment also provides a baseline against which future progress in climate adaptation can be measured.

Elected Representatives

1. The assessment provides evidence to support policy decisions on land-use planning, infrastructure investment, and climate adaptation priorities.
2. The quantitative evidence of climate risks and economic impacts supports advocacy for increased resources from national government.
3. The assessment validates and quantifies the concerns raised by constituents about flooding, drainage, and storm impacts.

Community Groups and Residents

1. The project outcomes provide evidence to support community advocacy for specific adaptation measures in their areas.
2. Understanding of climate risks will inform household and community-level preparedness measures.
3. The assessment validates the importance of community-led resilience initiatives, such as mutual aid networks and nature-based solutions.

Difficulties Encountered

The engagement process encountered several challenges as outlined below.

Participation and Representation Challenges

1. Attendance at public drop-in sessions varied by location, with some areas having stronger representation than others.
2. Limited responses were received to the online survey. This may have been linked to a lack of incentive for responders, or possibly a lack of knowledge, particularly in relation to longer-term time horizons.
3. While efforts were made to reach diverse groups, some vulnerable populations (e.g., non-English speakers, people with disabilities, homeless individuals) may have been underrepresented.

Communication Challenges

1. Communicating the inherent uncertainties in climate projections and risk assessments without undermining the urgency of action required careful framing.
2. Providing sufficient detail for technical stakeholders while maintaining accessibility for general public audiences required multiple communication products.

Governance and Coordination Challenges

1. The engagement process highlighted the challenge of fragmented responsibilities across multiple agencies, making it difficult to provide clear answers about who is responsible for specific adaptation actions.
2. Coordinating the engagement process with other ongoing planning processes (e.g., LCDP review) required careful timing and communication.

Data and Evidence Challenges

1. Some participants requested more detailed, location-specific data than was available from the EU-wide datasets, highlighting the need for Phase 2 local data integration.
2. Systematic documentation of past climate events and impacts was limited, making it challenging to validate model outputs against historical experience.
3. Limited availability of detailed socio-economic vulnerability data at the local level constrained the ability to conduct fine-grained vulnerability assessments.

Expectation Management Challenges

1. Some participants expressed frustration about the time required for the assessment process and desired more immediate action on known problems.
2. Managing expectations about what the assessment could deliver (evidence base for planning) versus what participants wanted (immediate implementation of adaptation measures) was sometimes challenging.
3. Participants raised concerns about whether sufficient resources would be available to implement the adaptation measures identified through the assessment.

2.2 Risk Exploration

2.2.1 Screen risks (selection of main hazards)

Risk exploration builds on the initial screening conducted in Phase 1, where a broad set of climate hazards were assessed using EU-wide datasets and progressively refined into a prioritised shortlist through application of the CLIMAAX framework. That process identified flooding (coastal and river), heavy rainfall, and windstorms as the most significant climate risks for County Louth. Phase 2 advances this step by validating and refining these hazards using local evidence, stakeholder input, and additional data sources to ensure that the assessment accurately reflects the current and emerging climate risk profile of the county.

No new primary hazards have been introduced in Phase 2. Instead, the screening process has focused on refining the understanding of the priority hazards identified in Phase 1, with particular emphasis on how these risks manifest spatially and impact different communities, infrastructure systems, and sectors across County Louth. The Phase 2 assessment confirms that flooding, heavy rainfall, and windstorms remain the most relevant climate hazards for the county, consistent with both the quantitative analysis conducted in Phase 1 and the qualitative evidence gathered through stakeholder engagement.

Stakeholder engagement undertaken in Phase 2 has provided additional insight into the observed and expected behaviour of these hazards. Participants consistently identified flooding, heavy rainfall, and windstorms as the most pressing risks affecting their communities, validating the Phase 1 hazard prioritisation. They also highlighted localised impacts that were not fully captured in the EU-level datasets, including recurring flooding at specific transport routes, drainage and culvert capacity constraints, and access limitations during extreme weather events. These insights confirm that the selected hazards are both current and highly relevant to the lived experience of communities across County Louth.

The decision to retain the same set of priority hazards in Phase 2 reflects both the robustness of the Phase 1 screening process and the strong alignment between modelled data and stakeholder feedback. Rather than expanding the hazard set, the focus of Phase 2 has been on deepening the analysis of these risks, particularly in terms of exposure, vulnerability, and the cascading impacts on infrastructure systems and communities. This approach is consistent with the CLIMAAX methodology, which emphasises progressive refinement of risk understanding across phases.

The assessment in Phase 2 draws on a combination of data sources, including EU-wide datasets from Phase 1, locally available data from Louth County Council and the Office of Public Works, and qualitative evidence gathered through stakeholder engagement. These data sources include flood risk mapping, planning and infrastructure data, post-storm incident reports, and community-reported experiences of past climate events. While these datasets have significantly strengthened the assessment, several data gaps remain. In particular, there is limited availability of high-resolution local data on asset-level exposure, infrastructure condition, and socio-economic vulnerability. There is also a lack of fully integrated datasets that combine hazard, exposure, and vulnerability information in a consistent and centralised format.

Overall, Phase 2 strengthens the initial risk screening by confirming the relevance of the priority hazards, refining their localised impacts, and identifying key data gaps and dependencies that will need to be addressed in subsequent phases.

2.2.2 Choose Scenario

The Phase 2 assessment considers multiple future climate conditions across the three priority hazards, reflecting both the range of possible emissions trajectories and the specific data architectures available for each hazard workflow. The scenario choices utilised RCP 4.5 (moderate emissions) and RCP 8.5 (high emissions) as the primary climate framing.

For the flooding hazard, the Phase 2 assessment adopts the OPW CFRAM / NIFM scenario framework, which defines three climate conditions: current (present climate), mid-range future scenario and high-end future scenario. The mid-range future scenario applies a +20 % uplift to peak river flows and a +500 mm uplift to coastal mean sea level, while the high-end future scenario applies +30 % and +1,000 mm respectively. These uplift envelopes were designed by the OPW to span the Intergovernmental Panel on Climate Change (IPCC)[28] 21st-century range for Ireland and are not directly aligned to individual RCP pathways. Instead, they function as bracketing scenarios that allow the assessment to stress-test flood risk under both a plausible mid-range and a precautionary high-end climate future. The use of the OPW scenario set ensures direct compatibility with the national flood risk management framework and the CFRAM programme outputs that underpin local planning decisions. Each scenario is assessed at three return periods for river flooding (RP10, RP100 and RP1000) and three for coastal flooding (RP10, RP200 and RP1000), producing a 3 × 3 matrix of hazard, exposure and damage outputs per analysis unit.

For the heavy rainfall hazard, assessment uses EURO-CORDEX-11[29] regional climate model output under both RCP 4.5 and RCP 8.5, assessed mainly across two 30-year future periods: near-term (2011–2040), mid-century (2041–2070), with less emphasis on the end-of-century period (2071–2100), as modelling for this timeframe produced more uncertain results. These future periods were compared against a historical baseline of 1976–2005. For Phase 2, the EURO-CORDEX-11 models are validated against Met Éireann data. The inclusion of both RCP 4.5 and RCP 8.5 enables the assessment to distinguish between a moderate-emissions pathway, where the forced climate signal does not clearly emerge from internal variability at 30-year windows, and a high-emissions pathway, where a positive intensification signal emerges at mid-century.

For the windstorm hazard, the Phase 2 assessment does not utilize future climate model projections under specific RCP pathways, as EURO-CORDEX does not provide windstorm-specific downscaled outputs comparable to precipitation or temperature variables. Instead, the assessment is event-based, analyzing three observed historical storms (Ophelia 2017, Éowyn 2025, Chandra 2026) using Met Éireann hourly wind observations from two synoptic stations (Dublin Airport and Dunsany). To assess climate change impacts, a simple scaling approach is applied to the most extreme event (Storm Éowyn): IPCC AR6 guidance indicates a +10% increase in North Atlantic windstorm intensity under RCP 8.5 by mid-century (2050).

The time horizons considered in Phase 2 therefore span the short-term (present climate conditions), medium-term (mid-century, approximately 2041–2070 under the CORDEX framework and the mid-range future scenario under the OPW framework) and long-term (end-of-century, approximately 2071–2100 under CORDEX and the high-end future scenarios under OPW). The inclusion of the near-term period (2011–2040) in the heavy rainfall analysis provides an additional diagnostic window, although results at this horizon are dominated by internal climate variability rather than a forced emissions signal and are interpreted accordingly. The inclusion of the long-term period is also more exploratory in nature, as modelling for this timeframe produced greater

[28] IPCC — Intergovernmental Panel on Climate Change
[29] EURO-CORDEX Data

uncertainty. The OPW CFRAM/NIFM scenarios do not map directly to specific time horizons but are designed to represent the envelope of plausible climate futures over the remainder of the 21st century, with the high end future scenario corresponding broadly to a late-century high-emissions outcome.

In terms of future socio-economic conditions, the Phase 2 assessment does not apply formal Shared Socioeconomic Pathway (SSP)[30] scenarios to model future population growth, economic development or land-use change. This reflects both the data constraints of the assessment and the practical focus of the deliverable on informing near-to-medium-term planning decisions. Instead, the exposure layers used in Phase 2 represent current socio-economic conditions as a fixed baseline. Population exposure is derived from the CSO Census 2022 Small Area Population Statistics, which provides the most recent and spatially detailed population data available for County Louth at sub-county level. Land-use exposure for the county-wide river risk assessment is based on the LUISA European land-use layer at 100 m resolution, consistent with the CLIMAAX methodology. Within the Dundalk Area for Further Assessment (AFA), the Dundalk Local Area Plan 2025–2031[31] zoning layer provides a higher-resolution and locally specific exposure dataset comprising over 19,000 zoning polygons across 21 land-use categories. The LAP zoning layer captures planned as well as existing development and therefore implicitly incorporates some degree of future land-use change within the Dundalk urban area, including areas designated for new residential, employment and strategic reserve development.

The combination of climate and socio-economic conditions in Phase 2 is therefore structured as a climate-sensitivity analysis applied to a fixed present-day exposure baseline. This approach is consistent with the CLIMAAX methodology and reflects the practical reality that locally calibrated SSP projections are not available at the county level in Ireland. The implication is that the Phase 2 damage and exposure figures represent the impact of future climate conditions on the current built environment and population distribution. Where future development increases the value or density of assets in flood-prone areas, actual future damages could exceed the Phase 2 estimates. Conversely, where adaptation measures or land-use restrictions reduce exposure in high-risk zones, actual damages could be lower. This limitation is acknowledged and will be considered in Phase 3 when adaptation pathways and implementation strategies are developed.

2.3 Regionalized Risk Analysis

The Phase 2 assessment fine-tunes the standard CLIMAAX Handbook risk workflows for each of the priority hazards by replacing EU-wide datasets with locally sourced products, integrating site-specific exposure and vulnerability layers, and supplementing modelled outputs with observational and stakeholder evidence. The approach varies by hazard because the available local data products differ in their structure, resolution and coverage. In each case, the objective has been to retain the methodological consistency of the CLIMAAX framework while producing results that are grounded in the specific conditions and data landscape of County Louth.

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[30] Shared Socioeconomic Pathways (SSPs) database | Information portals | Discover the key services, thematic features and tools of Climate-ADAPT Climate-ADAPT

[31] Microsoft Word - Dundalk LAP 2025-2031 SFRA.doc

2.3.1 Hazard #1 Rainfall - fine-tuning to local context

Table 2-3 Data overview workflow #1

Hazard data	Vulnerability data	Exposure data	Impact metrics/Risk output
EURO-CORDEX-11 (12 km), 24h precipitation, 3 GCM/RCM chains, RCP 4.5 + RCP 8.5, baseline 1976-2005, futures 2011-2040 / 2041-2070 / 2071-2100	Number of structures and population in Dundalk LAP 2025-2031 footprint; LCC zoning shapefiles, OSI.gdb buildings	Land use from LCC zoning + LUISA cross-walk; Population from CSO Census 2022 Small Area + GHS-POP 2025	Hazard-impact database: 29 events × 10 stations + 140 georeferenced stakeholder observations
Observed station data: 10 Met Éireann gauges (Ardee Boharnamoe, Ardee St Brigid's Hosp., Castlebellingham Lynns, Clogher Head Port, Drogheda Killineer, Dundalk Annaskeagh W.W., M.Dundalk Ballymakellett, Mellifont Abbey, Omeath, Riverstown Glenmore Upper) + 2 proxy stations	OPW Dundalk Flood Relief Scheme footprint	Critical infrastructure: schools, creches, community centres, protected structures from LCC LAP shapefiles	Risk Priority Index dashboard (RPI = Severity × Urgency × Capacity)

2.3.1.1. Hazard assessment

Methodology

Phase 2 projections were estimated utilising European climate simulations known as EURO-CORDEX. As this is the same family of data that the Environmental Protection Agency (EPA)[32] draws on for Ireland's national climate projections, this ensures consistency with the recognised national evidence base. To address limitations in raw climate models, particularly their tendency to underestimate extreme rainfall along the Irish coast, a bias correction step is applied. This process adjusts each model so that its historical outputs align with observed rainfall data from gauges. The same adjustment is then applied to future projections, ensuring that absolute rainfall values are realistic while preserving the underlying climate change signal.

Three EURO-CORDEX-11 model chains (EC-EARTH/RACMO22E, MPI-ESM-LR/RCA4, and HadGEM2-ES/RACMO22E)[33] were assessed, with the headline results based on the bias-corrected MPI-ESM-LR/RCA4 chain following quality assurance. HadGEM2-ES/RACMO22E was excluded due to physically implausible behaviour, projecting lower extreme rainfall under higher emissions. EC-EARTH/RACMO22E was also excluded as it significantly underestimated extreme rainfall.

The bias-corrected MPI-ESM-LR/RCA4 chain demonstrated the closest alignment with observed data and was therefore selected as the primary basis for analysis. Given the convergence of bias-corrected outputs, a single validated model was considered more robust and transparent than an

[32] Home | Environmental Protection Agency
[33] 20180130-eurocordex-simulations.pdf

ensemble approach, while also maintaining consistency with the Phase 1 methodology. Excluded models are retained for sensitivity testing only and do not inform the headline results.

A decision was made to anchor the headline analysis to the mid-century period (2041–2070), rather than extending it to late-century projections, based on the following considerations:

- Alignment with national evidence: The EPA's projections focus on mid-century outcomes; adopting the same horizon ensures consistency with the recognised Irish evidence base.
- Strength of the model signal: Ensemble results show that the key finding, intensification of rainfall, is already clearly established by mid-century; extending to late-century does not materially strengthen this conclusion and primarily introduces additional variability.
- Consistency with comparable studies: Other CLIMAAX regional assessments (including in Italy, Türkiye, and Greece) adopt a similar mid-century planning horizon, providing a clear precedent.
- Increasing uncertainty at longer horizons: Beyond mid-century, projections for rainfall become progressively influenced by model variability and wider uncertainty, reducing the reliability of late-century outputs for decision-making.

The most significant local adaptation in the rainfall workflow is the development of three impact-calibrated rainfall thresholds specific to County Louth. Rather than relying on generic European threshold values, the Phase 2 analysis utilises thresholds from Met Éireann return-period tables at the Louth representative point (53.9°N, −6.4°W): a Low threshold of 38.5 mm per 24 hours (baseline return period of 2 years), a Medium threshold of 56.0 mm per 24 hours (baseline return period of 10 years) and a High threshold of 63.3 mm per 24 hours (baseline return period of 20 years). These thresholds were cross-validated against a purpose-built hazard-impact database containing 29 recorded historic events with documented impacts across County Louth and 136 georeferenced stakeholder observations from the local stakeholder engagement.

The aim of the extreme-rainfall hazard assessment is to estimate rainfall intensities, specifically the annual-maximum 24-hour precipitation volume, that is, the wettest 24-hour total in each calendar year, for the current and future climate (historical reference 1976–2005 to future periods 2011–2040 to 2041–2070).

As part of Phase 2, an observational baseline data set was gathered. This data came from Met Éireann station records and storm datasets. They are independent of any climate-model or bias-correction choice.

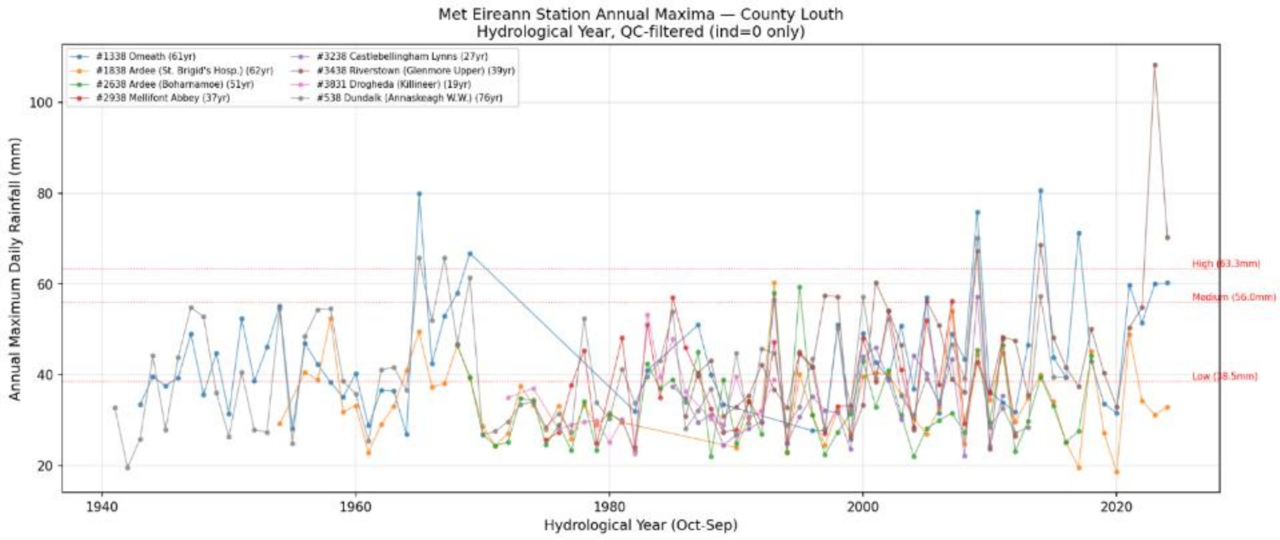

Figure 2-2. Met Eireann Station Annual Rainfall Maxima for County Louth

Some Met Éireann station records extend back to 1940, with consistent data available from seven stations from 1993 onwards, allowing identification of annual maximum 24-hour rainfall events. Notable peaks in 2014 and 2017 occur simultaneously across multiple stations, reflecting county-wide storm events, specifically ex-hurricane Bertha (August 2014)[34] and Storm Ophelia (October 2017). Data availability is more limited after 2020; however, the Riverstown station provides a record of extreme rainfall associated with Storm Babet in 2023[35].

Storm Éowyn (24 January 2025) was the most damaging windstorm to hit the Irish east coast in living memory and is therefore a useful reference point for the heavy-rainfall hazard. Cumulative 24-hour totals settle at 25–50 mm at inland stations, with elevated and coastal sites slightly higher. That puts Éowyn comfortably below the 63.3 mm/24h High threshold, Éowyn was a dangerous event but not a record rainfall event. The future projections describe something meaningfully worse than Éowyn.

Storm Chandra in January 2026, followed by an extreme rainfall event in February 2026, resulted in significant impacts across the county. Stakeholder accounts of these events, including photographic evidence, are available; however, localised datasets were not available to support modelling for this period. The incorporation of such data will be critical for future modelling and analysis.

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[34] [Storm Names - Met Éireann - The Irish Meteorological Service]
[35] [Storm Names - Met Éireann - The Irish Meteorological Service]

Figure 2-3. Blackrock February 2026

Figure 2-4. Bay Estate February 2026

Figure 2-5. Louth February 2026

Figure. 2-6. Louth February 2026

Results

Table 2-4: Rainfall intensities estimated using EURO-CORDEX-11 and MPI-ESM-LR/RCA4, climate-model data.

Period	RCP	Threshold	Intensity (mm/24h)	Baseline RP (yr)	Climate signal Δ%	Future RP (yr)
Near 2011-2040	4.5	Low	38.5	2	+23.8	2
Near 2011-2040	4.5	Medium	56	10	+15.7	6
Near 2011-2040	4.5	High	63.3	20	+12.5	13
Near 2011-2040	8.5	Low	38.5	2	+11.7	2
Near 2011-2040	8.5	Medium	56	10	+7.4	8
Near 2011-2040	8.5	High	63.3	20	+5.8	17
Mid 2041-2070	4.5	Low	38.5	2	+13.4	2
Mid 2041-2070	4.5	Medium	56	10	+22.0	6
Mid 2041-2070	4.5	High	63.3	20	+25.6	11
Mid 2041-2070	8.5	Low	38.5	2	+28.6	2
Mid 2041-2070	8.5	Medium	56	10	+40.3	4
Mid 2041-2070	8.5	High	63.3	20	+45.3	7

Table 2-4 contains the rainfall intensities estimated using EURO-CORDEX-11 and MPI-ESM-LR/RCA4, climate-model data for the two retained chains, two Representative Concentration Pathways (RCP 4.5 moderate-emissions, RCP 8.5 high-emissions) and two 30-year future periods.

The climate-signal results presented in Table 2-4 quantify how much extreme rainfall intensity is projected to change between the historical reference period of 30 years (1976–2005) and future periods. The values are expressed as percentages, calculated by comparing the model's future simulation of annual-maximum 24-hour rainfall against its own historical baseline. This approach isolates the change over time, rather than the absolute magnitude of rainfall.

By mid-century, the results indicate a clear intensification of heavy rainfall in County Louth. By this time, under the high emissions scenario (RCP 8.5), extreme rainfall events show substantial increases in intensity, up to +45.3% for high-threshold events, with associated return periods shortening significantly (e.g. a 1-in-20-year event occurring approximately every 7 years). Medium-threshold events show a similar pattern, with increases of around +40% and frequencies rising from 1-in-10-year to 1-in-4-year events.

By contrast, near-term projections (2011–2040) show more modest changes across both scenarios, with limited shifts in return periods, and weaker intensity increases. Differences between emissions pathways are also relatively muted in the near term. Indeed, the modelled results suggest greater intensification of heavy rainfall under RCP4.5 compared to RCP8.5, which is likely to indicate natural variability in the models having a larger impact than the projected climate changes. By mid-century, however, a consistent and physically coherent increase emerges, with both models showing higher extreme rainfall intensity and RCP 8.5 producing almost double the intensity increase observed under RCP 4.5.

