CLIMAAX
climate ready regions

Deliverable Phase 1 – Climate Risk Assessment

Applying the CLIMAAX Framework to County Louth, Ireland

County Louth, Ireland

Version 1.0 | August 2025

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

Funded by the European Union

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

Document Information

Deliverable Title	Phase 1 – Climate Risk Assessment
Brief Description	Climate Risk Assessment for County Louth
Project name	Applying the CLIMAAX Framework to County Louth, Ireland
Country	Ireland
Region/Municipality	County Louth
Leading Institution	Louth County Council
Author(s)	Grant Thornton Ireland in collaboration with M-CO and Louth County Council
Deliverable submission date	05/09/2025
Final version delivery date	05/09/2025
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Version	Date	Change editors	Changes
1.0	...	Institution name	Louth County Council
2.0	...	CLIMAAX's FSTP team	
5.0	...		Final version to be submitted

Table of contents

List of Figures

List of Tables

Abbreviations and Acronyms

Abbreviation / acronym	Description
AA	Appropriate Assessment
AICBRN	All-Island Climate and Biodiversity Research Network
CDS	Climate Data Store
CFRAM	Catchment Flood Risk Assessment and Management
CORINE	Co-Ordination of Information on the Environment
CRA	Climate Risk Assessment
CRS	Climate Risk Screening
CSO	Central Statistics Office
EC	European Commission
EPA	Environmental Protection Agency
ESB	Electricity Supply Board (Ireland)
EU	European Union
EURO-CORDEX	Coordinated Regional Climate Downscaling Experiment for Europe
GAA	Gaelic Athletic Association
GHG	Greenhouse Gas
GIS	Geographic Information System
GSI	Geological Survey Ireland
GTSM	Global Tide and Surge Model

Abbreviation / acronym	Description
JRC	Joint Research Centre
LACAP	Local Authority Climate Action Plan
LCC	Louth County Council
LCAS	Louth Climate Adaptation Strategy 2019–2024
LCDA	Low Carbon Development Act
LECP	Local Economic and Community Plan
LCDP	Louth County Development Plan
NASA	National Aeronautics and Space Administration
NCCRA	National Climate Change Risk Assessment (Ireland)
NCAC	National Climate Action Charter
NCAP	National Climate Action Plan
OPW	Office of Public Works (Ireland)
PDF	Portable Document Format
RCP	Representative Concentration Pathway
RSES	Regional Spatial and Economic Strategy
SEA	Strategic Environmental Assessment
SuDS	Sustainable Drainage Systems
WFD	Water Framework Directive

Executive summary (1 page)

This project presents the outcomes of Phase 1 of the Climate Risk Assessment (CRA) for County Louth, developed using the CLIMAAX methodological framework, a European methodology designed to help regions and communities understand and respond to climate risks. The primary motivation of the CLIMAAX framework is to support local authorities in identifying and addressing the most pressing climate risks facing the European Union's (EU) regions.

During Phase 1, EU wide datasets are analysed to quantitatively assess the key climate risks, serving as a foundation for the more detailed analysis and implementation strategies to follow in Phase 2. Local-level data and stakeholder engagement will be used in Phase 2 to ensure that the results are as locally tailored and impactful as possible. The lived experience of climate impacts from citizens within the region of Louth will be incorporated into this output.

The main actions undertaken in this project include the development of a tailored CRA methodology aligned with existing strategies, such as the Louth Climate Adaptation Strategy (LCAS) 2019–2024 and the Louth Climate Action Plan (LACAP) 2024–2029. A comprehensive Climate Risk Screening (CRS) was conducted, beginning with a broad inventory of potential risks. Through collaborative input and utilising the results and data from previous analyses, this initial inventory was refined into a focused shortlist. This process included workshops with Louth County Council (LCC), which enabled engagement with local stakeholders to validate the findings of the CRS.