Across all scenarios, higher rainfall thresholds exhibit the strongest proportional increases, indicating that the most extreme events intensify more rapidly than more frequent, lower-intensity rainfall. Overall, the results demonstrate a transition from modest near-term changes to a marked escalation in both the intensity and frequency of extreme rainfall by mid-century under higher emissions scenarios.

Spatial map analysis

The analysis also looked at threshold shifts with spatial maps. Spatial maps use a different metric (threshold-relative shift) from the point-based climate signal included in Table 2-4. The two should not be averaged or directly subtracted.

The spatial threshold-shift maps below (Figs. 2-7 to 2-8) show how projected rainfall compares to the historically observed high threshold (63.3 mm/24h) across County Louth under different time horizons and different climate scenarios. The maps should be interpreted as showing spatial patterns of change, rather than absolute percentage change. The magnitude of change is provided by the climate-signal results in Table 2-4.

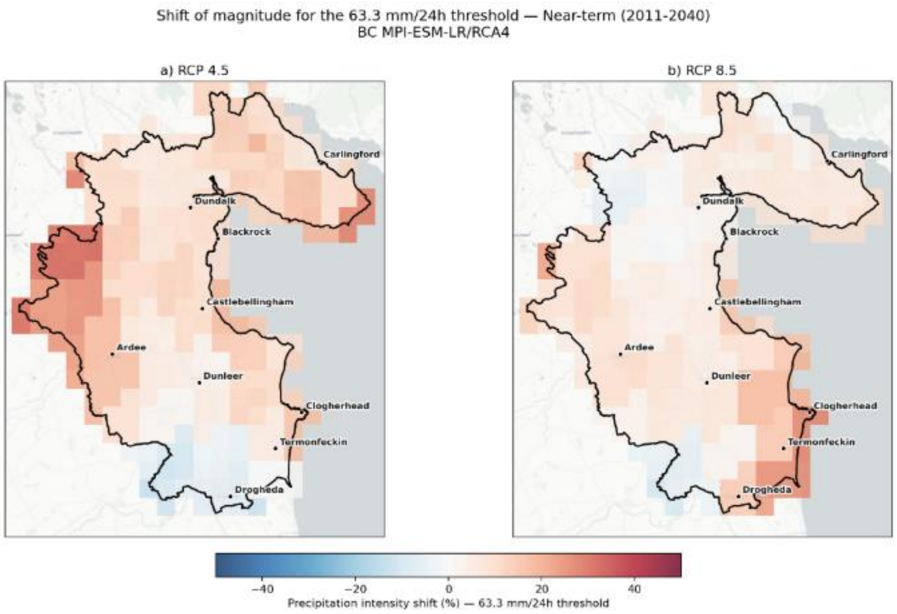

Figure 2-7. Spatial threshold-shift maps showing how projected rainfall across County Louth compares to the historically observed high threshold (63.3 mm/24h) during the Near term (2011-2040) period for RCP4.5 and RCP8.5.

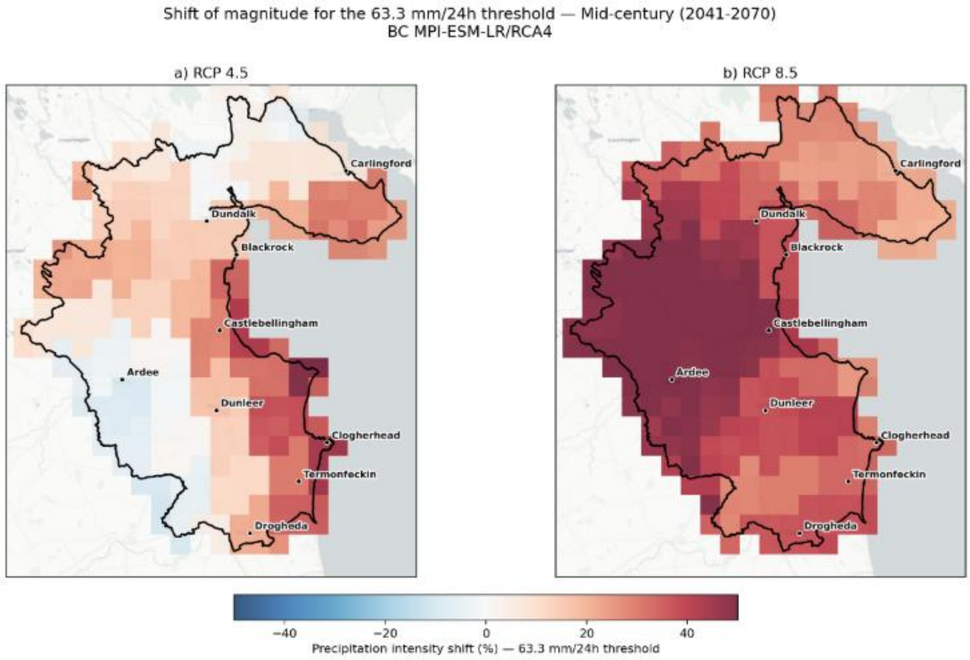

Figure 2-8. Spatial threshold-shift maps showing how projected rainfall across County Louth compares to the historically observed high threshold (63.3 mm/24h) during the Mid term (2041-2070) period for RCP4.5 and RCP8.5.

For the 2011-2040 period, the modelled precipitation shift is higher for RCP4.5 compared to RCP8.5. This may appear counter-intuitive, but it is important to note that, in the near-term (2011–2040), differences between emissions scenarios (e.g. RCP4.5 vs RCP8.5) are likely to be driven primarily by natural climate variability rather than the influence of the emissions pathway itself.[36]

Under both RCP emission scenarios, mid-century is when Louth is projected to see the biggest shift in precipitation increase from the threshold 63.3 mm/24h. The results for RCP 8.5 indicate that rainfall intensities associated with fixed-frequency events are projected to increase across the entirety of County Louth, with typical increases ranging from approximately 20% to 40%. The increase in rainfall intensity is strongest through the central areas, Ardee (+54%), Castlebellingham (+50%) and Dundalk (+45%), with the Drogheda corridor and Dunleer also high.

Under RCP 4.5 the increase is more muted, averaging approximately +14%, and is led by the south-east coast at Clogherhead (+44%) and Termonfeckin. The principal implication for planning is the spatial breadth of the high-emissions signal: the intensification is county-wide, so no part of the county can be considered unaffected.

Table 2-5: Summary of the modelled precipitation shifts illustrated in Figs. 2-7 and 2-8.

	RCP 4.5	RCP 8.5

[36] 01_Lee_Englebrecht_projections.pdf

Near Term (2011-2040)	Predictions across the county show an increase in 24-hour precipitation intensity at the high threshold (63mm). Areas in the West such as Ardee, Clonkeen and Kilnany and Tallanstown are projected to see the highest increase in 24hr precipitation intensity. This is validated by the stakeholder feedback and historical local data, as Ardee has historically seen high intensities of rainfall. An increase in precipitation intensity is also modelled in the North East in the area around Carlingford.	Under this scenario, although a modest increase in intensity is modelled for the western areas, the most significant increases in precipitation intensity occur in the South East at Drogheda and the nearby coast.
Mid Term (2041-2070)	There is an increase in the intensity in the North West, but overall, the increase is projected to be more intense in the East. The South East sees a signifcant shift in areas such as Clogherhead and Port beach. The North East, Carlingford areas also sees a significant shift.	Louth is projected to see a widespread increase in intensity, with a spatial mean of +41.8 %, and a peak above +60 %. The Dundalk–Drogheda corridor and central plain carry the highest values, with coastal areas slightly lower. Again we see Ardee and surrounding areas with a particularly pronounced shift.

The maps below (Figs. 2-9 to 2-11) show how the return period or frequency of the high threshold (63.3mm/24h) rainfall events is projected to change under different future climate scenarios.

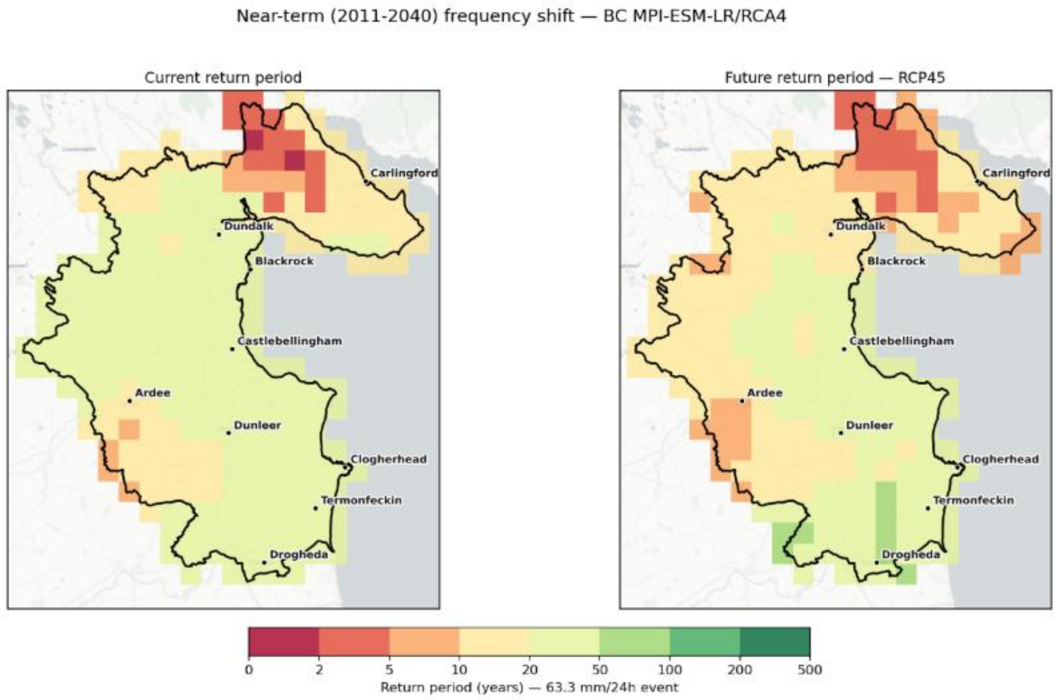

Figure 2-9. Projected return period of high threshold (63.3 mm/24h) rainfall events across County Louth under RCP4.5 for the Near term (2011-2040) period.

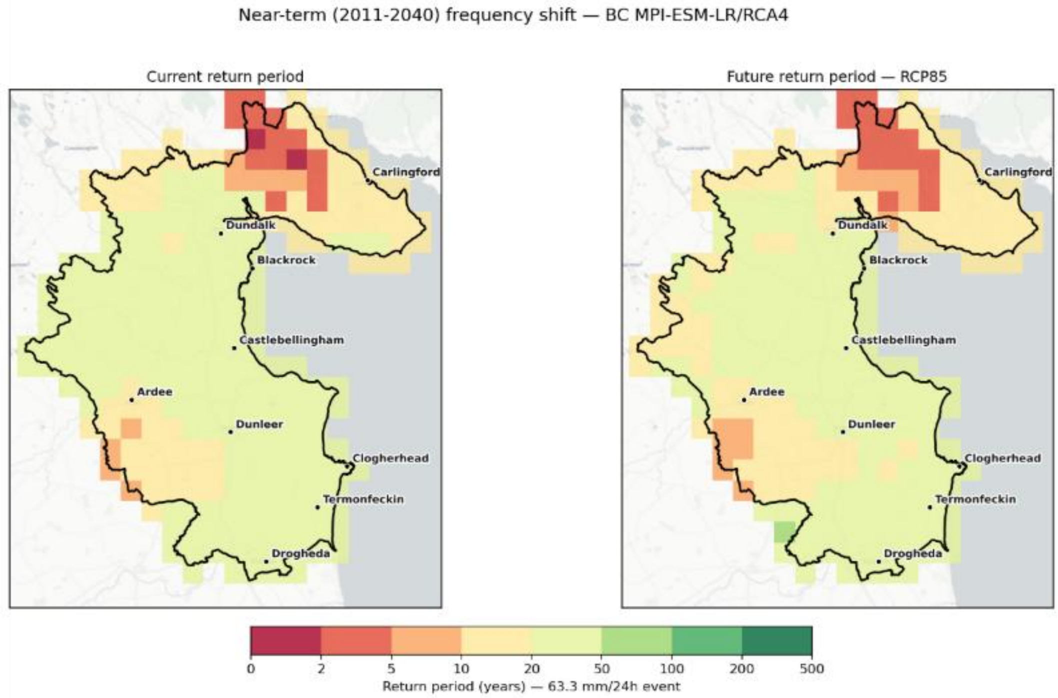

Figure 2-10. Projected return period of high threshold (63.3 mm/24h) rainfall events across County Louth under RCP8.5 for the Near term (2011-2040) period.

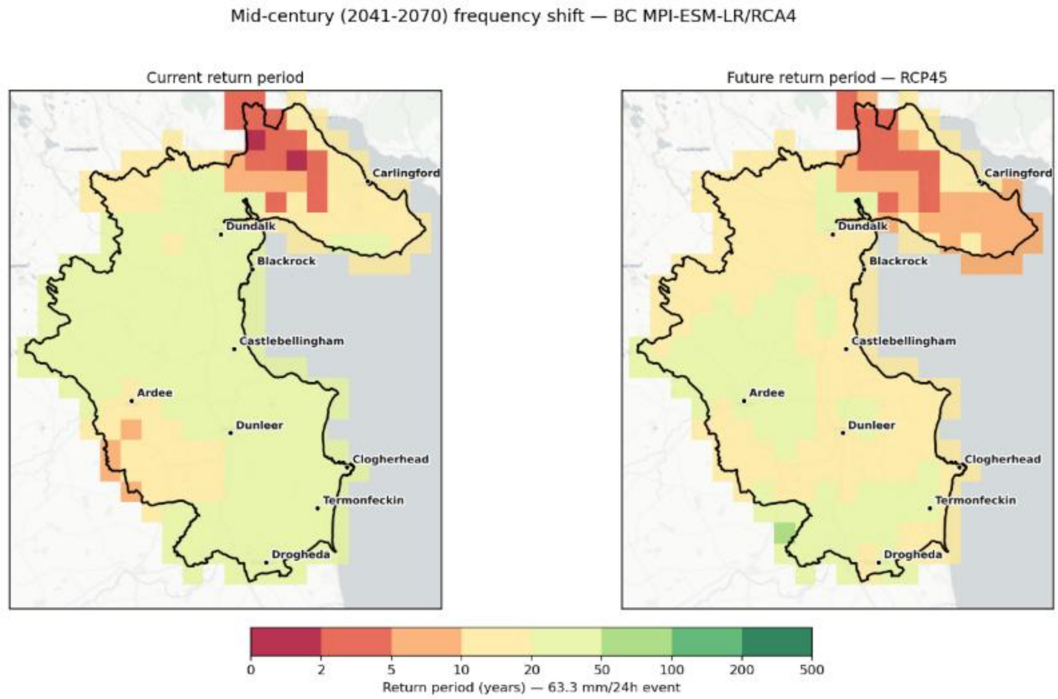

Figure 2-11. Projected return period of high threshold (63.3 mm/24h) rainfall events across County Louth under RCP4.5 for the Mid term (2041-2070) period.

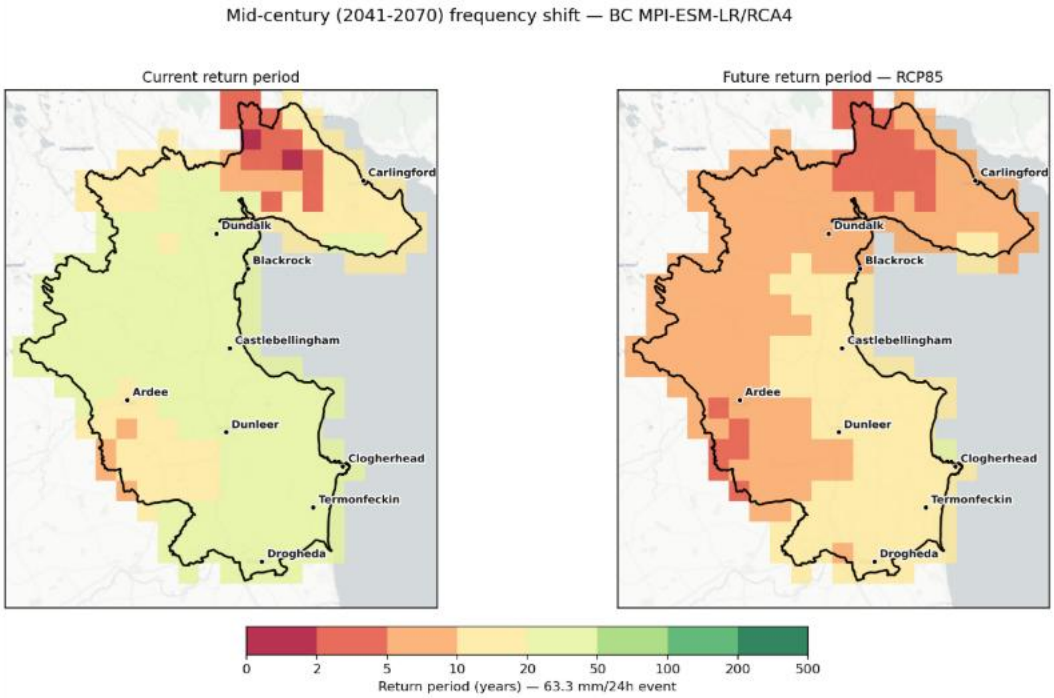

Figure 2-12. Projected return period of high threshold (63.3 mm/24h) rainfall events across County Louth under RCP8.5 for the Mid term (2041-2070) period.

In the near term 2011-2040, the twenty-year event shortens to roughly 13 years under RCP 4.5 and 17 under RCP 8.5 across much of the county, noting that in this near-term period, the model outputs are heavily influenced by natural climate variability rather than the emissions pathway itself.

By mid-century the change becomes substantial, under the high-emissions pathway the event currently expected 1 in 20 years is projected to recur roughly 1 in 7 years across much of Louth, close to 3 times as often, while under the moderate pathway it shifts to about 1 in every 11 years. For infrastructure with a long design life, this mid-century frequency shift is the figure that matters, because an asset sized today for a 20 year event would, on these projections, be tested far more often within its service life.

Table 2-6. Summary of the modelled return periods for intense rainfall events illustrated in Figs. 2-9 to 2-12.

	RCP 4.5	RCP 8.5
Near Term	The 20-year event return period is projected to shorten to 13 years, with the increase in frequency concentrated on the South-East coast and in the west around Ardee.	The 20-year event return period is projected to shorten slightly to 17 years. This is less than under RCP 4.5 at this pre-divergence horizon, consistent with the intensity maps.
Mid Term	The 20-year event shortens to about 11 years, roughly twice as frequent, with the South-East coast and Castlebellingham among the most affected.	The 20-year event is projected to shorten to approximately 7 years county-wide. This is almost 3 times more frequent than today, with the central belt (Ardee, Castlebellingham, Dundalk) most affected. The modelled projections suggest that

		infrastructure designed for a 20-year event would face it almost three times as often by mid-century.

Figure 2-13 below visualises both the return periods and the % precipitation change simultaneously, under RCP 8.5 for the 2041-2070 period. It is modelled that the whole county will experience these extreme events as frequently as every 5-20 years, with the intensity of events also increasing by 20% across the county, and by over 40% for much of the central region. Areas in the Carlingford region will experience the most frequent intense events.

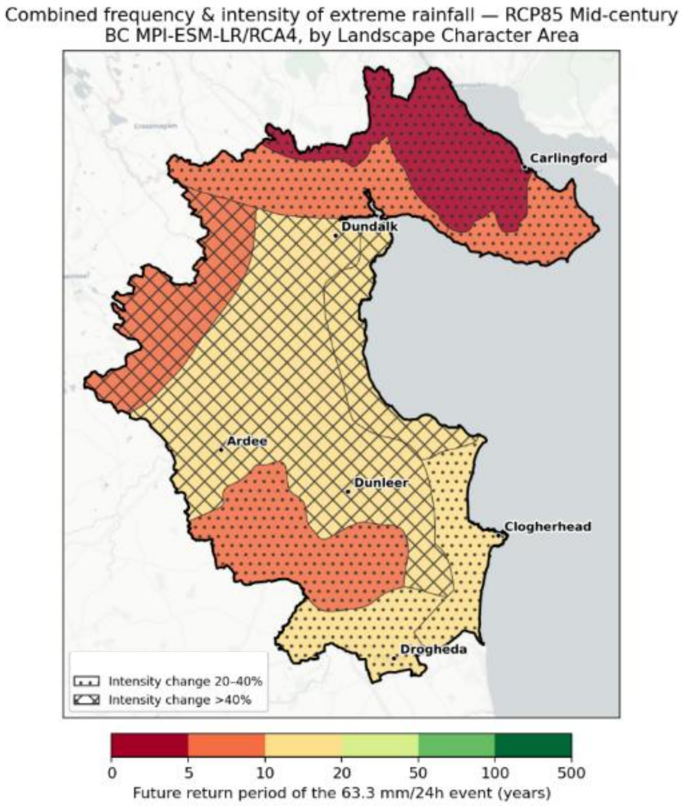

Figure 2-13. Combined frequency and intensity of rainfall events across County Louth projected in the Mid term (2041-2070) under RCP8.5.

2.3.1.2 Risk assessment

Figure 2-14 illustrates the spatial distribution of projected increases in high-intensity rainfall across County Louth, with the largest increases concentrated in the main population centres. Under the mid-century RCP 8.5 scenario, towns such as Drogheda, Dundalk and Ardee experience the highest intensification, with mean precipitation increases exceeding 40%. Notably, these locations also represent the most densely populated areas in the county, indicating that the greatest increases in rainfall intensity coincide with the largest population concentrations. This alignment highlights the extent to which a significant share of the population is exposed to the most pronounced changes in extreme rainfall conditions.