This process highlighted three climate risks for prioritisation: Heavy Rainfall, Flooding (coastal and river), and Windstorms. These will be brought forward for more detailed localised assessment in Phase 2. Flooding and heavy rain have historically caused the most extensive damage to Louth, and this damage is predicted to become more severe in the next 75 years, due to rising sea levels and projected increased precipitation. The analysis revealed that flooding and heavy rainfall are particularly damaging hazards in urban and coastal areas such as Dundalk, Drogheda, and Blackrock. Windstorm events are not projected to be as frequent but are expected to become unpredictable and extreme when they occur. This assessment identified the areas, sectors, and communities in Louth that are most exposed to climate-related hazards.

Phase 2 will build on these insights by incorporating local datasets, community and citizen knowledge, and site-specific analysis to develop a more detailed and actionable adaptation strategy. This next phase will ensure that Louth County Council is better prepared to manage climate risks and protect its people, infrastructure, and natural environment. The insights generated in this phase will support more targeted and effective adaptation measures in future planning. Particularly, the project provides a critical evidence base which can help inform the next Louth County Development Plan (LCDP), scheduled to commence preparation in Q4 2025.

1 Introduction

1.1 Background

Louth is a coastal county in the north-east of Ireland. It is the smallest county in Ireland by area but is the 2nd most densely populated. As of the 2022 census, Louth became just the 5th county to recover its pre-famine 1841 population level (the other counties being Dublin, Wicklow, Meath, and Kildare, indicative of the rapidly growing population of the commuter belt around Dublin City).[1] The coastal areas of the county are particularly vulnerable to flooding and storm surges during the winter months, and significant flood defences have been constructed along Dundalk Bay. With 51% of the county's population living within 5km of the coast, LCAS identified river and coastal flooding as the primary environmental risks to the county.[2] Louth has experienced severe wind events in the past, including fatalities and widespread damage. Storm Éowyn[3] in 2025 brought gusts of up to 148 km/h, causing widespread power outages, water supply disruptions, and road blockages due to fallen trees. Heatwaves, droughts, and fires are becoming increasingly relevant. June 2023 was the warmest month on record in Ireland, with Louth particularly affected, experiencing over 20 consecutive days of drought in some areas.[4] Although snow and cold spells are projected to become less frequent due to climate change, they still pose significant risks. Events like Storm Emma[5] in 2018 and the 2010 cold spell caused widespread road closures, burst pipes, and structural damage to homes.[6]

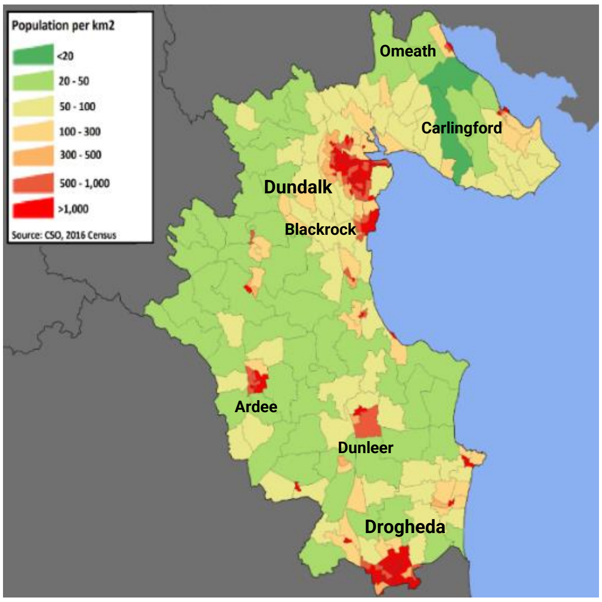

Figure 1-1 Map of County Louth and townlands/population clusters.

[1] https://data.cso.ie/
[2] https://www.cso.ie/en/releasesandpublications/ep/p-cp2tc/cp2pdm/pd/
[3] https://www.met.ie/forecasts/storm-names
[4] https://www.met.ie/warmest-june-on-record-dry-periods-and-intense-thunderstorm-activity
[5] https://www.met.ie/storm-names-2018-19-announced
[6] https://www.met.ie/cms/assets/uploads/2017/08/ColdSpell10.pdf

1.2 Main objectives of the project

The CLIMAAX methodological framework aims to understand Louth's exposure to climate risks by identifying people, areas, sectors, and communities most vulnerable to future impacts, and ensure resilience by implementing adaptations and management strategies.