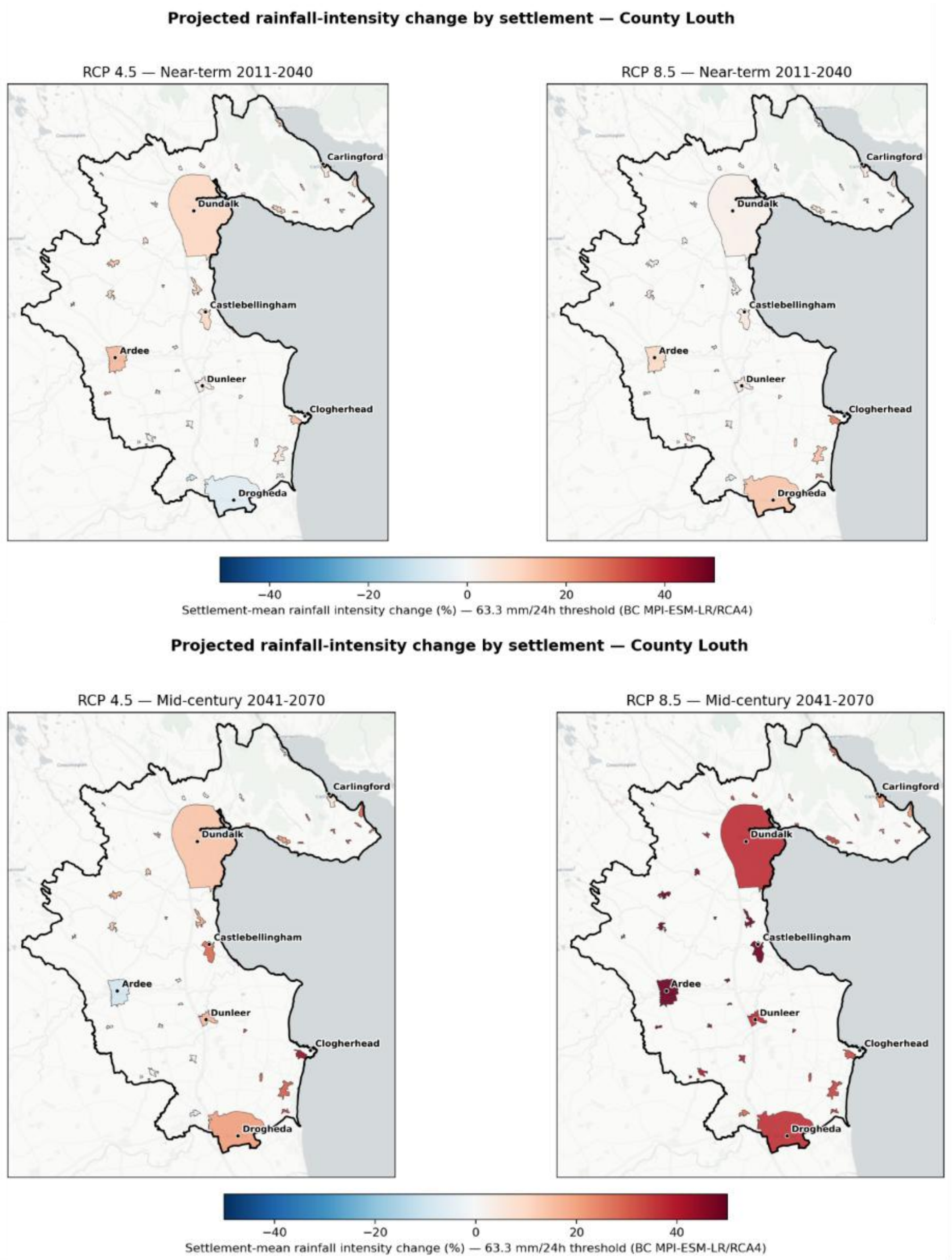

Figure 2-14. Projected changes in high-intensity precipitation events for population centres across County Louth.

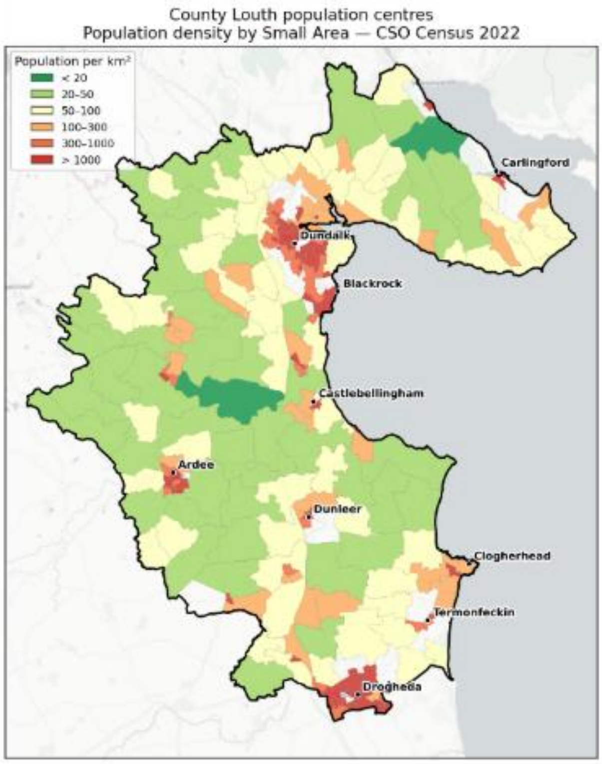

Figure 2-15. County Louth population centres.

The projected changes in precipitation are likely to have a significant impact on people and facilities. Key facilities associated with the population hubs are outlined in Fig. 2-15 and Table 2-7 below.

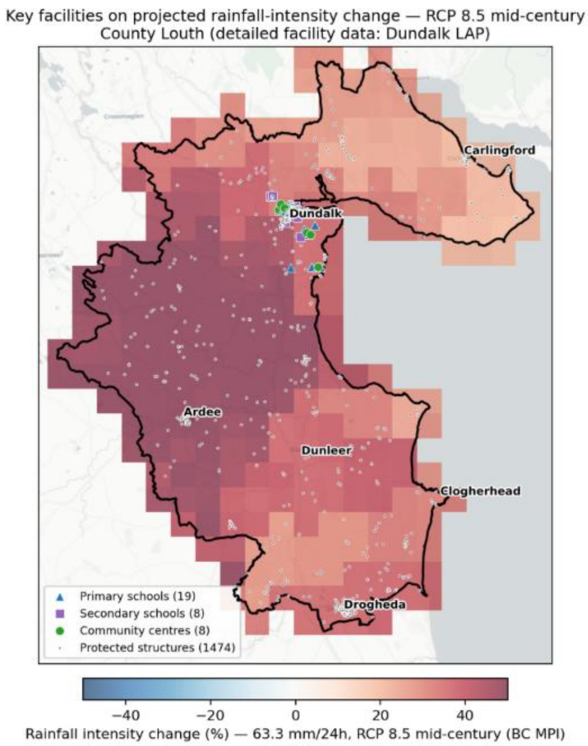

Figure 2-16. Key facilities mapped on mid century precipitation intensity changes under RCP8.5.

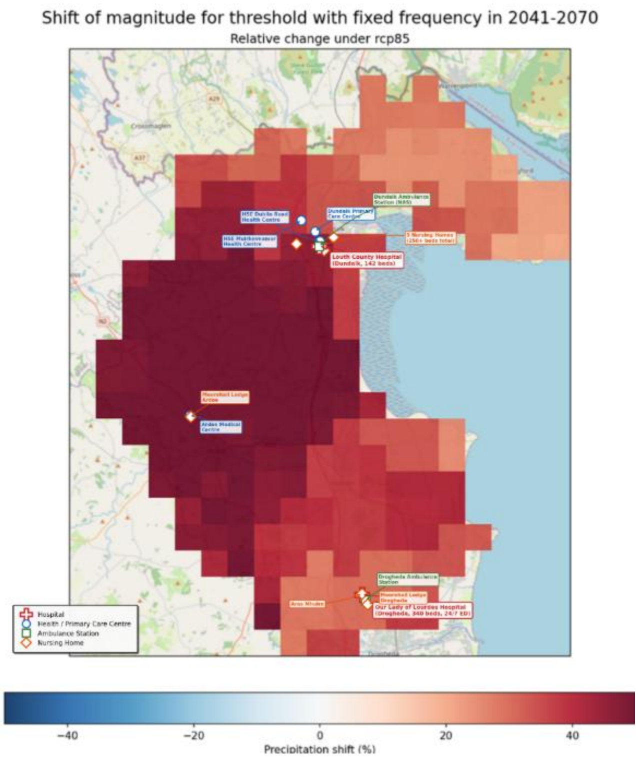

Figure 2-17. Healthcare facilities mapped on end of century precipitation intensity changes under RCP8.5.

Figures 2-16 and 2-17 illustrate the spatial distribution of projected increases in high-intensity rainfall across County Louth under RCP 8.5 scenario, alongside the location of key facilities. A consistent pattern is evident, with the largest increases concentrated across the central and western parts of the county, where projected intensification exceeds 40%. Coastal areas, particularly in the north-east, show comparatively more moderate increases, although still indicating a clear upward shift in rainfall intensity.

The overlay of critical infrastructure highlights that a significant number of key facilities—including hospitals, primary care centres, emergency services, schools, and protected structures are situated within areas experiencing the most pronounced increases. In particular, the Dundalk area shows a dense clustering of essential services within zones of substantial intensification, indicating a high level of co-location between exposure and infrastructure. Similarly, facilities in and around Drogheda and Ardee are also located within areas of elevated projected change.

Overall, the spatial alignment between projected rainfall intensification and the distribution of key facilities indicates that infrastructure serving the highest population concentrations is also situated in areas expected to experience the strongest increases in extreme rainfall. This reinforces the importance of considering spatial exposure in interpreting the results, as changes in rainfall intensity are not uniform and disproportionately affect areas with greater infrastructure density.

Table 2-7. Key facilities in County Louth.

Town	Key Facilities
Dundalk	23 (hospital, 5 nursing homes, fire/garda/ambulance, DkIT, 19 primary + 8 secondary schools, 4 community centres, library, courthouse)
Drogheda	14 (Our Lady of Lourdes Hospital, 2 nursing homes, fire/garda/ambulance, schools, library, 3 community centres, courthouse)
Ardee	10 (GP services, fire station, Moorehall Lodge nursing home, 2 schools, library, civic centre, community centre)
Dunleer	7 (fire station, 3 primary + 1 secondary school, 2 community centres)
Castlebellingham	4 (St Mary's Special School Drumcar, St Peter's NS Dromiskin, village hall)
Termonfeckin	4 (Scoil Naomh Feichin, Callystown NS, post office, GAA/community)

2.3.2. Hazard #2 Flooding – fine tuning to local context

Table 2-8 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
OPW CFRAM river and coastal flood extents (multiple scenarios and return periods)	Dundalk LAP zoning data (land use categories)	CSO Census 2022 population (Small Areas)	Sanity checks were applied across 13 criteria (including flood behaviour, climate trends, damage consistency, exposure patterns, and validation against observations and stakeholder input), with all checks successfully passed.
OPW NIFM flood depth data (5 m resolution)	Protected Structures dataset (heritage buildings)	Dundalk AFA boundary	River flood damage outputs (GeoTIFFs and summary tables)
OPW hydrometric station records (river flow and levels)	Stakeholder observations (flood reports and local insights)	OPW AFA boundaries (Louth)	Building-level damage estimates (by zoning category)
ESOTC / IPCC climate evidence and trends	Flood Relief Scheme (FRS) areas	Landscape Character Areas	Population exposure estimates (by Small Area and return period)
Recent storm events (e.g. Storm Éowyn, Storm Claudia)			Discharge analysis (recent vs historical conditions)

2.3.2.1. Hazard assessment

Methodology

The key methodological change for the Phase 2 Flooding assessment compared to Phase 1 is the replacement of the LUISA JRC 90 m flood layer with a two-layer OPW national dataset. This comprises the CFRAM community-scale flood extents for AFAs, based on detailed hydraulic modelling, and the NIFM, which provides 5 m depth data for rural areas outside AFAs. Together, these form a composite system, with NIFM supporting depth-based damage estimation in rural areas and CFRAM supporting extent-based estimation in urban, defended areas.

This structure required an adjusted damage methodology. Outside AFAs, the standard CLIMAAX approach is applied using LUISA land-use data and depth-damage curves at NIFM depths. Within AFAs, where depth data are unavailable, a representative depth of 1 m is applied based on nearby NIFM values, with damage calculated using zoning-specific values and the extent coverage. This introduces a sensitivity of approximately ±15–25%.

The exposure layer in Dundalk AFA was refined using the Local Area Plan zoning dataset, enabling high-resolution, locally relevant damage estimates. Population exposure was also improved using CSO Census 2022 Small Area data.

Finally, two local enhancements were incorporated: observed discharge data from OPW stations to provide a reality check on hazard trends, and 136 stakeholder observations (100 flood-related), with a 58% spatial alignment with CFRAM flood extents, providing qualitative validation of the model outputs.

Results

The following figures (Fig. 2-18 to Fig. 2-21) present the spatial outputs of the flood hazard assessment, illustrating the extent and distribution of fluvial and coastal flooding across County Louth under current and future climate scenarios. These maps translate the modelled hazard data into a geographic context, enabling identification of areas most exposed to flood risk, including key settlements, transport corridors, and critical infrastructure. They also highlight how flood extents vary under different return periods and climate scenarios, providing a visual representation of both current baseline risk and the potential scale of future change. Together, these outputs support a more detailed understanding of where flood impacts are likely to be most significant and inform the subsequent risk assessment analysis.

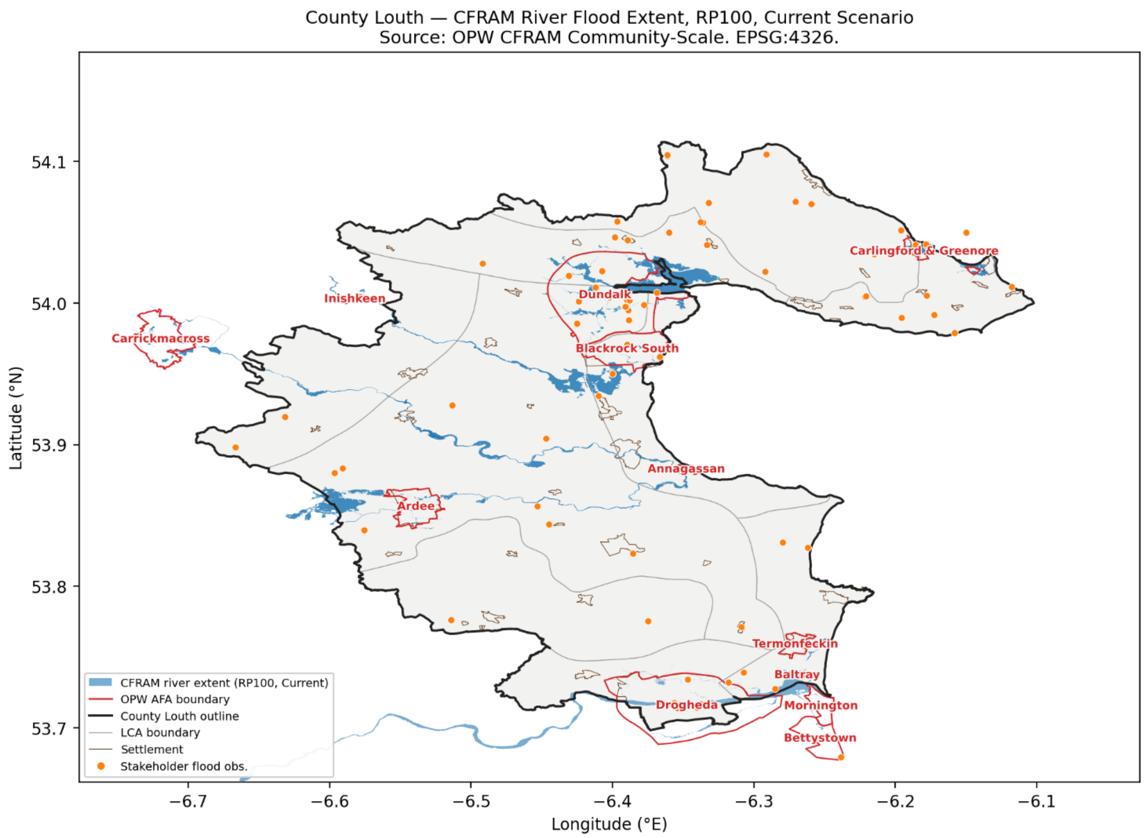

Figure 2-18. CFRAM river flood extent for 1-in-100-year return period.

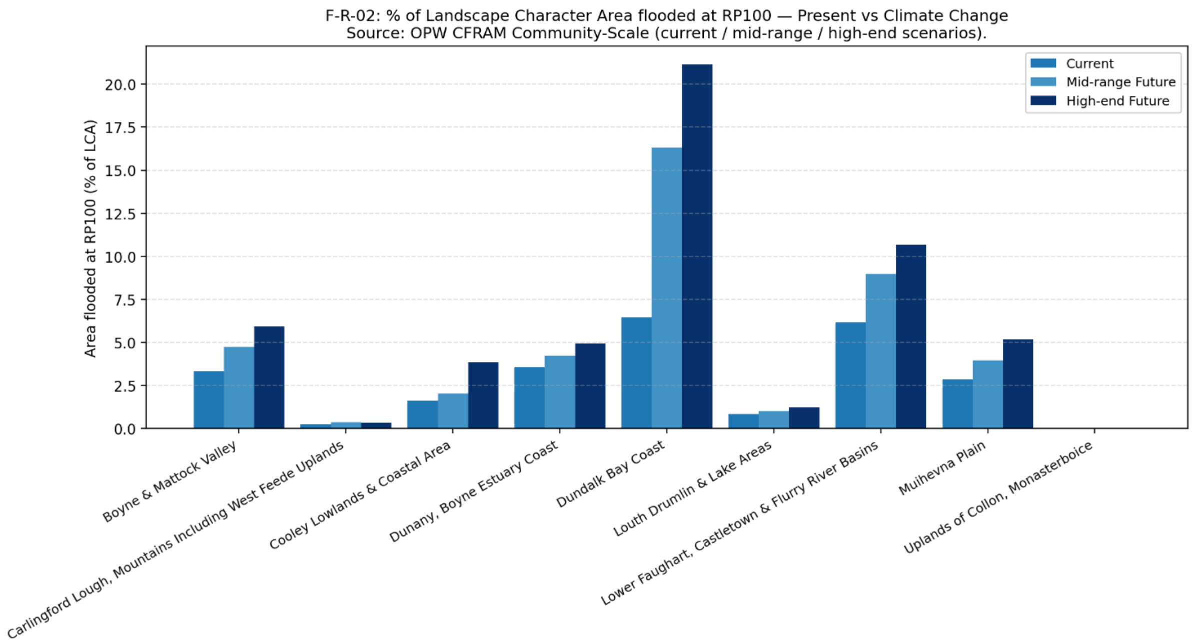

Figure 2-19. % of area flooded under current and future scenarios.

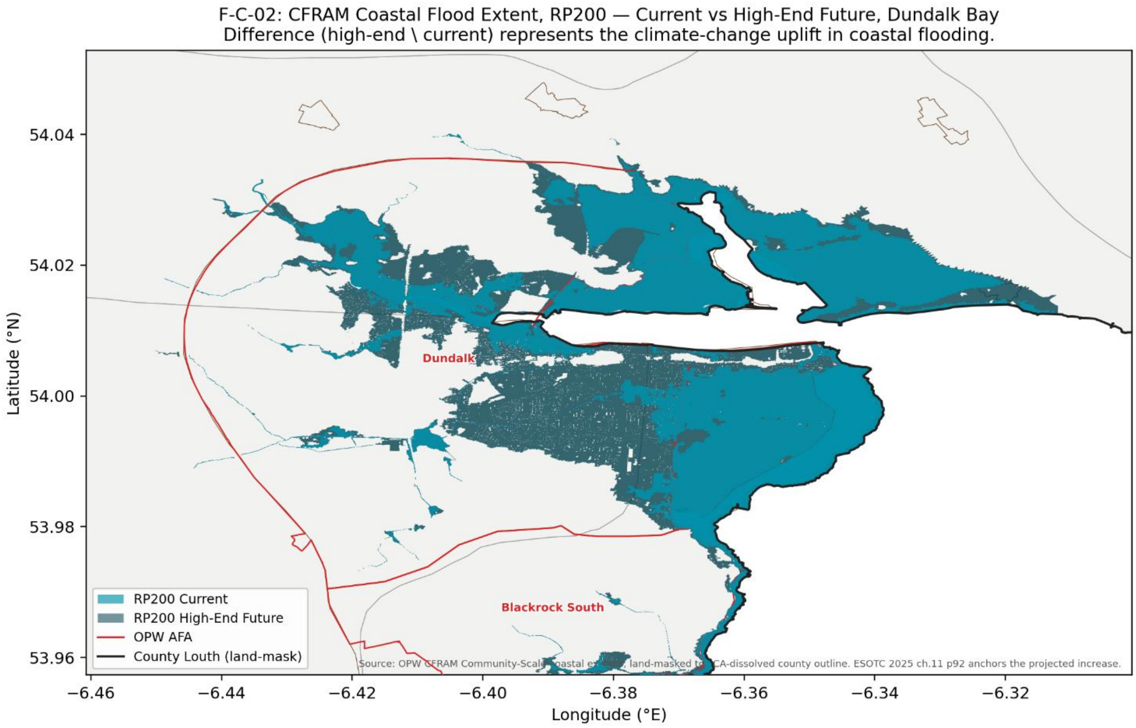

Figure 2-20. Dundalk Bay coastal flood extent at the 1-in-200-year return period under current and high-end-future scenarios, land-masked to the LCA-dissolved County Louth boundary to strip intertidal over-count. The high-end-future envelope extends the

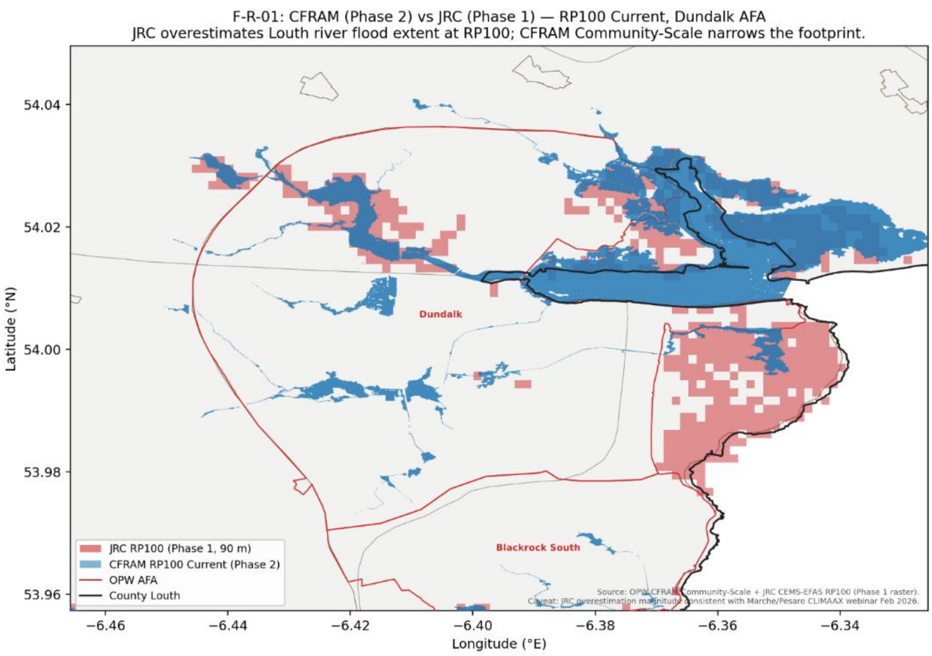

Figure 2-21. JRC modelling vs CFRAM. This illustrates how the JRC model overestimated the rare 100 year events, particularly in the coastal areas in the East. The Phase 2 modelling also indicates the addition of flooding in the Mid West, which JRC failed

2.3.2.2. Risk assessment

Building on the hazard mapping and spatial analysis presented above, this section assesses the implications of flooding for people, assets, and infrastructure across County Louth. The risk assessment integrates flood extent data with exposure and vulnerability information to quantify potential impacts, including economic damages, population exposure, and effects on critical services. Particular attention is given to high-risk urban areas such as Dundalk and Drogheda, where concentrations of population and infrastructure amplify potential impacts.

The analysis also considers how flood risk evolves under future climate scenarios, providing insight into both current risk levels and the trajectory of change. This enables a clearer understanding of priority areas for adaptation and supports evidence-based decision-making for planning, investment, and risk management.

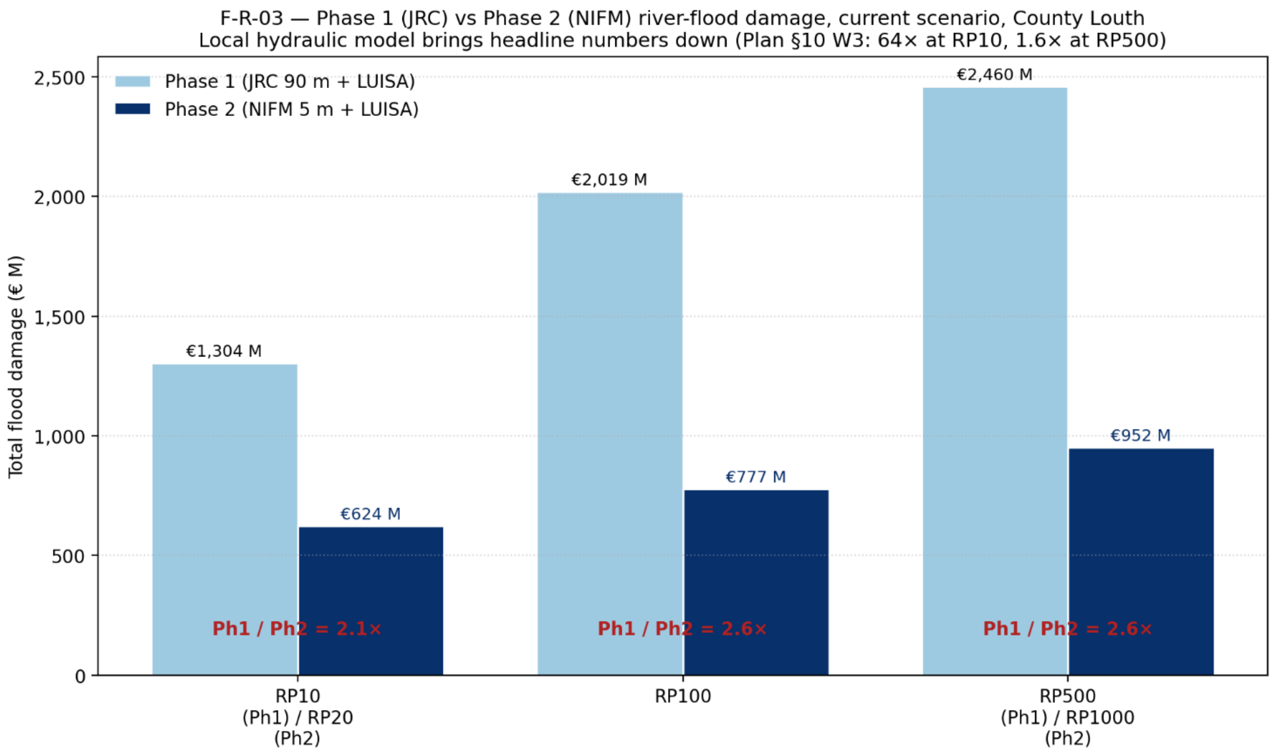

Figure 2-22. Phase 1 vs Phase 2 flood damage estimate comparison.

When Phase 1 and Phase 2 flood damage estimates are compared side by side, the Phase 1 figures are consistently higher — roughly 2 to 2.5 times larger across all return periods. For example, at the 100-year flood level, Phase 1 estimates total damage at approximately €2 billion compared with €777 million in Phase 2. This is because Phase 2 uses the more detailed OPW flood data (at 5 m resolution) in place of the broader European dataset used in Phase 1 (at 90 m resolution). The difference is consistent with validation benchmarks from other European studies, confirming that the reduction is methodologically expected rather than an error. In practice, this means Phase 1 figures should be treated as upper-bound estimates, while Phase 2 provides a more locally calibrated and realistic picture of flood damage in County Louth.

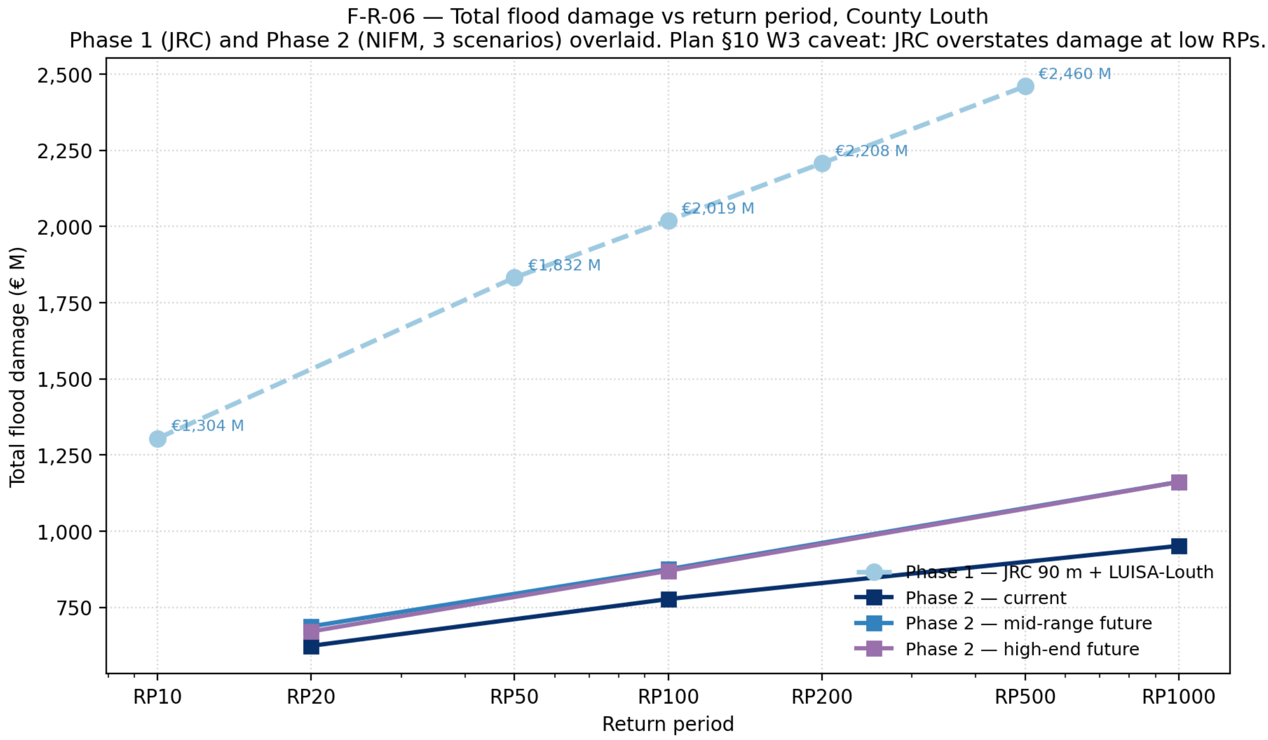

Figure 2-23. Total flood damage vs return period.

Phase 1 sits well above the three Phase 2 damage curves for current, mid-range, and high-end future scenarios. The vertical separation between the Phase 1 and Phase 2 bands visualises the ~60 % reduction. Within Phase 2, the mid-range and high-end curves sit close together (often within ~1 %).

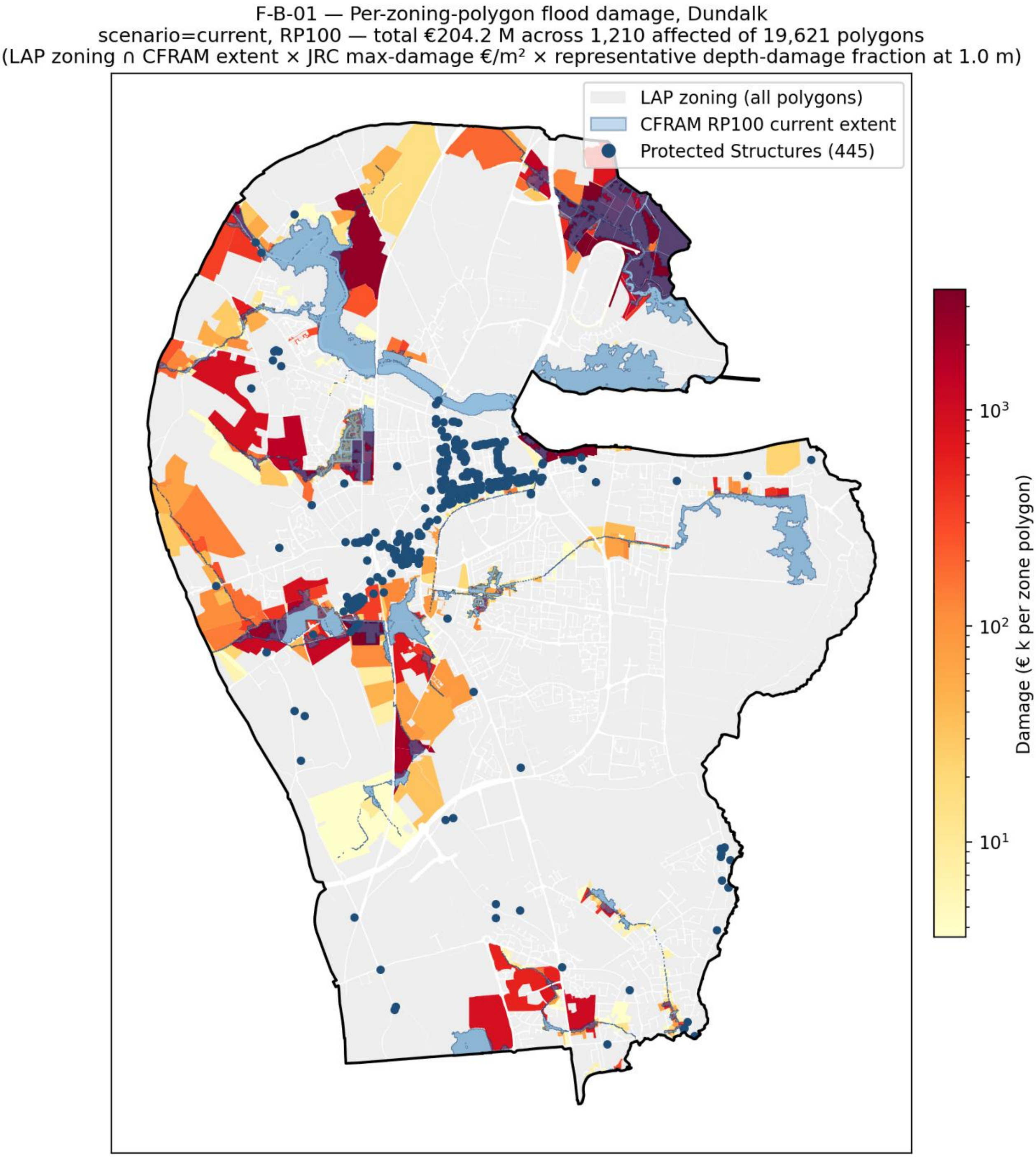

Figure 2-24. Flood damage in Dundalk

At the 100-year flood level, the estimated total damage across Dundalk is approximately €204 million, affecting around 1,210 of the town's 19,621 zoning areas. The map shows the CFRAM flood extent along the Castletown River corridor through the town centre, with damage levels shaded by severity. Over 440 protected structures are also marked.

The damage is concentrated in three main areas. The largest is along the Dundalk Bay frontage, where tourism and leisure land uses account for approximately €89 million. The second is residential areas on both sides of the Castletown River, mainly terraced housing close to the water, totalling around €43 million. The third is a mix of employment and strategic reserve land to the west of the town centre, sitting on low-lying ground within the flood zone, contributing approximately €53 million combined. Notably, the historic town centre itself shows very low damage (€0.4 million) because it sits on slightly higher ground above the floodplain — a local detail that only becomes visible when detailed local zoning data is used instead of broader European datasets.

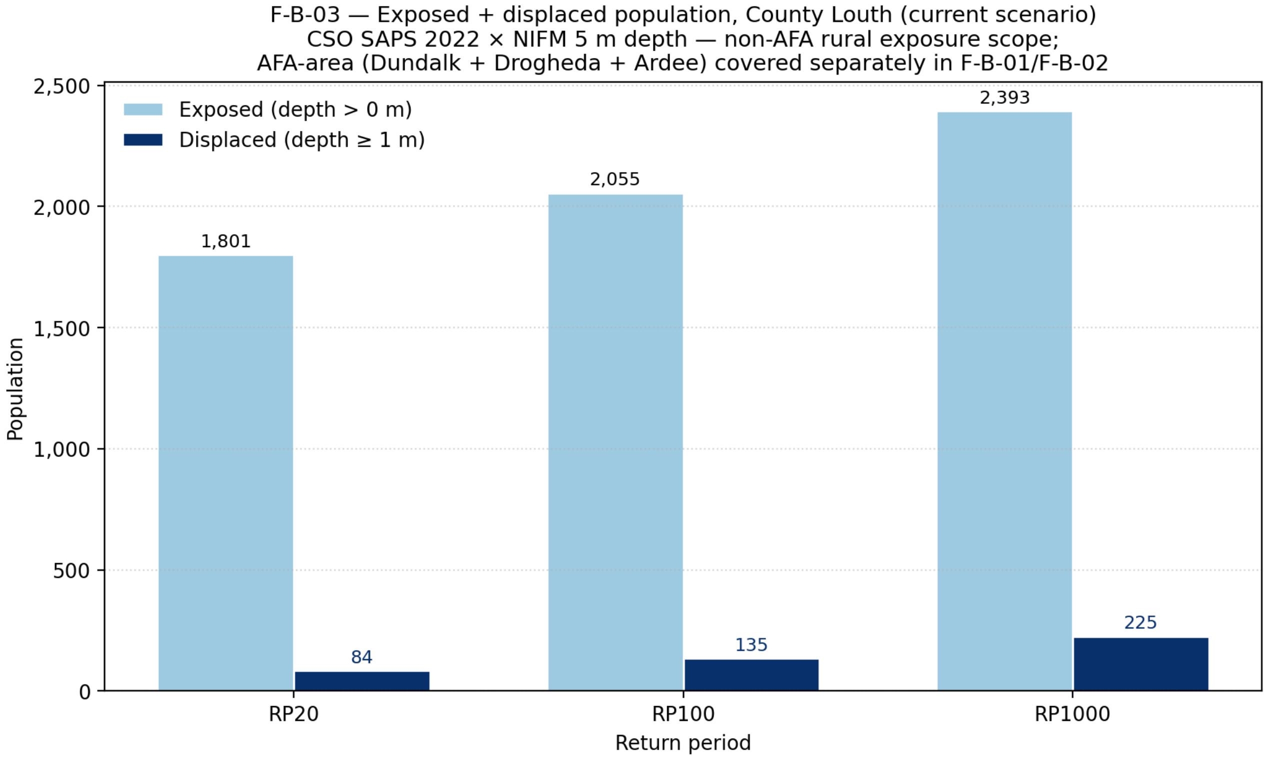

Figure 2-25. Exposed and displaced population.

The population figures shown here cover only the rural parts of County Louth outside the main towns. "Exposed" refers to people living in areas touched by flooding, while "displaced" applies a stricter threshold, counting only those in areas where flood depth reaches 1 metre or more. The larger urban populations in Dundalk, Drogheda and Ardee are not included here because they fall within designated town flood areas (AFAs), where exposure is captured separately through the building-level damage analysis.

Workflow #3 Windstorms – fine tuning to local context

Table 2-9 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Met Éireann hourly wind observations (Dublin Airport, Dunsany synoptic stations); spatial	Feuerstein et al. (2011) damage curves; damage scales with a cubic relationship to wind relationship; max damage values per land-use zone from LCC zoning attributes	LCDP 2021–2027 zoning (4,200 polygons, 22 zone types, 17 settlements); Dundalk LAP 2025–2031 (19,622 polygons); 1,474 protected structures (RPS); 26 council buildings	Total county damage (EUR); damage by settlement (17 towns); damage by zone type (22 categories); protected structures at risk (count, % exposure, damage/m²)

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
interpolation to 50 m raster			
Storm Éowyn (24 Jan 2025), Storm Ophelia (16 Oct 2017, Storm Chandra (26 Feb 2026)		Stakeholder observations (8 wind-related from 140 total records, Nov 2024 engagement); Storm Chandra actual damage sites (82 locations, €3.58M verified); critical infrastructure facilities (schools, community centres)	Stakeholder validation rate (88% spatial agreement); model-vs-actual damage comparison; building type vulnerability ranking; council building exposure analysis; critical infrastructure risk assessment
Future scenario (RCP 8.5, 2050): IPCC AR6 +10% wind intensity scaling applied to Storm Éowyn baseline			Future total damage: €287.4M (+33% vs €215.8M current); return period shift (1-in-50 yr → 1-in-37 yr); settlement-level future damage projections; top 10 settlements current vs future comparison

2.3.2.3. Hazard assessment

Methodology

The key methodological change for the Phase 2 Windstorm assessment compared to Phase 1 is the replacement of Climate Store Data (CDS)[37] synthetic storm footprints with Met Éireann hourly observational wind data. This comprises wind speed measurements from two synoptic stations (Dublin Airport and Dunsany), spatially interpolated to a 50 m resolution grid covering County Louth. The observational approach provides a more accurate representation of extreme wind events, capturing peak gusts 27% higher than CDS synthetic data for Storm Éowyn (140 km/h vs 108–115 km/h). Three storms were analysed: Ophelia (2017), Éowyn (2025), and Chandra (2026), providing both historical context and contemporary baseline conditions.

The damage methodology follows the standard CLIMAAX approach using Feuerstein et al. (2011)[38] damage curves, but with a critical adjustment to the exposure layer. In addition to the LUISA 50 m land cover with 10 generic classes, Phase 2 uses LCDP 2021–2027 zoning (4,200 polygons, 22 zone types across 17 settlements). Each LCC zone type was mapped to one of the six Feuerstein building categories (residential, commercial, industrial, public, agricultural, other), with maximum damage values assigned based on Irish construction cost data. The cubic wind-damage relationship is preserved from the CLIMAAX Handbook methodology.

The exposure layer in Dundalk was further refined using the Adopted Dundalk Local Area Plan 2025–2031 dataset, which provides 19,622 ultra-high-resolution zoning polygons, enabling street-level and parcel-level damage mapping. An additional heritage vulnerability layer was incorporated using the LCC Record of Protected Structures (1,474 buildings), enabling quantification of cultural

[37] Climate Data Store
[38] Towards an improved wind speed scale and damage description adapted for Central Europe - ScienceDirect

asset exposure and identification of building types at elevated risk (e.g., coastal structures showing damage rates 3× higher than typical residential).

Two local enhancements were incorporated to validate the model outputs. First, stakeholder observations from November 2025 public engagement sessions (8 wind-related observations from 136 total records) were spatially overlaid on modeled damage zones, showing 88% spatial agreement and confirming the model's ability to identify high-impact areas. Second, Storm Chandra actual damage records (82 sites, €3.58M verified) provided ground-truth validation, demonstrating strong spatial correlation between modeled and observed damage locations while highlighting that non-building impacts (trees, power lines) are not captured by the structural damage model.

Results

The following figures (Fig. 2-26 – Fig. 2-37) present the spatial outputs of the windstorm hazard and risk assessment, illustrating wind speed distributions and resulting structural damage across County Louth for the three analysed storms. These maps translate the wind speeds into geographic damage estimates, enabling identification of settlements and neighborhoods most exposed to windstorm risk. They also illustrate the impact of data source choice (CDS vs Met Éireann) and land cover resolution (LUISA vs LCC zoning) on damage estimation, demonstrating the value of local data integration. A future climate scenario (RCP 8.5, mid-century 2050) applies IPCC AR6 wind intensity scaling to Storm Éowyn, projecting a 33% damage increase and highlighting the potential scale of climate-driven change. Together, these outputs support identification of priority areas for building retrofit, heritage protection, and infrastructure resilience measures.