The objectives of the project in Phase 1 are to conduct an initial multi-risk assessment for Louth, which will serve as a foundation for more detailed analysis in Phase 2. Specifically, the project aims to develop a CRA methodology with clearly defined goals and anticipated outcomes. It also seeks to carry out an analysis to align the CRA with existing efforts, such as the LCAS and to support the formulation of relevant policies. Another key objective is to perform CRS by compiling a comprehensive inventory of risks. This process will begin with a broad list of potential risks, which will be refined into a final shortlist through the analysis of existing data and stakeholder engagement. Finally, the project will produce detailed reports to communicate findings and facilitate public and stakeholder involvement in future phases.

By applying the CLIMAAX framework, Louth County Council can gain a clear insight into the climate risks that pose the largest threats to the county. The framework depicts how these climate risks will evolve over time. With this insight, Louth is better positioned to take action on climate risk defences and mitigations. In particular, the outcomes of the CRA allow Louth to make more informed choices regarding climate risk in their next LDP, which will be drafted at the end of 2025.

1.3 Project team

LCC have enlisted Grant Thornton Ireland to act as consultants to complete the CLIMAAX project. The team from Grant Thornton is supported by specialist subcontractor M-CO, combining the technical expertise, cross-sector experience and stakeholder knowledge needed to deliver a locally relevant CLIMAAX aligned programme. The team is made up of the following individuals:

Table 1-1 Project Team

Project Team	
Louth County Council	Climate Action Steering Committee and Climate Action Team
Janice Daly, CFA	Engagement Partner, Climate Risk SME
Dr Simon O'Rafferty	Engagement Director, M-CO
Antonia Shields	Associate Director, M-CO
Dr Jonathan Leather	Director, Geology and Energy SME
Catherine McQuaid	Director, Environmental and Greenhouse Gas (GHG) SME
Aine Rowan	Programme Manager, Climate Risk
Sophie Anthony	Manager, Climate Risk Analyst
Sam O'Neill	Assistant Manager, Climate Risk Analyst
Hamza Ghazali	Assistant Manager, Climate Risk Analyst

1.4 Outline of the document's structure

This document opens with an executive summary that outlines the purpose, key findings, and conclusions of the CRA. The introduction provides background context, project objectives, and an overview of the team and document layout. The core of the report, Section 2, details the Phase 1 assessment. This section covers the scoping process, hazard identification, scenario planning, and the decision process of selecting the chosen workflows. The next step involves the application of the CLIMAAX framework to the chosen workflows; flooding, windstorms, and heavy rainfall. It also presents key findings on risk severity, urgency, and capacity, followed by lessons learned and stakeholder feedback. The document concludes with a summary of Phase 1 outcomes, a forward-looking work plan outlining next steps, progress evaluation, supporting materials, and technical appendices.

2 Climate Risk Assessment – Phase 1

2.1 Scoping

The scoping phase of the Climate Risk Assessment (CRA) established the objectives and intended outcomes of the analysis, outlined the conditions necessary for implementation, and identified key stakeholders to be involved in project preparation. It also included a review of existing knowledge, data, and relevant climate risks. It focused on building a baseline understanding of Louth's climate risk context and the role of CLIMAAX in supporting future resilience planning.

The objective of Louth's CRA was to identify prioritised risks that will impact people, places, and sectors by applying the CLIMAAX methodology. This process used existing datasets and community insights to map risks and vulnerabilities, ensuring that findings are grounded in local realities. Stakeholder engagement guided the prioritisation of the most vulnerable areas and communities, while addressing data gaps to inform both short- and long-term climate action.

The CRA also supports the development of local strategies tailored to Louth's evolving climate risks and planning requirements. While the LCDP 2021–2027 is currently in place, work is underway on the next plan, and the CRA presents a valuable opportunity to shape its direction. The CRA will support decision-making on infrastructure development, ensuring that future investments are designed to adapt to and protect against the impacts of climate change, such as flooding, windstorms, and coastal erosion.