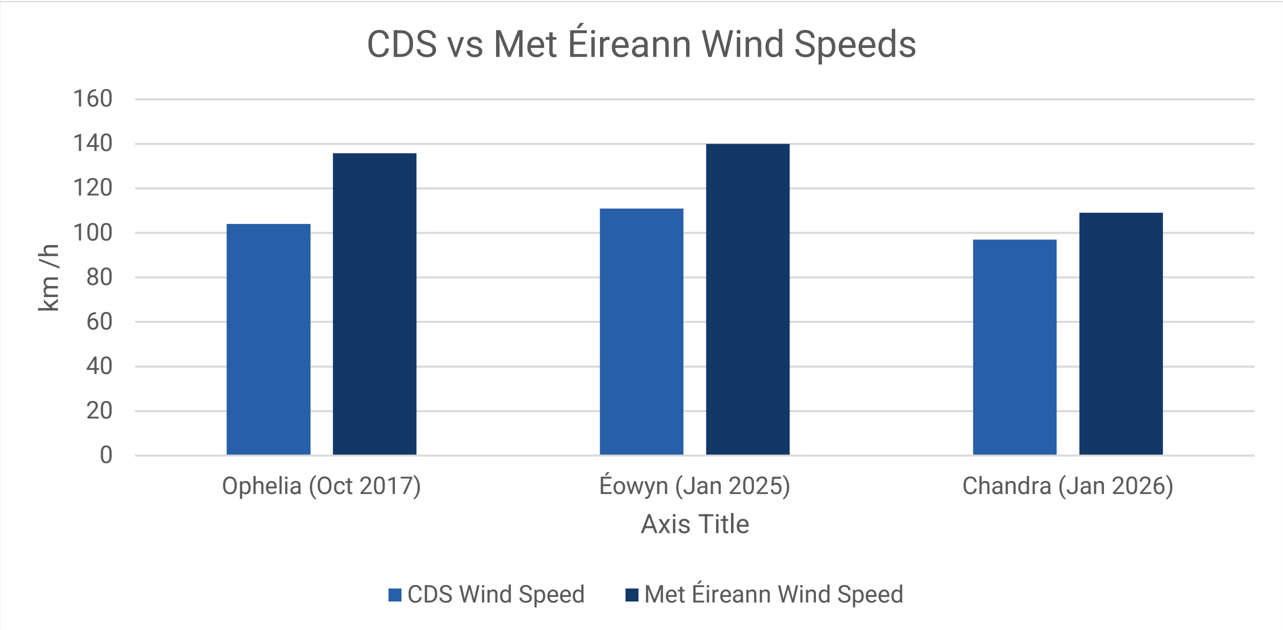

Figure 2-26. CDS vs Met Éireann Wind Speeds.

Table 2-10. CDS vs Met Éireann Wind Speeds.

Storm	CDS Wind Speed (km/h)	Met Éireann Wind Speed (km/h)	Difference
Ophelia (Oct 2017)	104.0	135.8	+31.8
Éowyn (Jan 2025)	111.0	140.0	+29.0
Chandra (Jan 2026)	97.0	109.0	+12.0

The comparison between CDS synthetic storm footprints and Met Éireann observational data reveals significant differences in spatial wind field representation. This discrepancy suggests CDS synthetic footprints may systematically underestimate extreme wind events in the Irish East coast context. Figure 2-27 shows how the CDS data has a spatial pattern with a North-South gradient with the highest winds in Northern Coastal areas. The Met Éireann data recorded for the event, however, has much more consistent wind speeds across the entire County. This was also the case for Storm Éowyn and Storm Chandra.

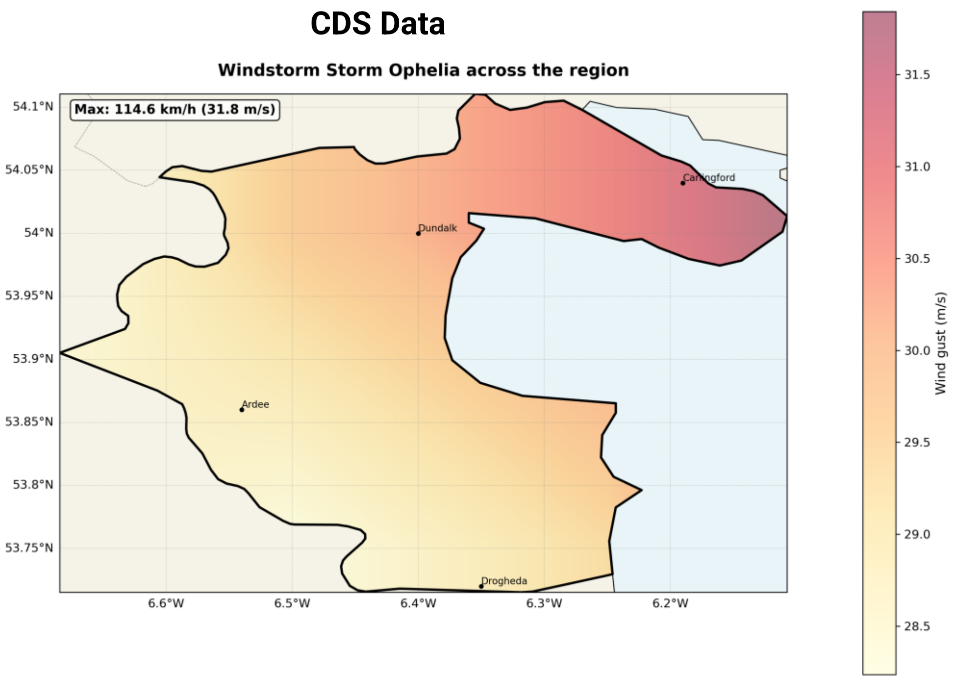

Figure 2-27. Storm Ophelia CDS Wind Speeds.

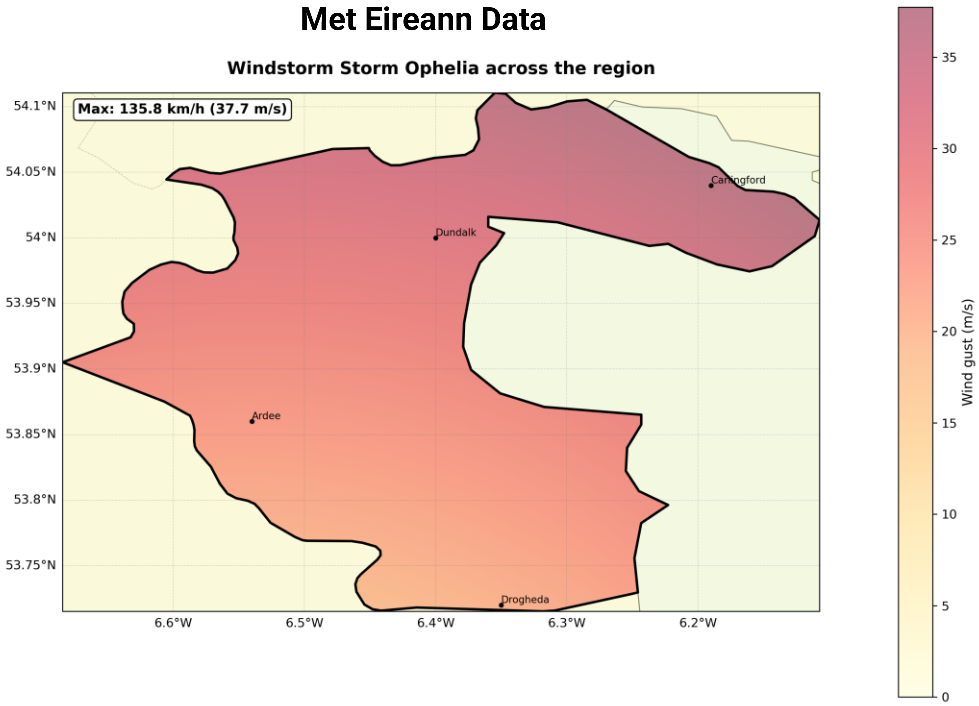

Figure 2-28. Storm Ophelia Met Éireann Wind Speeds.

2.3.2.4. Risk assessment

To evaluate the influence of improved hazard and exposure datasets on estimated storm impacts, damage calculations were undertaken using three methodological configurations. These represent successive stages in the development of the assessment, allowing the contribution of each enhancement to be examined separately. The first configuration reproduces the original Phase 1 approach, while the second isolates the effect of replacing CDS wind data with observed Met Éireann data. The final configuration incorporates both the improved Met Éireann hazard representation and the locally derived exposure datasets used in Phase 2. Comparing the results across these approaches provides a clear illustration of how local data integration affects both the magnitude and spatial distribution of estimated damages, while also demonstrating the added value of locally calibrated information for climate risk assessment and adaptation planning.

The comparison highlights the sensitivity of damage estimates to hazard intensity. While Met Éireann observations recorded peak wind speeds only 20–30% higher than the CDS synthetic storm footprints, the non-linear relationship between wind speed and structural damage amplifies this difference considerably. As a result, the enhanced hazard representation in Phase 2 leads to a substantial increase in estimated damages, demonstrating that accurate characterisation of extreme wind speeds is a critical determinant of storm risk assessment outcomes.

Structural damage increases approximately with the cube of wind speed (wind^3), meaning that relatively small increases in wind speed can produce disproportionately large increases in losses. For Storm Éowyn, the maximum wind speed derived from Met Éireann observations was 140 km/h compared to approximately 111 km/h in the CDS dataset. Applying the wind-damage relationship gives a damage multiplier of:

$$\left(\frac{140}{111}\right)^3 = 2.01$$

This indicates that a 26% increase in wind speed results in damage estimates that are approximately 2.0 times higher.

Table 2-11. Comparison of storm damage estimates under the Phase 1, hybrid, and Phase 2 methodologies. Higher observed wind speeds from Met Éireann significantly increase estimated damages, while local zoning data provides additional refinement to the fi

Storm	CDS Wind (km/h)	Met Éireann Wind (km/h)	% Change	Damage Multiplier	CDS + LUISA (Estimated)	Met Éireann + LUISA (Estimated)	Met Éireann + Local (Actual)
Éowyn	111.0	140.0	+26%	2.01×	€107.6M	€194.2M	€215.8M
Ophelia	104.0	135.8	+31%	2.23×	€88.5M	€177.3M	€197.0M
Chandra	97.0	109.0	+12%	1.42×	€16.6M	€21.2M	€23.5M

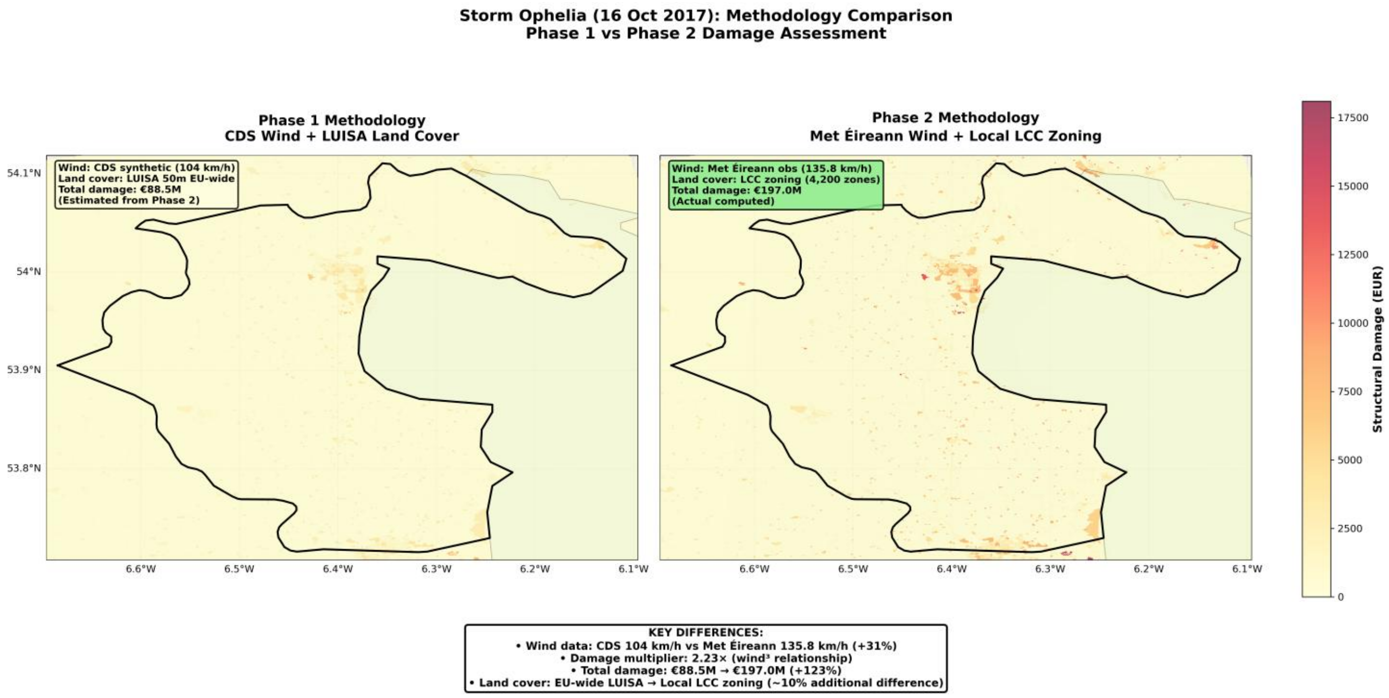

Figure 2-29. Comparison of storm damage estimates for Storm Ophelia under the Phase 1 and Phase 2 methodologies.

Figure 2-29 illustrates the effect of the Phase 2 methodology enhancements on the estimated impacts of Storm Ophelia. While both the Phase 1 and Phase 2 assessments identify the same broad areas of exposure, the Phase 2 results indicate substantially higher damage levels and greater spatial detail.

The combination of the Met Éireann Data with the local polygons and zoning allowed for detailed view of potential damage in County Louth. The assessment looks closely at Drogheda and Dundalk for the most extreme Storm Éowyn. With local observations and recorded data from Storm

Chandra, this enabled an assessment of actual recorded damage with the estimated damage derived from the local data.

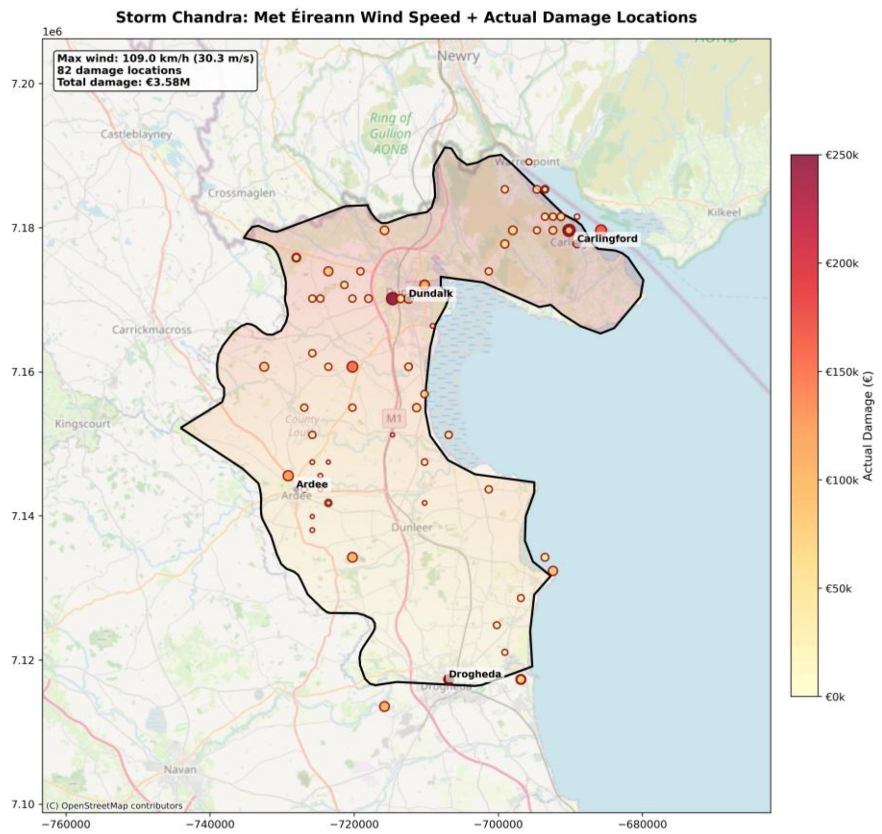

Figure 2-30. Storm Chandra actual damages recorded in Louth.

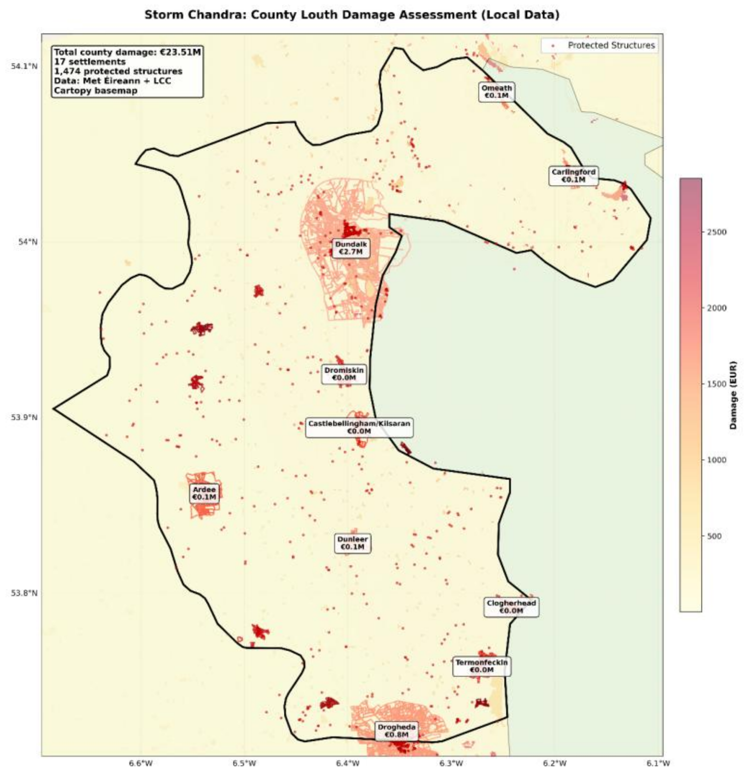

Figure 2-31. Storm Chandra damage estimates based on recorded Met Éireann data and local polygons/zoning.

Storm Chandra provides a unique validation opportunity through 82 actual damage locations recorded by Louth County Council with associated costs totaling €3.58M). Damage incidents cluster in; Dundalk - Shelling Hill (€250K), Navy Bank (€80K), multiple residential areas; Drogheda: Scattered incidents along coastal areas; Rural areas: Tree damage, power line failures. Highest-cost incidents all fall within the estimated high-damage zones utilizing the local polygons and zoning. It is likely that rural damage incidents (trees, power lines) are underestimated by the building-focused estimate, which does not account for vegetation or utility infrastructure.

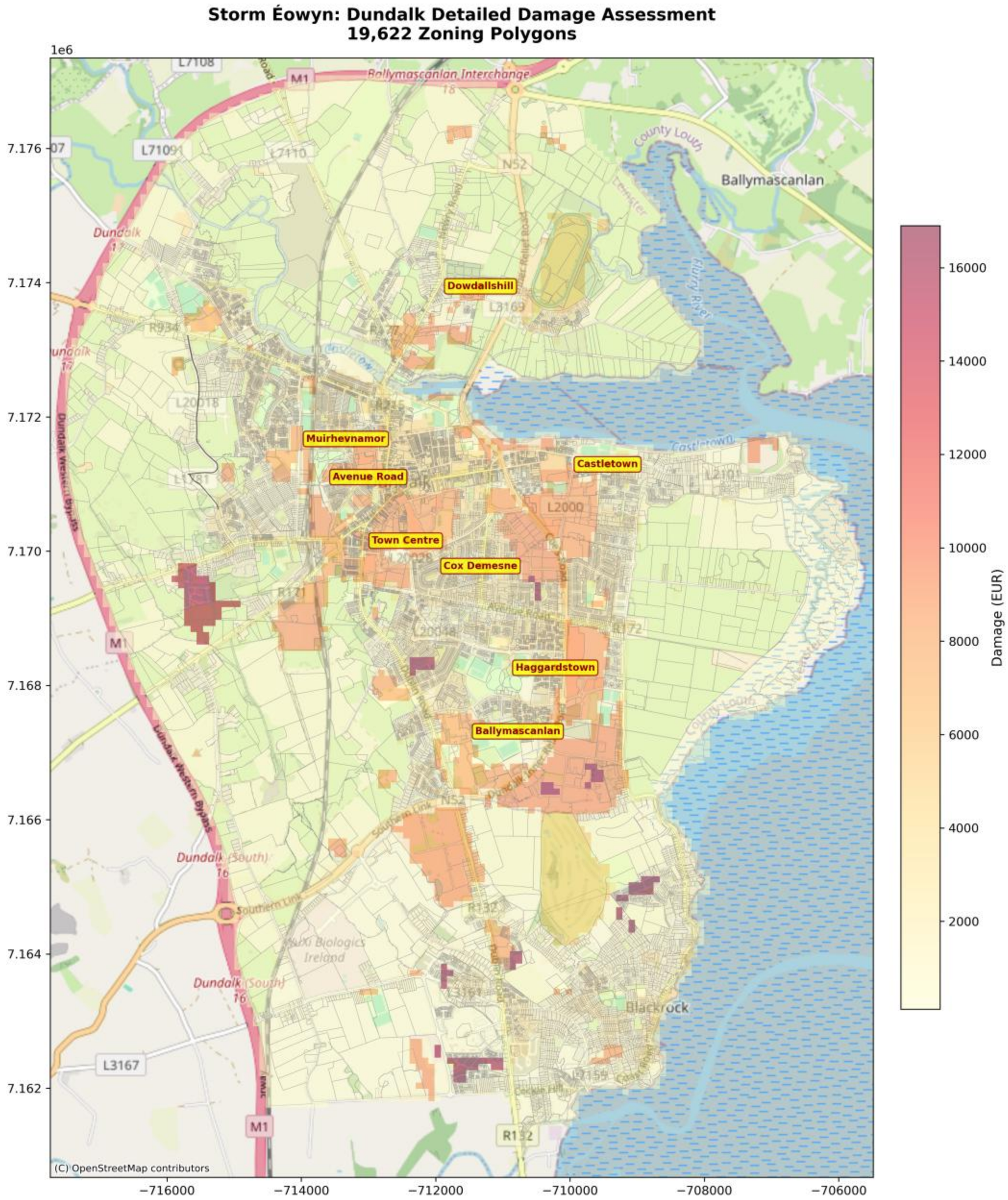

Figure 2-32. Dundalk Detailed Damage assessment.

The high-resolution analysis in Figure 2-32 leverages the Dundalk Local Area Plan 2025-2031 dataset containing 19,622 individual zoning polygons - a 10-fold increase in spatial detail compared to the county-wide dataset (1,812 zones for Dundalk in the CDP 2021-2027). The damage overlay is in red/yellow pixel-level damage distribution. Labeled high-damage areas include:

- Dowdallshill: Residential area, exposed to northern winds;
- Muirhevnamor: Dense residential estate
- Town Centre: Commercial core, heritage buildings
- Avenue Road: Mixed residential/commercial
- Castletown: Suburban residential
- Haggardstown: Residential, some industrial
- Bay Estate: Western residential zone
- Cox Demesne: Southern area.

Northern and western estates (Dowdallshill, Muirhevnamor, Bay Estate) show highest intensity - consistent with Éowyn's east-northeast wind trajectory.

Damage across Dundalk is not evenly distributed; there is clear spatial clustering within particular neighbourhoods. Northern and western estates, such as Dowdallshill, Muirhevnamor, and the Bay Estate, experience the highest intensity impacts, aligning with Storm Éowyn's east-northeast wind trajectory. The ultra-high resolution data enables street-level adaptation planning. For example, it enables prioritisation of building retrofits in Dowdallshill over lower-damage southern areas, while the roads overlay provides navigational context for local planners.

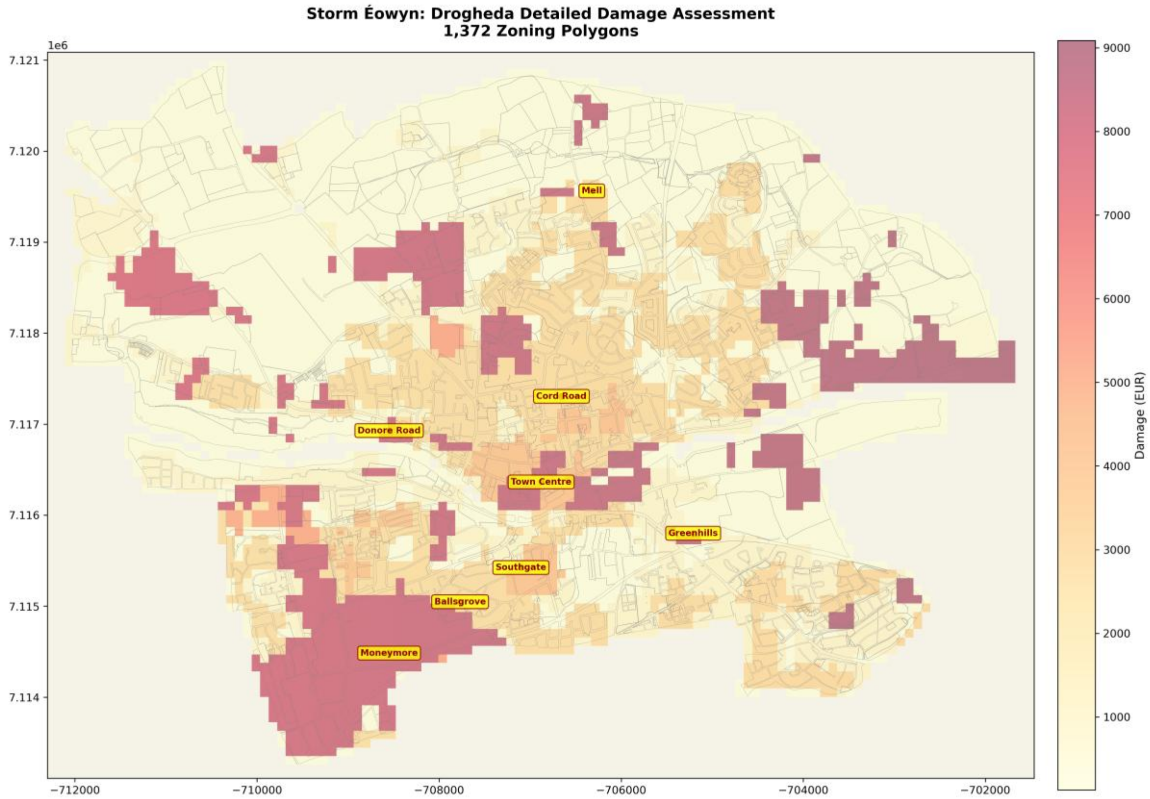

Figure 2-33. Drogheda Detailed Damage assessment.

The Drogheda analysis uses the LCDP zoning (1,372 zones for Drogheda). This is less detailed than Dundalk LAP but still substantially finer than Phase 1 LUISA 50m grid.

Labeled high-damage areas (Top 8):

Town Centre: Historic core, Boyne riverfront

- Moneymore: Residential, elevated exposure
- Yellowbatter: Residential estates
- Mell: Coastal proximity
- Greenhills: Suburban development
- Ballsgrove: Mixed residential
- Donore Road: Residential corridor
- Cord Road: Eastern area

Drogheda damage pattern is more dispersed than Dundalk, suggesting Drogheda may require a distributed adaptation strategy across multiple neighborhoods rather than the focused intervention approach suitable for Dundalk's more concentrated risk.

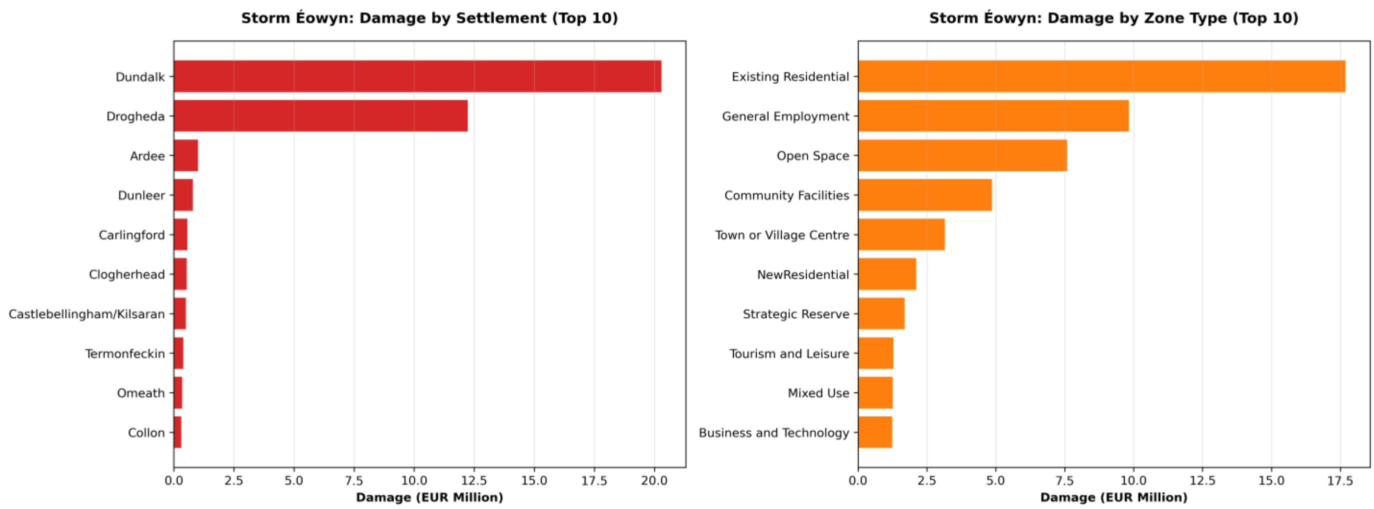

Figure 2-34. Drogheda and Dundalk Detailed Damage assessment.

Dundalk and Drogheda together account for €32.5M, representing 15.1% of the county's €215.8M total damage. This concentration reflects their dominance in population and building stock compared to rural areas and smaller settlements. "Existing Residential" zones dominate damage (€17.7M), but "General Employment" zones show disproportionately high damage (€9.8M) given their smaller land area - suggesting industrial/commercial structures are particularly vulnerable to wind damage.

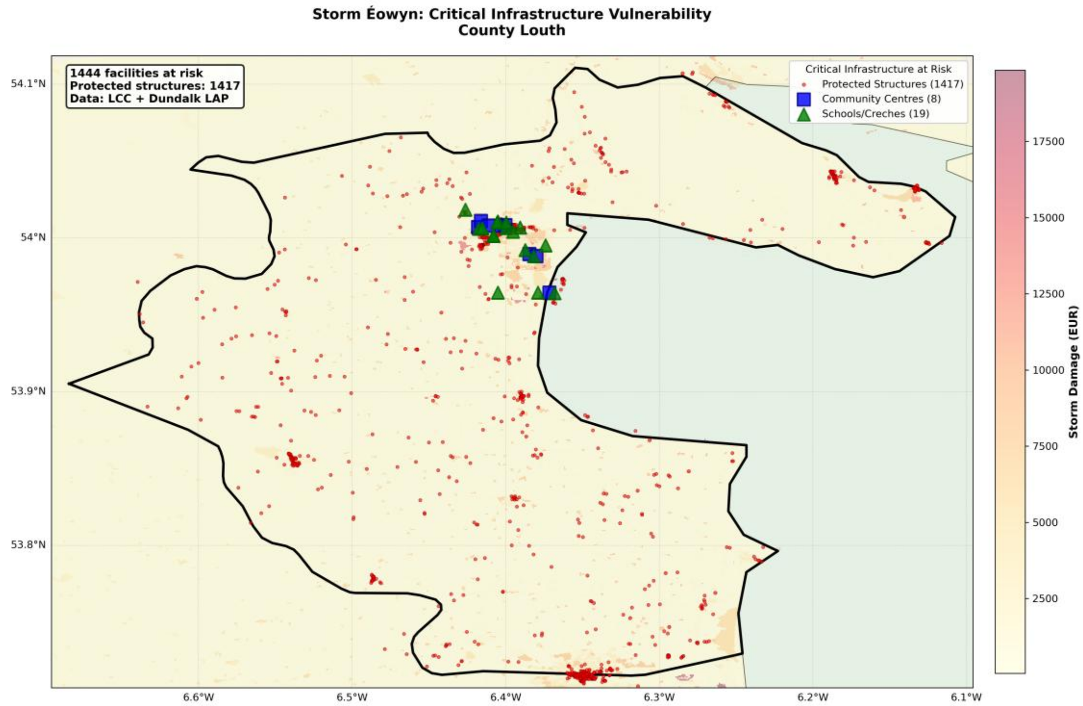

Figure 2-35. County wide infrastructure at risk.

This map overlays three categories of critical infrastructure on the Storm Éowyn damage scale. Protected Structures are heritage buildings from LCC Record of Protected Structures, including churches, historic houses, bridges, and monuments. They are concentrated in Dundalk and Drogheda historic cores, with 60% of all at risk heritage buildings in Dundalk. The dot size of these sites are scaled by damage intensity, 1,417 of 1,474 protected structures (96%) located in damage zones (any damage >€0). Coastal structures such as Carlingford and Greenore show elevated individual risk. The analysis also maps community centres and schools in high-damage zones facing potential closure during/after major storms, disrupting essential services. School closures affect working parents; community centre damage eliminates emergency shelter capacity.

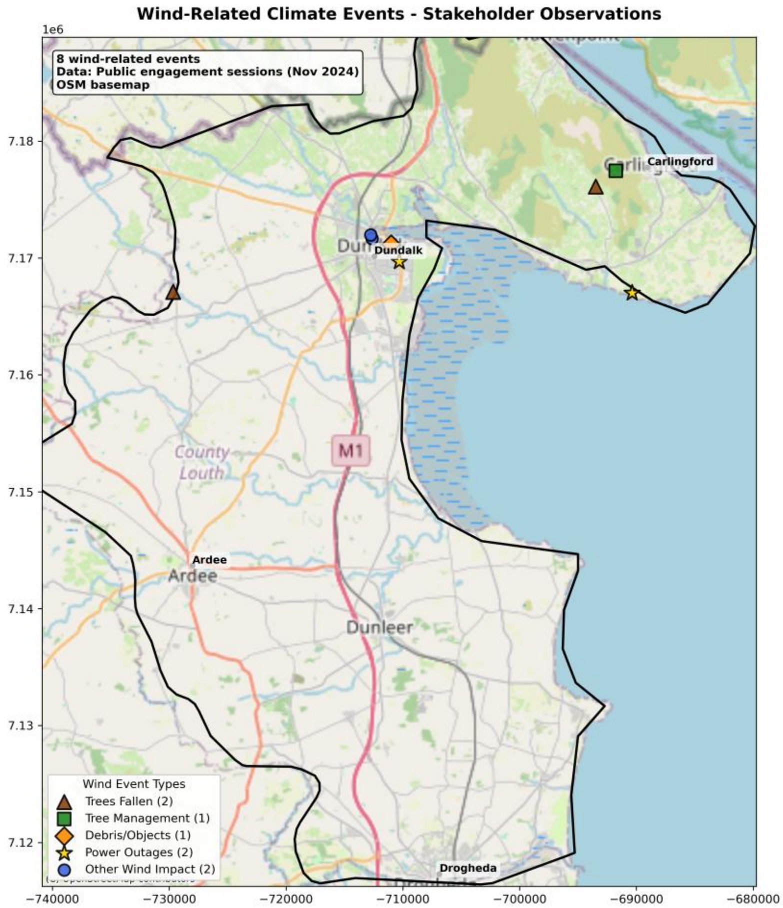

Figure 2-36. Wind-related climate events – stakeholder observations.

Figure 2-36 presents the spatial distribution of eight wind-related observations collected during the November 2024 public engagement sessions held in Ardee, Dundalk, and Drogheda. The observations encompass a range of storm impacts, including fallen trees, debris damage, power outages, and broader concerns regarding vegetation management and resilience.

A clear spatial clustering is evident in Dundalk and northern County Louth, with additional tree-related incidents reported in the Carlingford area and a power outage recorded in a rural location. The stakeholder feedback highlights three recurring themes. Firstly, tree-related impacts were the dominant concern, with six of the eight observations referring to fallen trees, branches, or trees obstructing roads and footpaths. Secondly, comments regarding trees remaining uncleared following storm events point to challenges in post-event recovery and maintenance. Finally, reports of prolonged power outages underline the vulnerability of rural communities to disruptions in critical infrastructure during severe wind events. Together, these observations provide valuable local context for understanding the types of impacts experienced during major storms and offer an important source of qualitative validation for the storm damage assessment.

Future storm damages were estimated by applying a climate-change scaling factor to the baseline Storm Éowyn damage assessment. Under the RCP 8.5 mid-century (2050) scenario, wind speeds were assumed to increase by 10%, raising the peak wind speed from 140 km/h to 154 km/h. Given the cubic relationship between wind speed and structural damage, this increase results in a damage multiplier of 1.331, equivalent to a 33.1% increase in expected losses. To generate the future damage surface, the baseline Storm Éowyn damage raster was used as the reference dataset and each pixel value was multiplied by the 1.331 scaling factor. This preserves the spatial pattern of damage observed in the baseline event while increasing the magnitude of impacts to reflect projected future wind intensities. The resulting future scenario increases total estimated damages from €215.8 million to approximately €287.3 million across County Louth.

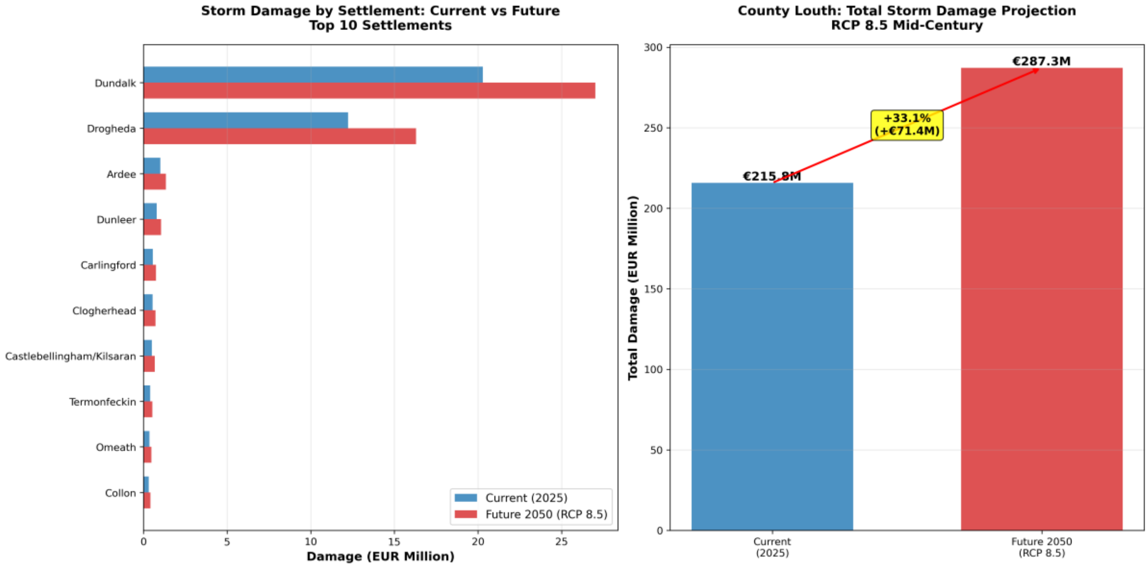

Figure 2-37. Future windstorm damage projections based on Storm Eowyn for 2050 under RCP 8.5.

The climate change projection indicates a uniform increase in storm-related damages across County Louth, with all settlements experiencing an approximate 33% rise in losses under the RCP 8.5 mid-century scenario.

- Dundalk remains the most exposed settlement, with estimated damages increasing from €20.3 million to €27.0 million (+€6.7 million).
- Followed by Drogheda, where damages increase from €12.2 million to €16.3 million (+€4.1 million).
- Ardee experiences a smaller but proportionally similar increase, rising from €1.0 million to €1.3 million.

Collectively, Dundalk and Drogheda account for €10.8 million of the total €71.6 million increase in projected county-wide damages, representing approximately 75% of the additional future losses and highlighting these settlements as priority locations for adaptation and resilience measures.

The projected 33% increase in damages also implies a corresponding increase in the frequency of severe storm events. Under this scenario:

- Events currently associated with a 10-year return period would occur approximately every 7 years.
- A current 20-year event would occur every 15 years.
- A storm with the intensity of Storm Éowyn, currently considered a 1-in-50-year event, would be expected approximately once every 37 years by mid-century.
- A present-day 1-in-100-year event would become equivalent to a 1-in-75-year event.

This shift has important implications for infrastructure design and resilience planning, as buildings and assets designed to withstand current return-period standards may experience more frequent exposure to extreme wind conditions over their operational lifetime. It should be noted, however, that this analysis is based on a scaled version of a single historical storm event and should therefore be regarded as a first-order estimate of future risk. Future changes in storm frequency, storm tracks, and regional climate dynamics are not explicitly represented and will require refinement through dedicated regional climate model projections as they become available.

2.4. Key Risk Assessment Findings

2.4.1 Mode of engagement for participation

As the overall engagement and participation process has already been outlined in section 2.1.5, this section will reflect on the feedback gathered regarding risk assessment and evaluation.

Overview

Stakeholder feedback on risks generally aligned with the main climate risks identified in Phase 1. Across all engagement locations, participants highlighted river and coastal flooding (impacting roads, access routes, homes, farmland, and sports facilities), heavy or sudden rainfall (overwhelming drainage systems, culverts, and gullies) and wind and storm events (causing fallen trees, blocked roads, damage to electricity lines, and increased challenges for vulnerable households) as the main events they associated with climate change.

However, the process also identified that while there is some fragmented and qualitative data on risks relating to climate, County Louth does not currently have a formal, documented statement of acceptable risk levels for different climate hazards. There are no clearly defined quantitative thresholds for acceptable economic losses, service disruption durations, or population exposure levels.

Organisations and risk assessment role

Data gathered in the engagement process did allow for the documentation of the main organisations involved and their role in risk assessment as shown in Table 2-11 below.

Table 2-12: Stakeholder Groups and Participation Status

Stakeholder Category	Specific Groups/Organisations	Participation Status	Role in Risk Evaluation
Local Government	Louth County Council (Climate Action Team, Planning, Roads, and Environment Departments, local Emergency Services)	Ongoing active participation	Lead organisation; risk identification, assessment, and mitigation responsibility
Elected Representatives	Louth County Councillors (all Municipal Districts)	Active participation (Nov 6, 2025 meeting)	Policy oversight; resource allocation; community representation

Community Groups	Residents from Ardee, Dundalk, Cooley and Drogheda	Active participation (Nov 11-19, 2025, drop-in sessions)	Local knowledge; vulnerability identification; adaptation ideas
Vulnerable Groups	Elderly residents, Low-income households, Coastal residents, Rural/isolated communities	Participation in community sessions	Priority group identification; specific needs assessment
Public Participation Network	Community and voluntary organisations across Louth	Regular active participation	Community outreach; feedback gathering; dissemination
National Agencies	OPW	Collaborative relationship	Flood relief scheme delivery; major infrastructure projects
National Agencies	Uisce Éireann (Irish Water)	Collaborative relationship	Water services; drainage infrastructure; wastewater management
National Agencies	Inland Fisheries Ireland	Collaborative relationship	River management; environmental protection
National Emergency Services	Health Service Executive (HSE), Civil Defence	Coordination relationship	Emergency response; vulnerable population support
Sectoral Representatives	Agricultural community, Tourism operators, Business community	Indirect participation	Sectoral vulnerability input; economic impact assessment
Environmental Organisations	Local biodiversity and tidy town advocacy groups	Active participation	Nature-based solutions advocacy; environmental stewardship

Challenges in risk ownership

Stakeholder engagement also revealed several challenges in the current risk ownership structure such as:

- **Fragmented Responsibilities** - participants identified confusion around which agency is responsible for specific aspects of climate risk management, particularly for drainage, river maintenance, and land management.
- **Coordination Gaps**- Limited coordination between agencies can result in delayed action or gaps in risk management coverage.
- **Resource Constraints** - Both the County Council and community stakeholders noted insufficient funding, staff capacity, and resources to maintain drainage infrastructure and implement comprehensive adaptation measures. There are also resource constraints in terms of community engagement.
- **Accountability Concerns** - Community members expressed limited confidence in follow-through and a perceived lack of accountability in the current governance structure.

Key observations on risk assessment

The analysis of the information gathered on risk assessment generated some key observations:

- **Need for data integration** – the engagement process identified that there is a lack of integration of the risk assessment data. There is a need for a centralised process to capture the risk data.
- **Need to manage expectations** – the process also highlighted that there is a lack of understanding among some community members about the planning and timelines involved in conducting measures. It will be important to manage those expectations going forward.
- **Importance of the precautionary approach** – as climate events are unpredictable and evolving, it will be important to keep the precautionary approach at the heart of climate action planning to ensure that uncertainty about future risks does not delay action needed to protect communities.