By providing evidence-based risk assessments, the CRA will support more sustainable land-use planning and help LCC make informed decisions that protect both communities and long-term development goals. The CRA can play a vital role in informing future iterations of the Local Economic and Community Plan (LECP) beyond the current 2024–2029 cycle. By embedding climate risk considerations into long-term spatial and socio-economic planning, the CRA can help ensure that future strategies are resilient and inclusive.

Limitations and Boundaries

The CRA for Louth will be shaped by some anticipated limitations and boundaries. These include:

- Downscaled projections for drought, fire and snow events remain limited. This will constrain the CRA's ability to support long-term planning in sectors sensitive to these hazards, such as agriculture, forestry, and emergency services.
- Stakeholder engagement will be a central component of the CRA process, but this could present challenges. Ensuring inclusivity will be critical, especially in capturing the perspectives of vulnerable and underrepresented groups.
- The National Climate Change Risk Assessment (NCCRA)[7] has highlighted the lack of detailed local CRAs, along with the gaps in understanding how socio-economic and health factors influence vulnerability to extreme heat, which will need to be addressed in the Louth CRA.
- From a policy and planning perspective, the CRA will need to align with existing frameworks, including the LDP 2021–2027, the National Adaptation Framework, the National Climate Action Charter (NCAC), LACAP and Low Carbon Development Act (LCDA).

[7] https://www.climateireland.ie/media/epa-2020/monitoring-amp-assessment/climate-change/climate-ireland/EPA_NCCRA_Main-Report_Published_June_2025.pdf

While this alignment ensures consistency, it may limit flexibility in adopting innovative or experimental adaptation strategies.

2.1.1 Context

To date, LCC has taken a proactive and structured approach to assessing and managing climate hazards, impacts, and risks. Since signing the NCAC in 2019, LCC has made climate action a core priority, committing to the development of a LACAP in line with national legislation. The recently published LACAP outlines a clear roadmap for delivering national climate goals through a local lens, focusing on key areas such as waste and the circular economy, compact sustainable growth, transport, citizen and community engagement, and climate resilience.[8]

Risk assessment has been a central component of Louth's climate strategy. The LCAS included the development of a risk register, which evaluated the level of impact and consequences across critical operational areas such as infrastructure, land use, waste systems, business continuity, and community health. This register has helped prioritise adaptation actions and inform planning decisions.[9]

Governance

LCC's existing CRA is outlined in the LACAP. The LACAP is developed in compliance with the NCAC and LCDA 2021, which requires local authorities to prepare climate action plans, along with the European Strategic Environmental Assessment (SEA) Directive (2001/42/EC) and Appropriate Assessment (AA) requirements under the Habitats Directive.[10] There are also additional local government obligations, whereby LCC is legally required to assess and address climate risks, reduce greenhouse gas emissions, and enhance climate resilience at the local level.[11] The LACAP describes climate action tailored to local conditions and vulnerabilities, aligned with NCAC and the NCCRA. The CRA for LCC is supported by the EU under CLIMAAX, funded through Horizon Europe, which provides the use of the CLIMAAX Handbook Toolkit for Multi-risk climate assessments.

Relevant Sectors

As part of the CRA, the relevant sectors for Louth have been identified, with a particular focus on how climate change and the individual climate risks will affect these sectors.

Table 2-1 Climate Change Impacts/Features by Sector

Sector	Climate Change Impacts/ Key Features
Water Services & Management	• Climate change is placing increasing strain on Louth's water infrastructure. • Intense rainfall and storms can overwhelm drainage systems, leading to water contamination and ecosystem degradation. • Conversely, prolonged dry spells and droughts are reducing reservoir and groundwater levels, threatening water supply for households, agriculture, and emergency services.