2.4.2 Gather output from Risk Analysis step

The risk evaluation draws on the quantitative and qualitative outputs generated in the Risk Analysis step for the three priority hazards: flooding, heavy rainfall, and windstorms. These outputs include spatial hazard maps (e.g. CFRAM and NIFM flood extents), projected changes in hazard intensity and frequency (e.g. EURO-CORDEX precipitation projections), and associated impact metrics such as economic damage estimates, exposed population, and affected infrastructure assets. These outputs are supplemented by observational datasets and stakeholder-reported impacts, which ground-truth model outputs against local experience.

For heavy rainfall, the core outputs include projected changes in rainfall intensity and frequency derived from EURO-CORDEX model ensembles, threshold exceedance analysis based on locally calibrated rainfall thresholds, and return period shifts across near-, mid-, and long-term time horizons. These are supported by observed station data and an impact database of historical events, enabling calibration of model outputs against real-world impacts.

For windstorms, the assessment draws on detailed event-based modelling supported by Met Éireann observational data, enabling a more accurate representation of hazard intensity and spatial distribution. Key outputs include high-resolution wind speed surfaces, structural damage estimates at settlement and parcel level, and validated comparisons with recorded damage from Storm Chandra. The analysis also incorporates vulnerability assessments for different building types, exposure of protected structures and critical infrastructure, and a future climate scenario applying IPCC-aligned intensity scaling. Together, these outputs provide a robust evidence base for understanding both current windstorm risk and its potential escalation under climate change.

In addition to quantitative metrics, qualitative evidence from stakeholder engagement plays a critical role in shaping the risk evaluation. Community-reported flooding locations, infrastructure vulnerabilities, and disruption scenarios provide context for interpreting modelled results and help identify cascading impacts not fully captured in datasets.

These combined outputs form the evidence base for the subsequent assessment of risk severity, urgency, and resilience capacity. They are synthesised within the Key Risk Assessment framework to ensure a consistent and transparent evaluation across hazards.

2.4.3 Assess Severity

The severity of climate risks in County Louth has been assessed based on the scale, frequency, and consequences of impacts identified through the Risk Analysis step, considering both current conditions and projected future changes. The assessment applies the four CLIMAAX severity categories (limited, moderate, substantial, and critical), based on the extent of human, economic, environmental, and infrastructure impacts.

Severity has been evaluated using a combination of quantitative outputs (including damage estimates, spatial exposure analysis, and hazard intensity projections) and qualitative inputs from stakeholder engagement, ensuring that both modelled impacts and observed experience are reflected in the categorisation. Each hazard has been assessed using a methodology tailored to its characteristics, drawing on the most suitable available datasets and modelling approaches.

Flooding

Flooding is assessed as having substantial to critical severity, reflecting its capacity to generate significant economic damages, disrupt critical infrastructure, and affect concentrated population centres. The analysis identifies high-value exposure in urban areas such as Dundalk, where damages associated with a 1-in-100-year flood event are estimated to exceed €200 million, alongside risks to residential areas, employment zones, and critical services. The potential for coastal flooding and river overflow to affect transport networks and access routes further amplifies severity through cascading impacts on emergency response and economic activity. Note that although the impact of flooding may be severe, it is being addressed for County Louth through a number of ongoing initiatives (e.g. OPW Flood Relief Schemes; CFRAM implementation). In this report more focus has therefore been given to windstorms and heavy rainfall, which in itself can be a key risk driver of surface water flooding and river overflow.

Heavy Rainfall

Heavy rainfall is assessed as having moderate to substantial severity, with the primary impacts arising from surface water flooding, drainage exceedance, and localised disruption. Increasing rainfall intensity contributes directly to surface water flooding, river overflow, and drainage system exceedance, resulting in widespread disruption to transport networks, residential areas, and critical infrastructure. The analysis indicates that even moderate increases in rainfall intensity can lead to significant impacts where systems are already operating at or near capacity, particularly in urban areas such as Dundalk and Drogheda.

The severity of heavy rainfall is further amplified by its cascading effects, including restricted access routes, wastewater overflow, and indirect economic losses due to service disruption. Unlike more spatially confined hazards, heavy rainfall can affect large geographic areas simultaneously, creating compound pressures on emergency services and infrastructure systems.

Windstorms

Windstorms are assessed as having substantial severity, reflecting their ability to generate high economic damages and widespread disruption despite their relatively short duration. Phase 2 modelling indicates total damages of over €200 million for a single extreme storm event, with impacts concentrated in urban centres but extending across the county. The analysis highlights that relatively small increases in wind speed can produce disproportionately large increases in damage due to the cubic wind, damage relationship, amplifying future risk. In addition to direct structural losses, windstorms pose significant cascading risks through power outages, transport disruption, and impacts on critical services and heritage assets, reinforcing their classification as a high-impact hazard.

Stakeholder feedback reinforces these findings, highlighting recurring impacts from both heavy rainfall and storm events, including blocked roads, infrastructure damage, and service interruptions. The assessment also recognises potential longer-term impacts, including infrastructure degradation and increased maintenance costs, as well as indirect impacts on vulnerable population groups.

Overall, the severity of these hazards is driven not only by the magnitude of individual events but by their interaction with existing infrastructure constraints and system vulnerabilities, leading to impacts that are disproportionate to the initial hazard magnitude.

2.4.4 Assess Urgency

The urgency of climate risks in County Louth has been assessed by considering the timing and trajectory of risk escalation, the persistence of hazards, and the need for timely intervention to minimise future impacts. The assessment applies the CLIMAAX urgency categories (no action needed, watching brief, more action needed, and immediate action needed), based on both current risk levels and projected changes over time.

Flooding

The assessment conducted here suggests that flooding should be categorized as requiring immediate action, reflecting both its current impact and its projected intensification under future climate scenarios. Evidence from the analysis demonstrates that flooding is already affecting communities and infrastructure across the county, with recurring impacts in urban centres and coastal areas. Future projections indicate increased flood extent and damage potential under mid-range and high-end scenarios, reinforcing the need for proactive adaptation measures. Note that action on flood adaptation is already being addressed in County Louth through a number of ongoing projects (e.g. OPW Flood Relief Schemes; CFRAM implementation).

Heavy Rainfall

Heavy rainfall is assessed as requiring immediate action, reflecting both its current impact and its projected intensification over time. Evidence from the assessment demonstrates that rainfall-related impacts, including drainage exceedance and localised flooding, are already occurring across the county. While near-term projections (2011–2040) show variability driven by natural climate fluctuations, a clearer and more consistent increase in rainfall intensity emerges by mid-century, particularly under high-emissions scenarios.

This trajectory highlights a critical window for intervention. Without proactive measures, increasing rainfall intensity is likely to exacerbate existing infrastructure constraints, leading to more frequent and severe disruption. The fact that relatively modest increases in rainfall can trigger significant impacts underscores the need for early and sustained adaptation action, particularly in relation to drainage capacity, urban design, and land-use planning.

Windstorms

Windstorms are assessed as requiring more action needed, reflecting their episodic but high-impact nature and the projected increase in damage under future climate conditions. While less frequent than rainfall-driven events, the modelling demonstrates that a mid-century increase in wind intensity could raise damages by approximately one-third and shift the return period of severe storms (e.g. a current 1-in-50-year event becoming closer to 1-in-37 years). This indicates a narrowing window for proactive adaptation. Priority actions include strengthening building resilience, enhancing vegetation and asset management, and improving emergency response coordination to reduce disruption during extreme events.

Stakeholder engagement reinforces the urgency assessment, with participants highlighting the increasing frequency of disruptive weather events, the strain on infrastructure systems, and the need for preventative measures rather than reactive responses. The combination of current impacts and projected future intensification supports a precautionary approach, prioritising early and sustained action to reduce risk over time.

2.4.5 Understand Resilience Capacity

The assessment of resilience capacity in County Louth is informed by a review of existing strategies, plans, and investment programmes, alongside targeted engagement with Louth County Council representatives, engineers, and a range of local stakeholders. This combined evidence base ensures that the evaluation reflects both formal policy and investment frameworks, as well as practical, on-the-ground experience of system performance and constraints.

Resilience capacity has been assessed in line with the CLIMAAX framework across multiple dimensions, including financial, human, physical, natural, social, and institutional capacity. This approach considers the extent to which existing measures, resources, and governance arrangements support the county's ability to anticipate, respond to, and recover from climate risks. Capacity is categorised as low, medium, substantial, or high, based on the maturity and effectiveness of these components.

Flooding

For flooding, resilience capacity is assessed as substantial. This is underpinned by robust institutional and financial capacity, including national-level investment through the OPW and a clear pipeline of flood relief schemes. Physical capacity is supported by established flood defence infrastructure and planning mechanisms such as the LCDP and Strategic Flood Risk Assessment, which guide risk-informed land use. Human and social capacity are also relatively strong, with well-developed expertise within local and national agencies and established processes for public communication and engagement. While natural capacity continues to play a role, particularly in catchment management, residual risks remain, particularly in urban areas where exposure is highest. Nonetheless, the overall system demonstrates a comparatively strong ability to manage and reduce flood risk.

Heavy Rainfall

For heavy rainfall, resilience capacity is assessed as medium. While there are positive developments in financial and institutional capacity, including ongoing investment in drainage improvements and increasing recognition of nature-based solutions, physical capacity remains a key constraint. Drainage and wastewater systems in several locations are already operating at or near capacity, limiting the ability to absorb additional rainfall intensity. This creates a structural vulnerability whereby even moderate increases in rainfall can lead to system exceedance, localised flooding, and disruption to services. Human capacity, in terms of awareness and technical understanding, is developing, while natural capacity, particularly the use of green infrastructure and sustainable drainage systems, remains an area for further expansion. Overall, resilience is constrained by infrastructure performance and requires targeted enhancement to keep pace with projected climate impacts.

Windstorms

For windstorms, resilience capacity is assessed as medium, though it varies across sectors. Institutional and human capacity are relatively strong, reflected in effective emergency planning, coordination mechanisms, and response capabilities. These support timely and organised responses to storm events. However, physical capacity is more variable, with vulnerabilities in critical infrastructure networks, buildings, and heritage assets, particularly in areas identified as being at higher risk of storm damage. Financial capacity is more limited in terms of proactive investment in wind resilience, while natural capacity, such as the management of vegetation and tree cover, remains an important but not fully integrated component of risk management. In addition, social capacity, including community preparedness and awareness, varies across locations. Current approaches do not fully capture indirect and non-structural risks, such as disruption caused by damage to utilities and transport networks, which can have cascading impacts.

In summary, the assessment indicates that resilience capacity in County Louth is shaped by a combination of established governance arrangements, ongoing investment programmes, and locally embedded expertise, but is moderated in practice by constraints in infrastructure performance and system integration. The most significant limitations are observed in the capacity of drainage and wastewater systems to accommodate increasing rainfall intensity, alongside gaps in the integration of natural and nature-based solutions within existing grey infrastructure. Variability in capacity across hazards and sectors also highlights the need for more coordinated, cross-agency approaches, particularly where risks interact across systems. Strengthening resilience will therefore depend on targeted infrastructure upgrades, improved alignment between planning, engineering, and environmental functions, and the continued development of locally relevant adaptation measures informed by both technical analysis and stakeholder input.

2.4.6 Decide on Risk Priority

The assignment of risk priorities for County Louth follows the CLIMAAX Key Risk Assessment methodology, which combines quantitative scoring with qualitative validation. The process draws on the outputs of the preceding assessment steps, including hazard characterisation, exposure and vulnerability analysis, and the evaluation of resilience capacity. These inputs are consolidated through the CLIMAAX evaluation dashboard, where risks are systematically scored and compared, and the results are subsequently reviewed and refined through stakeholder engagement to ensure alignment with local knowledge and experience.
The prioritisation of climate risks for County Louth has been undertaken using the CLIMAAX Key Risk Assessment framework, which combines severity, urgency, and resilience capacity into a consolidated Risk Priority Index (RPI). This provides a transparent and consistent basis for comparing hazards, supported by both quantitative analysis and stakeholder input.

Priority outcomes:

Heavy rainfall, flooding, and windstorms all emerge as high-priority risks, but for different reasons.

Heavy rainfall is identified as an important near-term risk driver, reflecting its direct interaction with drainage and wastewater capacity constraints and its role in triggering multiple cascading impacts, including surface water flooding, transport disruption, and service interruption. A clear mid-century intensification signal further reinforces the need for early and sustained intervention.

Flooding (river and coastal) remains the highest-impact hazard in absolute terms, with substantial to critical consequences for economic assets and infrastructure. However, its prioritisation is moderated by the presence of established mitigation programmes, particularly OPW-led flood relief schemes. As a result, the focus shifts towards managing residual risks and addressing indirect and compound impacts.

Windstorms emerge as a high-impact and previously under-recognised risk, with event-based modelling indicating damages exceeding €200 million for extreme storms. The use of observed wind data and local exposure datasets significantly increases estimated impacts compared to Phase 1. Importantly, the non-linear relationship between wind speed and damage means that modest increases in intensity could drive disproportionately large increases in losses (approximately +33% under mid-century conditions). While less frequent than rainfall-driven events, windstorms present a significant risk of widespread disruption to power, transport, and critical services.

Risk Workflow	Severity		Urgency	Capacity	Risk Priority
	C	F		Resilience/ CRM	
Flooding	Substantial	Critical	Immediate	Substantial	High
Heavy rainfall	Moderate	Substantial	Immediate	Medium	High
Wind	Substantial	Critical	More Action	Medium	High

Figure 2-38. Prioritisation of risks using the CLIMAAX risk evaluation dashboard.

The fact that all three risks are designated as high priority highlights the need to move beyond single-hazard analysis towards a more integrated, systems-based approach. Heavy rainfall acts as a cross-cutting driver of risk, while flooding represents the largest defined exposure, and windstorms introduce a non-linear, high-impact risk dynamic that is particularly relevant for future planning.

2.5. Monitoring and Evaluation

Phase 2 of the Climate Risk Assessment represents a significant step forward in understanding climate risks in County Louth. By integrating local data sources, refining methodologies, and incorporating stakeholder input, the assessment has moved beyond the high-level screening undertaken in Phase 1 to provide a more detailed and locally grounded analysis. At the same time, the process has highlighted a number of areas where further improvements are required, particularly in relation to data availability and the integration of different evidence sources.

A key outcome of Phase 2 is the enhanced relevance and spatial resolution of the assessment. This has been achieved through the use of locally sourced datasets, including OPW CFRAM flood data, LAP zoning information, and CSO Census data, combined with the calibration of hazard thresholds using observational records and documented impact data. Crucially, the assessment has also incorporated stakeholder knowledge and lived experience, allowing modelled outputs to be grounded in real-world observations. Together, these developments have enabled a shift towards a more granular and spatially differentiated understanding of risk, particularly in urban centres such as Dundalk and Drogheda.

A further important insight emerging from Phase 2 is the significance of interactions between hazards and infrastructure systems including drainage networks, and transport and communication networks. In particular, the analysis of heavy rainfall demonstrates how relatively modest increases in rainfall intensity can lead to disproportionately large impacts where systems such as drainage and wastewater infrastructure are already operating at or near capacity. This reinforces the importance of considering climate risks in a systems context rather than assessing hazards in isolation.

Despite these advancements, the assessment process encountered a number of challenges and limitations. Data constraints remain a key issue, particularly in relation to the availability of high-resolution, asset-level data and detailed socio-economic vulnerability information. While windstorm modelling has been significantly advanced through the use of observational data and event-based analysis, uncertainties remain regarding future storm frequency, track behaviour, and regional climate dynamics. There also remains a lack of integrated datasets that combine hazard, exposure, and vulnerability in a consistent format. Methodological constraints were also evident, including the reliance on present-day exposure as a baseline, which limits the ability to fully assess future socio-economic change, and the need for simplifying assumptions in some workflows, for example in relation to flood depth estimates in AFAs. Stakeholder engagement, while valuable, also presented challenges, including uneven participation across locations and groups, difficulty in reaching certain vulnerable populations, and the need to carefully manage expectations regarding the distinction between risk assessment and the implementation of adaptation measures.

Stakeholders continue to play a central role in both validating the assessment outputs and supporting ongoing monitoring. Their input has been critical in ground-truthing modelled results, identifying emerging risks and infrastructure pressures, and supporting the communication and dissemination of findings. Feedback from the engagement proneocess indicates a strong alignment between modelled results and local experience, which in turn increases confidence in the robustness and relevance of the assessment.

Looking ahead, several priorities have been identified to strengthen monitoring and improve the evidence base. These include the development of more detailed asset-level and infrastructure datasets, improved socio-economic vulnerability data at sub-county scale, and the establishment of more systematic approaches to event-based data capture, such as post-storm reporting. There is also a clear need for a more integrated data environment, including the development of a centralised risk data platform to support decision-making.

The assessment process has also embedded learning mechanisms through the documentation of methodologies and assumptions, ongoing stakeholder engagement, and alignment with policy and planning processes. The final outputs will be communicated through a combination of technical reports, spatial datasets, policy briefings, and public-facing summaries, ensuring that the findings are accessible to both decision-makers and the wider community.

Overall, Phase 2 has substantially strengthened the evidence base for climate risk assessment in County Louth, while also enhancing stakeholder engagement and institutional capacity. These developments provide a strong foundation for Phase 3, where the focus will shift to translating risk insights into targeted and implementable adaptation actions.

2.6. Work plan Phase 3

This phase will focus on transforming the prioritised climate risks identified in Phase 2 into a locally deliverable, policy-aligned adaptation strategy and a set of targeted risk management plans. The approach follows the CLIMAAX CRM framework while building directly on Louth's Climate Action Plan. Outputs from this phase are designed to be feasible, aligned with Louth County Council's operational and emergency planning systems, and focused on measures that can reduce future climate impacts and strengthen climate resilience at local level.

Main activities of Phase 3

1. **Refining the Prioritisation Approach**

Phase 3 will focus exclusively on the priority climate risks identified. The results from Phases 1 and 2 will be consolidated to define clear adaptation objectives that respond to the most pressing and decision-relevant risks for County Louth.

This will seek to incorporate Phase 2 prioritised risk inventory; CLIMAAX CRM principles and good practice; relevant existing policies and responsibilities of Louth County Council; and stakeholder feedback. Outputs of this stage will include:

- Adaptation strategy framework evaluation and prioritisation criteria.
- Defined governance, delivery and monitoring structures.

2. **Risk-specific Adaptation Option Identification**

We will identify potential adaptation options for each priority risk, drawing on the CLIMAAX Toolbox, established best-practice approaches and technical knowledge at local level. We will also take account of risk inventory and climate scenario data; local demographic, asset and spatial data sets to ensure a balanced and integrated approach to option identification.

Outputs for this stage will include:

- Longlist of adaptation options.
- Stakeholder and community co-design documentation.
- Mapping of options to sectors, systems, and population groups

3. Evaluation & Strategy Finalisation

Adaptation options will be evaluated through a structured multi-criteria process, using factors such as urgency, cost-effectiveness, equity, and potential for co-benefits, including biodiversity, health, and economic resilience. A key focus of this phase is to ensure that proposed adaptation measures are well-understood, feasible, and implementable.

Strategy outputs will include:

- Prioritised adaptation strategy.
- Adaptation pathways for near-term, medium-term, and long-term implementation.
- Indicator set for monitoring impact and strategy refinement

4. Targeted Risk Management Plans

This phase will include three standalone risk management plans that provide in-depth, action-ready guidance for: Louth County Council-owned buildings, vulnerable communities, and heritage assets. Each plan will include detailed climate risk characterisation, GIS-based mapping, and exposure overlays, with analysis tailored to real locations and operational needs. These reports will be structured for direct use in planning submissions, capital budgeting, emergency preparedness, and external funding applications, ensuring they are technically robust, policy aligned, and implementation-ready.

Outputs for this phase will include:

- Three targeted, standalone climate risk and adaptation reports.
- GIS and tabular outputs with at-risk locations.
- Briefing materials for policy, funders, and public use.

Note:

Phase 3 will not revisit the detailed modelling or analysis already completed. It will focus solely on those climate risks that were identified as priorities through the Key Risk Assessment process.

3. Conclusions Phase 2- Climate risk assessment

Phase 2 of the CLIMAAX Climate Risk Assessment for County Louth has substantially deepened the understanding of climate risks by integrating local data, refining modelling approaches, and incorporating stakeholder insights.

Overall, the Phase 2 assessment identifies windstorms, heavy rainfall, and flooding as the three dominant and interacting climate risks for County Louth, each demonstrating a clear increase in intensity under future climate conditions. Across all hazards, the most pronounced changes emerge under the high-emissions scenario (RCP 8.5) at the mid-century horizon (2041–2070), which provides the most robust and decision-relevant representation of future risk. This period captures a point at which the climate change signal has strengthened sufficiently to be clearly distinguishable from natural variability, while still remaining within the planning horizon of current infrastructure and policy decisions.

Heavy rainfall results indicate substantial intensification by mid-century, with increases of up to approximately +45% in extreme events under RCP 8.5, alongside a significant shortening of return periods. Windstorm analysis shows that even modest increases in wind speed translate into disproportionately large increases in damage due to the non-linear wind–damage relationship, resulting in an estimated ~33% increase in impacts by mid-century. Flooding risk, while more spatially variable, is similarly projected to intensify through the combined effects of increased rainfall and discharge, leading to greater inundation extents and economic damages.

Taken together, these results demonstrate a consistent pattern across all three hazards: moderate changes in the near term transition to a step-change in severity by mid-century, particularly under high-emissions conditions. The mid-century RCP 8.5 scenario therefore represents the most appropriate basis for interpreting future risk, as it reflects both the upper bound of plausible climate impacts and the timing at which these impacts become materially significant for infrastructure, population exposure, and planning decisions.

Key conclusions

1. **Validation and refinement of priority hazards**
   Flooding, heavy rainfall, and windstorms remain the dominant climate risks for County Louth. Phase 2 confirms the robustness of the Phase 1 screening while providing greater spatial and sectoral detail.

2. **Non-linear risk dynamics**
   The assessment highlights the importance of non-linear risk dynamics, particularly for windstorms and rainfall, where relatively small changes in hazard intensity can lead to disproportionately large increases in impact. This reinforces the need for anticipatory, systems-based adaptation approaches.