[8] https://consult.louthcoco.ie/ga/system/files/materials/259/DRAFT%20Louth%20County%20Council%20Climate%20Action%20Plan%202024-2029.pdf
[9] https://www.gov.ie/en/louth-county-council/consultations/draft-climate-change-adaptation-strategy/
[10] https://consult.louthcoco.ie/en/system/files/materials/259/Annex%204%20Louth%20NIR---Louth%20NIR.pdf
[11] https://www.gov.ie/en/department-of-climate-energy-and-the-environment/publications/climate-action-and-low-carbon-development-amendment-bill-2021/

Sector	Climate Change Impacts/ Key Features
	• Rising sea levels also pose a risk to water quality through saltwater intrusion, particularly in estuarine areas.
Transport & Infrastructure	• Louth's transport networks including roads, bridges, and public transport are increasingly exposed to climate-related hazards. • Flooding and storm events can block roads and disrupt emergency services, while heatwaves and cold spells damage road surfaces and housing infrastructure. • These impacts lead to costly repairs, service interruptions, and increased vulnerability for communities dependent on reliable transport links.
Health & Social Services	• The County's health and social services are under pressure from extreme weather events such as floods, heatwaves, and cold spells. • Flooding has disrupted access to healthcare in rural areas like Cooley and Mansfieldtown-Castlebellingham, delaying emergency response.
Community	• Vulnerable populations, including older adults and low-income households, face heightened risks of respiratory issues, and mental health challenges due to isolation and service disruption during extreme weather. • Key aspects of the community in Louth, such as Gaelic Athletic Association (GAA)[12] clubs, can be impacted as a result of climate hazard. Sporting events are often a way for communities to come together, however the impact of cold spells or heavy rainfall damages the playing grounds, resulting in cancelled events.
Tourism	• Louth's tourism sector is increasingly affected by climate-related disruptions. • Coastal destinations like Clogherhead and Templetown have experienced temporary bathing closures due to contamination from heavy rainfall, windstorms and algal blooms, threatening public health and local business revenue. • Inland, snow and icy conditions in upland areas such as the Cooley Peninsula have led to road closures and trail damage, reducing accessibility and increasing maintenance costs. • Power outages and rising insurance costs further challenge the sector's resilience. • Additionally, many archaeological sites such as Monasterboice and other medieval structures face growing threats, such as flooding and coastal erosion in low-lying coastal zones.
Biodiversity	• Louth's diverse natural landscapes, including coastal dunes, estuaries, wetlands, bogs, and uplands, are increasingly vulnerable to climate change. • Rising sea levels, storm surges, and flooding are eroding coastlines and riverbanks, particularly between Baltray and Clogherhead. • Fragile habitats in areas like Carlingford Lough and the Cooley Mountains are under pressure, with invasive species, pests, and diseases becoming more prevalent as native ecosystems are disrupted. • Wildfires in the Cooley region are damaging biodiversity-rich bogs and wetlands, while estuaries such as the Boyne, Dee, and Glyde are experiencing pollution, land-use pressures, and salinity changes that threaten migratory birds and rare plant species.

[12] GAA.ie

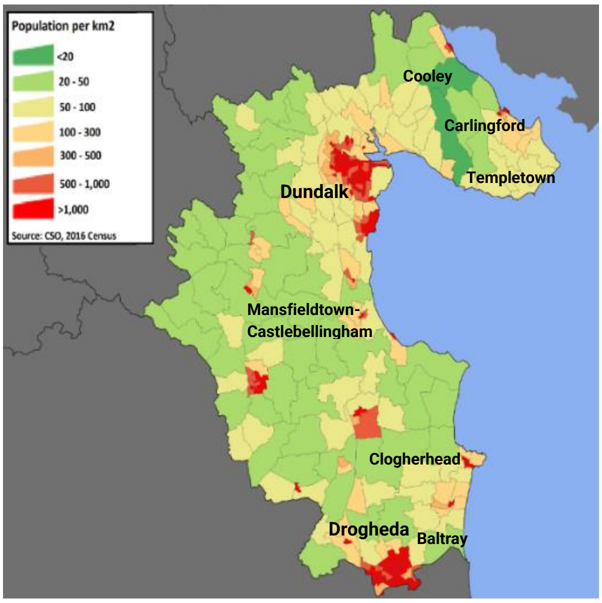

Figure 2-1 Map of County Louth with townlands/regions mentioned in table 2-1.