3. **Heavy rainfall as a critical risk driver**
   While flooding represents the highest impact risk in absolute terms, heavy rainfall emerges as a key systemic driver of disruption, particularly through its influence on surface water flooding, drainage and wastewater exceedance, and transport and access disruptions.

4. **Impact of windstorms**
   Windstorms emerge as a high-impact, spatially variable risk, with Phase 2 demonstrating

that the use of observed wind data and local exposure significantly increases estimated losses and reveals critical vulnerabilities in the built environment, particularly in urban centres. With the focus on this risk in the 2025 NCCRA report, exploring its impact on a local level should also help support adaptation at a national level.

5. **Uneven distribution of risk and vulnerability**
   Risk is not uniform across the county. Urban centres such as Dundalk and Drogheda, alongside certain rural areas, face elevated exposure due to a combination of infrastructure constraints, geographic characteristics, and socio-economic factors.
6. **Improved accuracy through local data integration**
   The use of Met Eireann data, OPW flood datasets and local zoning data has significantly improved the realism of impact estimates, reducing overestimation observed in Phase 1.
7. **Resilience capacity is established but constrained**
   While strong institutional frameworks exist, resilience is limited by drainage and infrastructure capacity constraints, fragmented responsibilities across agencies, and wider resource limitations.
8. **Stakeholder validation strengthens findings**
   Engagement confirms strong alignment between model outputs and community experience, enhancing confidence in the results and highlighting practical adaptation needs.

Challenges not fully resolved

Despite the progress made in Phase 2, several challenges remain. Persistent gaps in high-resolution data continue to limit the ability to undertake fully granular analysis, particularly in relation to asset-level exposure and socio-economic vulnerability. The limited integration of future socio-economic scenarios also constrains the assessment of how risk may evolve over time beyond climate-driven changes.

Stakeholder engagement, while beneficial through workshops and direct consultations, was not comprehensive across all intended channels. In particular, no responses were received to the stakeholder survey despite it being widely circulated. This limited the ability to systematically capture broader perspectives and may result in certain viewpoints or local insights not being fully reflected in the assessment

In addition, while windstorm modelling has been significantly advanced through the use of observational data and event-based analysis, uncertainties remain regarding future storm frequency, and regional climate dynamics. Finally, the need for improved coordination across agencies remains a recurring issue, with fragmented responsibilities posing challenges for integrated risk management and implementation.

Overall conclusion

Phase 2 has transitioned the assessment from a screening-level exercise to a locally grounded, decision-relevant evidence base. The findings provide a robust foundation for adaptation planning and emphasise the importance of adopting a systems-based approach to managing climate risks in County Louth, where interactions between hazards, infrastructure, and communities are fully considered.

4. Progress evaluation

The Phase 2 deliverable represents a critical step in the CLIMAAX project lifecycle, moving from the initial risk identification undertaken in Phase 1 to a more refined and evidence-based climate risk assessment in Phase 2. In doing so, it directly informs the next stage of the project, which will focus on the development of targeted adaptation measures in Phase 3.

The outputs of Phase 2 make a significant contribution to the overall project objectives. They provide an enhanced and more locally grounded understanding of climate risks across County Louth, while also supporting the integration of climate considerations into planning and policy frameworks. In addition, the development of a prioritised risk framework establishes a clear and structured basis for guiding adaptation efforts.

These outputs will underpin the activities planned for Phase 3. In particular, the findings from Phase 2 will inform the identification and prioritisation of adaptation measures, ensuring that interventions are aligned with the most significant and urgent risks. They will also support the development of practical implementation pathways, translating risk insights into actionable strategies. Continued stakeholder engagement will remain a central component of this process, enabling the co-design of adaptation measures that are both technically robust and locally relevant.

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
At least two workflows successfully applied in Deliverable 1.	Completed as part of Phase 1 deliverable.
Four in-person communication events to share results and collect local data with stakeholders. One for Drogheda, Ardee, Dundalk, and Carlingford.	Completed. In-person events with active stakeholder participation were held in Ardee, Dundalk, Cooley, and Drogheda during November 2025.
All LCC Buildings and assets to be risk assessed.	LCC Buildings are mapped and included in additional documents submitted.
Risk Assessment of Heritage structures in Louth.	Protocted structures and heritage sites are assessed against wind and flood damage.
Submission of articles to regional and national media mentioning the project.	Article covering Phase 1 results published digitally, and press releases shared with regional and national media.

Table 4-2 Overview milestones

Milestones	*Progress*
Presentation of the results of Phase 1 to policy and decision-makers in Louth.	Completed. The results of Phase 1 were presented and discussed with Louth elected officials on the 6th November 2025. The results were also presented during Climate Action Week via a Webinar delivered to local authorities across Ireland (14th October 2025), and at the Environ Conference held in Dundalk on the 28th April 2026.
Community and stakeholder engagement and data collection workshops for Phase 2.	Completed. This was delivered through in-person events held in Ardee, Dundalk, Cooley, and Drogheda, as well as engagement through the webinars, conferences and briefing sessions described above.
Delivery of Phase 2 refined risk assessment.	Completed.
Presentation of the results of Phase 2 to policy and decision-makers in Louth.	To be arranged during July 2026.

5. Supporting documentation

Main Report

Other Materials
CLIMAAX Louth County - Environ Conference April 2026 v2.pptx
CLIMAAX Communications Material.docx
CLIMAAX Louth County Internal Stakeholders 10_12_25_Draft.pptx
CLIMAAX_Phase2_Engagement Summary.docx
CLIMAAX Engagement Notes.docx
Louth Engagement Posters.pdf
CLIMAAX Phase 1 Louth Climate Action Week 14_10_25.pdf

Heavy Rainfall
<u>Scripts</u>
analyse_storm_eowyn.py
build_hazard_impact_database.py
build_hr_chapter_docx.py
calculate_return_period.py
critical_rainfall_threshold.py
download_cordex_ensemble.py
export_geotiff_v2.py
fill_idf_grid.py
generate_deliverable_outputs.py
geocode_hazard_events.py
HEAVY_RAINFALL_Hazard_CountyLouth.py
HEAVY_RAINFALL_Risk_CountyLouth.py
make_allperiods_bcmpi_table.py
make_facilities_map.py
make_hotspot_map.py
make_idf_overlay.py
make_lca_combined.py
make_midcentury_bars.py
make_midcentury_bcmpi_table.py
make_midcentury_ensemble_table.py
make_population_centres.py
make_prec_2panel.py
make_settlement_map.py
make_table26_bcmpi.py
make_trajectory_timeline.py
met_eireann_utils.py
preflight_check.py
process_cordex_ensemble.py
regen_midcentury_maps.py
run_mpi_regional.py
validate_cordex_with_stations.py
validate_event_database.py
validate_hazard_refactoring.py
validate_refactoring.py

Data
CLIMAAX Stakeholder Engagement Lat Long.csv
dly1338.csv
dly1375.csv
dly1838.csv
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dly3338.csv
dly3438.csv
dly3831.csv
dly538.csv
dly9938.csv
hly1375.csv
hly675.csv
louth_hazard_events_geocoded.csv
Louth_hazard_impact_database.xlsx
Louth_return_period_1hr_24hr.csv
Louth_return_period_1hr_24hr_filled.csv
StationDetails.csv

Outputs and Figures
01_Fig11_station_maxima.png
02_Fig24_PREC_2panel_near.png
03_Fig25_PREC_2panel_mid.png
04_Fig26_PREC_2panel_long.png
05_Fig29_RP_near_rcp45.png
06_Fig30_RP_near_rcp85.png
07_Fig31_RP_mid_rcp45.png
08_Fig32_RP_mid_rcp85.png
09_Fig33_RP_long_rcp45.png
10_Fig34_RP_long_rcp85.png
11_Fig37_combined_lca_mid_rcp85.png
12_Fig40_settlement_near.png
13_Fig40_settlement_mid.png
14_Fig40_settlement_long.png
15_Fig41_population_centres.png
16_Fig43_key_facilities_mid_rcp85.png
climate_signal_timeline_BC_MPI.png
event_table_24h.xlsx
event_validation_results.csv
hotspot_overlay_rcp45_2011-2040.png
hotspot_overlay_rcp45_2041-2070.png
hotspot_overlay_rcp45_2071-2100.png
hotspot_overlay_rcp85_2011-2040.png
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hotspot_overlay_rcp85_2071-2100.png
idf_overlay_BC_MPI_2011-2040.png
idf_overlay_BC_MPI_2041-2070.png
idf_overlay_BC_MPI_2071-2100.png
lca_priority_rcp45_2011-2040.png
lca_priority_rcp45_2041-2070.png

lca_priority_rcp45_2071-2100.png
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lca_priority_rcp85_2071-2100.png
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magnitude_change_bars_BC_MPI_2071-2100.png
municipality_zonal_stats_24h.xlsx
PREC_shift_threshold_rcp45_2011-2040.png
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PREC_shift_threshold_rcp45_2071-2100.png
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PREC_shift_threshold_rcp85_2041-2070.png
PREC_shift_threshold_rcp85_2071-2100.png
risk_priority_dashboard_24h.xlsx
summary_table_24h.xlsx
summary_table_24h_climate_signal.csv
table_2_6_bcmpi.csv
table_2_6_bcmpi.png
table_2_6_bcmpi.xlsx
validation_observed_vs_BC_MPI.png

Floods
<u>Scripts</u>
FLOOD_BUILDING_POPULATION_Risk_CountyLouth.py
FLOOD_COASTAL_Hazard_CountyLouth.py
FLOOD_DISCHARGE_CountyLouth.py
FLOOD_RIVER_Hazard_CountyLouth.py
FLOOD_RIVER_Risk_CountyLouth.py
generate_deliverable_outputs.py
lcc_data_utils.py
run_final_sanity_gate.py

<u>Data</u>
06014_tallanstown_q_complete.csv
CLIMAAX Stakeholder Engagement Lat Long.csv
curves.csv
Glossary_Saps_2022_REVISED_21102024.xlsx
hp-deprivation-index-scores-2022.csv
JRC_damage_curves.csv
LUISA_damage_info_curves_County_Louth.xlsx
maxdam_luisa.csv
SAPS_2022_Small_Area_UR_171024.csv

<u>Outputs and Figures</u>
afa_panel_Annagassan.png
afa_panel_Ardee.png
afa_panel_Baltray.png
afa_panel_Bettystown.png
afa_panel_Blackrock_South.png
afa_panel_Carlingford_&_Greenore.png
afa_panel_Carrickmacross.png
afa_panel_Drogheda.png

afa_panel_Dundalk.png
afa_panel_Inishkeen.png
afa_panel_Mornington.png
afa_panel_Termonfeckin.png
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cfram_coastal_current_RP1000.png
cfram_coastal_current_RP200.png
cfram_coastal_highend_RP10.png
cfram_coastal_highend_RP1000.png
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cfram_coastal_midrange_RP10.png
cfram_coastal_midrange_RP1000.png
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cfram_river_midrange_RP1000.png
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coastal_afa_panel_Drogheda.png
coastal_afa_panel_Dundalk.png
coastal_afa_panel_Mornington.png
coastal_afa_panel_Termonfeckin.png
coastal_hazard_area_summary.xlsx
council_buildings_exposure.csv
council_buildings_stakeholder_crossref.csv
dundalk_zoning_damages_by_category.csv
dundalk_zoning_damages_current.csv
F-B-01_dundalk_zoning_damage.png
F-B-02_dundalk_damage_vs_rp_mead.png
F-B-03_population_exposure.png
F-C-01_water_level_timeseries_2015.png
F-C-02_cfram_coastal_dundalk_bay_current_vs_highend.png
F-D-01_station_map.png
F-D-02_discharge_timeseries.png
F-R-01_cfram_vs_jrc_rp100_dundalk.png
F-R-02_lca_flooded_pct_present_vs_cc.png
F-R-03_phase1_vs_phase2_damage.png
F-R-04_dundalk_triple_panel_current_0100.png
F-R-05_phase1_damage_per_lca.png
F-R-06_damage_vs_rp.png
F-R-07_damage_maps_current.png
louth_discharge_summary.csv
population_exposure_current.csv

river_hazard_area_summary.xlsx
river_risk_phase2_damages_by_landuse.csv

Windstorms
<u>Scripts</u>
STORM_Risk_CountyLouth.py
STORM_Risk_CountyLouth_CDS.py
STORM_Risk_CountyLouth_MetEireann.py
add_county_boundary_to_figures.py
analyse_chandra_damage_local_data.py
analyse_chandra_local_EXACT.py
analyse_chandra_local_EXACT_COPY.py
analyse_critical_infrastructure.py
analyse_dundalk_damage_detailed.py
analyse_louth_damage_local_data.py
check_and_run_ophelia.py
check_cpi_doubling.py
compare_chandra_methodologies.py
compare_ophelia_methodologies.py
compare_phase1_phase2_damage.py
config_paths.py
create_cds_meteireann_comparison_chart.py
create_chandra_map_exact_match.py
create_future_storm_projections.py
create_ophelia_damage_from_eowyn.py
create_settlement_zoom_maps.py
download_ireland_counties.py
explore_met_eireann_data.py
explore_osi_buildings.py
find_storm_data.py
fix_ophelia_damage.py
generate_deliverable_outputs.py
generate_maxdam_map_minimal.py
generate_phase1_style_figures.py
generate_wind_maps_cartopy.py
generate_wind_speed_maps.py
geocode_chandra_locations.py
geocode_chandra_manual.py
get_county_boundary.py
identify_storms.py
lcc_storm_utils.py
map_chandra_damage_detailed.py
map_chandra_damage_meteireann_local.py
map_heritage_chandra_damage.py
map_heritage_eowyn_damage.py
map_wind_stakeholder_events.py
parse_chandra_damage.py
parse_chandra_damage_v2.py
plot_chandra_actual_cartopy_cached.py
plot_chandra_actual_contextily.py
plot_chandra_actual_damage.py
plot_chandra_actual_simple.py

plot_damage_council_buildings_cartopy.py
plot_damage_potential.py
plot_damage_potential_simple.py
plot_eowyn_damage_council_osm.py
plot_most_extreme_storm_council_buildings.py
plot_most_extreme_storm_damage_council_buildings.py
plot_storms_with_council_buildings.py
storm_plotting_utils.py
test_environment.py
test_tile_sources.py
validate_storm_damage_with_stakeholders.py
validate_with_met_eireann.py
verify_downloaded_storms.py

Data
CURVES_feuerstein_koks.csv
Council_Buildings.shp (+ .dbf, .prj, .cpg, .shx)
County_Louth_Boundary.gpkg
Louth_County.shp (+ .dbf, .prj, .cpg, .shx)
LUISA_damage_info_curves.xlsx
Storm Chandra 5th feb 26 update5 (002).docx
chandra_damage_geocoded.csv
chandra_damage_records.csv
chandra_land_use_region.tif
chandra_land_use_region_meteireann.tif
chandra_windstorm_matched.tif
chandra_windstorm_matched_meteireann.tif
create_luisa_damage_file.py
damage_curves_luisa.csv
eowyn_land_use_region.tif
eowyn_land_use_region_meteireann.tif
eowyn_windstorm_matched.tif
eowyn_windstorm_matched_meteireann.tif
fix_luisa_damage_values.py
juneCLIMAAX Stakeholder Engagement Lat Long.csv
key_risks_dashboard_template_simple (1).xlsx
maxdam_luisa_irish.csv
mjCounty Louth Storm Report 26.2 26 (002).docx
ophelia_land_use_region.tif
ophelia_land_use_region_meteireann.tif
ophelia_windstorm_matched.tif
ophelia_windstorm_matched_meteireann.tif
storm_track-hodges-raw-194001_202601-all-v1_0.csv
storm_track-tempest_extremes-raw-194001_202601-all-v1_0.csv
wind_events_categorized.csv
windstorm_chandra_County_Louth_damagemap.tif
windstorm_chandra_County_Louth_damages.csv
windstorm_eowyn_County_Louth_damagemap.tif
windstorm_eowyn_County_Louth_damagemap_RCP85_2050.tif
windstorm_eowyn_County_Louth_damages.csv
windstorm_ophelia_County_Louth_damagemap.tif
windstorm_ophelia_County_Louth_damages.csv

All events.zip
Chandra.zip
Eowyn.zip
Jan 2026.zip
Ophelia.zip
general_data/LUISA_basemap_020321_50m.tif
met eireann/Airport Daily Chandra Jan 2026 26-29th.csv
met eireann/Airport Daily Eowyn Jan 2025 22-26th.csv
met eireann/Airport Daily Ophelia Oct 2017 14-18th.csv
met eireann/Airport Hourly Chandra Jan 2026 26-29th.csv
met eireann/Airport Hourly Eowyn Jan 2025 22-26th.csv
met eireann/Airport Hourly Ophelia Oct 2017 14-18th.csv
met eireann/Dunsany Daily Chandra Jan 2026 26-29th.csv
met eireann/Dunsany Daily Eowyn Jan 2025 22-26th.csv
met eireann/Dunsany Daily Ophelia Oct 2017 14-18th.csv
met eireann/Dunsany Hourly Chandra Jan 2026 26-29th.csv
met eireann/Dunsany Hourly Eowyn Jan 2025 22-26th.csv
met eireann/Dunsany Hourly Ophelia Oct 2017 14-18th.csv
LCC - County Development Plan 2021-2027/ (21 thematic subdirectories with shapefiles)
Adopted Dundalk LAP 2025-2031 (Shape Files)/ (21 subdirectories with shapefiles)
LCC - Dunleer Local Area Plan 2017-2023/ResidentialZoningMap.shp (+ associated files)
OSI.gdb/ (Ordnance Survey Ireland geodatabase)
STORMS/ (Storm footprint NetCDF files - Ophelia, Éowyn, Chandra)
storm_footprint-hodges-raw-* (43 CDS storm footprints, 1940-2026)
storm_footprint-tempest_extremes-raw-* (13 TempestExtremes footprints)

<u>Outputs and Figures</u>
Airport Daily Chandra Jan 2026 26-29th.csv
Airport Daily Eowyn Jan 2025 22-26th.csv
Airport Daily Ophelia Oct 2017 14-18th.csv
Airport Hourly Chandra Jan 2026 26-29th.csv
Airport Hourly Eowyn Jan 2025 22-26th.csv
Airport Hourly Ophelia Oct 2017 14-18th.csv
CDS_vs_MetEireann_ChartData.csv
CDS_vs_MetEireann_Comparison.xlsx
CLIMAAX_Phase2_Key_Risk_Assessment_Dashboard_CountyLouth.xlsx
Complete_Damage_Methodology_Comparison.xlsx
CURVES_feuerstein_koks.csv
Dunsany Daily Chandra Jan 2026 26-29th.csv
Dunsany Daily Eowyn Jan 2025 22-26th.csv
Dunsany Daily Ophelia Oct 2017 14-18th.csv
Dunsany Hourly Chandra Jan 2026 26-29th.csv
Dunsany Hourly Eowyn Jan 2025 22-26th.csv
Dunsany Hourly Ophelia Oct 2017 14-18th.csv
LUISA_damage_info_curves.xlsx
STORMS_Phase2_Chapter_Complete.docx
chandra_county_louth_damage_map_LOCAL.png
chandra_damage_analysis_LOCAL.png
chandra_damage_assessment_LOCAL.xlsx
chandra_damage_by_settlement_LOCAL.csv
chandra_damage_by_zone_type_LOCAL.csv
chandra_damage_dual_panel_cds.png

chandra_damage_dual_panel_meteireann.png
chandra_damage_meteireann_local.png
chandra_damage_summary.xlsx
chandra_protected_structures_at_risk_LOCAL.csv
chandra_wind_meteireann_actual_damage_overlay.png
chandra_wind_speed_map_cds.png
chandra_wind_speed_map_meteireann.png
damage_curves_luisa.csv
damage_potential_map.png
eowyn_county_louth_damage_map_LOCAL.png
eowyn_critical_infrastructure_analysis.xlsx
eowyn_critical_infrastructure_vulnerability.png
eowyn_damage_analysis_LOCAL.png
eowyn_damage_assessment_LOCAL.xlsx
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eowyn_damage_by_zone_type_LOCAL.csv
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eowyn_damage_dual_panel_meteireann.png
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eowyn_damage_meteireann_council_buildings_CARTOPY.png
eowyn_damage_meteireann_council_buildings_OSM.png
eowyn_drogheda_zoom_map.png
eowyn_dundalk_community_centres_at_risk.csv
eowyn_dundalk_damage_assessment_DETAILED.xlsx
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eowyn_dundalk_schools_at_risk.csv
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eowyn_future_comparison_chart_RCP85_2050.png
eowyn_future_damage_RCP85_2050.png
eowyn_future_projections_RCP85_2050.xlsx
eowyn_infrastructure_vulnerability_charts.png
eowyn_protected_structures_at_risk_LOCAL.csv
eowyn_stakeholder_validation.csv
eowyn_stakeholder_validation_map.png
eowyn_wind_meteireann_council_buildings_MOST_EXTREME.png
eowyn_wind_speed_map_cds.png
eowyn_wind_speed_map_meteireann.png
maxdam_luisa_irish.csv
ophelia_county_louth_damage_map_LOCAL.png
ophelia_damage_assessment_LOCAL.xlsx
ophelia_damage_by_settlement_LOCAL.csv
ophelia_damage_by_zone_type_LOCAL.csv
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ophelia_damage_dual_panel_meteireann.png
ophelia_methodology_comparison_phase1_vs_phase2.png
ophelia_methodology_comparison_summary.xlsx
ophelia_protected_structures_at_risk_LOCAL.csv
ophelia_wind_speed_map_cds.png
ophelia_wind_speed_map_meteireann.png
storm_track-hodges-raw-194001_202601-all-v1_0.csv
storm_track-tempest_extremes-raw-194001_202601-all-v1_0.csv
wind_stakeholder_events_map.png

windstorm_chandra_County_Louth_damages.csv
windstorm_eowyn_County_Louth_damages.csv
windstorm_ophelia_County_Louth_damages.csv

6. References

1 Louth County Council: Storm Chandra Post-Event Reports and Incident Data, https://www.louthcoco.ie/, 2026.

2 Met Éireann: Named Storm Records (including Storm Ophelia 2017 and Storm Éowyn 2025), https://www.met.ie/forecasts/storm-names, n.d.

3 Louth County Council: Louth County Development Plan 2021–2027, https://www.louthcoco.ie/en/services/planning/development-plans/louth-county-development-plan-2021-2027/, 2021.

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