External Initiatives

In addition to the NCCRA and the EU projects already mentioned, there are other climate-related efforts happening in Louth. For example:

- The Community Climate Action Programme has given over €600,000 to support local climate projects.[13]
- Louth is part of the National Public Lighting Energy Efficiency Project, which is working to reduce carbon emissions by upgrading public lighting.[14]
- There are a number of cross-border projects with Northern Ireland, including the Shared Island Fund and the PEACE PLUS Programme (2021–2027). These EU-funded initiatives support sustainable development in areas such as biodiversity, coastal and marine management, and water quality in Northern Ireland and the border counties.[15][16]
- Research groups are also involved, including the All-Island Climate and Biodiversity Research Network (AICBRN), which helps researchers from both sides of the border work together on climate and biodiversity issues.

Adaptation Interventions

Possible adaptation interventions for climate risks in Louth have been identified, based on measures outlined in the LACAP and LCAS, along with the assessment of the climate risks and how they will impact the various sectors and communities in Louth.

[13] https://consult.louthcoco.ie/en/content/community-climate-action-programme-expressions-interest-small-grants-form
[14] https://www.seai.ie/case-studies/obligated-party-support-energia
[15] https://www.gov.ie/en/department-of-the-taoiseach/press-releases/25-cross-border-projects-awarded-funding-under-shared-island-local-authority-development-funding-scheme/
[16] https://www.eufunds.ie/peace-plus/

Table 2-2 Climate Change Impacts/Adaptations by Sector

Sector	Climate Change Impacts	Adaptation Interventions
Water Services & Management	- Intense rainfall - Droughts - Pollution - Salinity shifts	• Integrated catchment-based planning. • Expand Sustainable Drainage Systems (SuDS) and wastewater treatment capacity. • Promote water conservation through awareness and incentives. • Invest in rainwater harvesting and greywater reuse. • Real-time water quality monitoring, especially in estuaries like the Boyne and Dee.
Transport & Infrastructure	- Flooding - Heatwaves - Cold spells - Storm damage	• Reinforce roads and bridges in flood-prone areas (e.g. near coastal zones). • Use heat- and frost-resistant materials. • Expand SuDS for runoff management. • Assess critical transport corridors for climate risk. • Update emergency protocols and install backup power systems. • Utilise climate-resilient materials in restoration of historic buildings can preserve cultural value while enhancing resilience.
Health & Social Services	- Floods - Heatwaves - Cold spells - Air quality deterioration - Mental health stress	• Establish community cooling/warming centres (e.g. in Cooley and Mansfieldtown-Castlebellingham). • Deploy mobile healthcare units in rural areas. • Monitor air quality and promote clean heating. • Expand mental health services. • Train healthcare providers on climate-related health risks.
Tourism	- Beach contamination - Algal blooms - Coastal erosion - Flooding - Development pressure - Trail damage - Power outages - Insurance costs	• Reinforce trails, signage, and coastal amenities (e.g. Clogherhead, Templetown). • Map and prioritise vulnerable heritage sites (e.g. Monasterboice, coastal castles). • Embed heritage protection in land-use and emergency planning. • Monitor water quality to maintain Blue Flag status • Diversify tourism to inland and off-season attractions (e.g. Cooley Peninsula). • Support local businesses with adaptation grants and insurance guidance.
Biodiversity	- Storm surges - Sea-level rise - Wildfires - Habitat degradation - Invasive species	• Restore coastal dunes and wetlands (e.g. Carlingford coast). • Rewet bogs in areas such as the Cooley region and Ardee to reduce wildfire risk. • Expand invasive species control. • Strengthen ecological corridors between uplands and estuaries. • Support citizen science and community-led monitoring.

2.1.2 Participation and risk ownership

A key concern when examining the impacts of climate risk is the vulnerability of certain groups. Communities most at risk include low-income households who often lack the resources to adapt to changing climate conditions. Coastal residents and businesses face additional threats from coastal flooding. Rural or isolated communities, as well as elderly individuals, are particularly exposed to hazards like windstorms, heatwaves, droughts, and wildfires, and often lack timely access to emergency services.[17,18]

While the ultimate responsibility for managing and implementing policies to reduce climate risks lies with government bodies, local authorities, such as LCC, can play a key role in identifying those risks.

Successfully achieving the goals outlined in the LACAP requires strong coordination between departments to clearly assign responsibility, evaluate legal implications, and effectively plan, support, and track progress through regular monitoring and reporting.

The outcomes of this work, including reviews and reports, will be communicated through internal channels, local authorities, government bodies, and most importantly, with the general public, including those communities most affected by climate risk and in need of support for adaptation and resilience planning.

2.2 Risk Exploration

2.2.1 Risk Screening

Using the LACAP and LCAS frameworks, historical climate-related hazards and risks have been analysed, providing insight into the most relevant risks to Louth. A key element of this analysis is to identify the locations of past hazards, and the communities affected.

Table 2-3 Screen risks: Hazards

Hazard	Summary of Risk / Hazard	Adaptation Measures and Barriers	Future Projections and Influence[19]
Flooding & Heavy Rainfall	Frequent river and surface flooding in areas like Dundalk, Drogheda, Blackrock due to intense rainfall and overwhelmed drainage systems. Historical events include floods in 2002, 2014, and 2015.[20]	Multiple flood relief schemes in progress (e.g. Dundalk, Drogheda, Carlingford).[21] High capital costs and land-use conflicts present barriers. Public engagement, flood risk mapping, and collaboration with Office of Public Works (OPW) are core strategies.[22]	Projected 25% increase in very wet days (>30mm). More frequent and severe flooding expected across the county.[23]

17 https://www.gov.ie/en/louth-county-council/consultations/draft-climate-change-adaptation-strategy/
18 https://assets.gov.ie/static/documents/Louth_LEP_06_2025.pdf
19 https://atlas.climate.copernicus.eu/atlas
20 https://www.gov.ie/en/office-of-public-works/publications/flood-and-erosion-mapping/
21 https://www.gov.ie/en/office-of-public-works/policy-information/major-flood-relief-schemes/
22 https://constructionprocurement.gov.ie/capital-works-management-framework/
23 Copernicus Interactive Climate Atlas – Rate of change in Very Heavy precipitation days: Near Term, Medium Term, Long Term – RCP 8.5 scenario

Hazard	Summary of Risk / Hazard	Adaptation Measures and Barriers	Future Projections and Influence[19]
Heatwaves, Drought & Fire	Rising temperatures and extended dry spells impacting health, infrastructure, and ecosystems. Events in 2018 and 2023 caused fires, road damage, and water shortages. Vulnerable populations at risk.[24]	LCC is reviewing water conservation and fire response plans. Rural infrastructure is insufficient for water storage. Awareness campaigns and early warning systems are being explored. Tourism and public health impacts are being considered.[25]	~6.5 more heatwave events/year and -3% summer rainfall projected. Drought and fire risk likely to rise, especially in the Cooley region.[26]
Windstorms [27] [28]	Major national risk due to infrastructure damage, fatalities, and power outages. Recent events include Storm Éowyn (2025)[29], Debi (2023)[30], and Ophelia (2017)[31]. Roads and services disrupted.	Emergency plans are being updated. Coordination with Electricity Supply Board (ESB) and telecoms ongoing. Barriers include public opposition to tree removal and uncertainty in windstorm projections.	Slight decrease in average wind speed expected, but extreme events may persist. Storm impact remains uncertain and highly disruptive to infrastructure.
Snow / Cold Spells	Still pose localised disruption despite declining frequency. Events like Storm Emma (2018)[32] and 2010 cold spell caused road closures and damage. Vulnerable groups remain at risk.	Continued investment in gritting, snow clearance, and energy efficiency upgrades. Risk of underinvestment due to perceived declining relevance. Emergency response capacity is stretched during such events.	Frost and snow days projected to decline. Cold weather hazards becoming less frequent but still disruptive when they occur.[33]

Observed and Expected Hazards

The observed and expected hazards for the region are determined by analysing the national and regional climate action plans, the regional and national climate adaptation strategies and frameworks along with quantitative data analysis using the Copernicus Atlas. The figures discussed below have been sourced from 2050 projections under the RCP 8.5 high-emissions scenario.

[24] https://www.gov.ie/en/louth-county-council/consultations/draft-climate-change-adaptation-strategy/
[25] https://www.gov.ie/en/department-of-housing-local-government-and-heritage/consultations/public-consultation-on-the-draft-water-quality-and-water-services-infrastructure-sectoral-adaptation-plan-2025/
[26] https://www.gov.ie/en/department-of-transport/publications/current-climate-and-projected-climate-changes-in-ireland/
[27] https://www.met.ie/climate/storm-centre
[28] https://www.met.ie/name-a-storm
[29] https://www.met.ie/meteorologists-commentary/storm-eowyn-commentary/
[30] https://www.met.ie/climate-statement-for-november-2023
[31] https://www.met.ie/ophelia-report
[32] https://www.met.ie/cms/assets/uploads/2019/02/EmmaReport2019.pdf
[33] https://www.gov.ie/en/department-of-transport/publications/current-climate-and-projected-climate-changes-in-ireland/

Table 2-4 Hazards Description

Risk Workflow	Description of Hazard(s)
Flooding	• Daily Rainfall to climb to 2.5 mm/day, sea-level rise to reach 0.45m, increasing the severity of flood events, particularly in Dundalk and Blackrock.[34] • 26.9% increase in very wet days (days where accumulated precipitation exceeds 20mm), increasing risk of river flooding.[35] • 170,000 residents are expected to be living in towns with high flood risk (such as Carlingford, Drogheda, Dundalk) as populations increase.[36] [37] • Erosion and past flood events (for example, Blackrock 2015) highlight ongoing risks to heritage, housing, and critical assets.
Heavy Rainfall	• Precipitation intensity expected to increase to 37.9 mm daily median, stressing drainage systems and increasing the likelihood of river flooding.[38] • Increase in rate of change of maximum 1-day accumulated precipitation to 2.7 mm median, implying extreme rainfall events will be significantly more frequent.[39] • Roads, draining, and power systems are disrupted by heavy rain. Sensitive areas such as Carlingford Lough face biodiversity loss and ecosystem stress. • Heavy rainfall events like storms Desmond and Ciarán caused major damage and service failures.
Windstorms	• Average median windspeeds expected to remain similar, approx. 5.8 metres per second (m/s), although the number of windstorms will become less frequent, those that do will be of higher windspeeds.[40] • Extreme high-speed storms expected to occur up to 3.6 times more frequently by 2060. Despite the expected reduction by 10% in the number of storms, there is an eastward extension of more severe storms projected.[41] • Effects of storm Éowyn highlighted the public risks, such as power outages, property damage, and potential fatalities. • Impact on roads, transport, schools, businesses, supply chain disruptions, facilities, and local amenities all face property damage (such as GAA clubs and community centres).
Heatwaves	• Median maximum daily temperatures are expected to reach 23.1°C by 2050 (up from 22.3°C currently).[42] • Mean daily temperature is expected to reach 10.0°C by 2050 (up from 8.6°C currently).[43]

[34] Copernicus Interactive Climate Atlas – Mean of daily accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[35] Copernicus Interactive Climate Atlas – Rate of change in Very Heavy precipitation days: Near Term, Medium Term, Long Term – RCP 8.5 scenario
[36] https://www.cso.ie/en/releasesandpublications/ep/p-rpp/regionalpopulationprojections2023-2042/data/
[37] https://www.cso.ie/en/releasesandpublications/ep/p-cp2tc/cp2pdm/pd/
[38] Copernicus Interactive Climate Atlas – Median of Maximum of 1-day accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[39] Copernicus Interactive Climate Atlas – Rate of change of Maximum of 1-day accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario
[40] Copernicus Interactive Climate Atlas – Median of daily mean wind speed (m/s): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario
[41] https://www.gov.ie/en/department-of-transport/publications/current-climate-and-projected-climate-changes-in-ireland/
[42] Copernicus Interactive Climate Atlas – Median of maximum of daily maximum temperature (°C): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[43] Copernicus Interactive Climate Atlas – Mean of daily mean temperature (°C): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

Risk Workflow	Description of Hazard(s)
Drought	• Average of 14.7 maximum consecutive dry days expected (days in a row where precipitation is less than 1mm), an increase from 14.4 currently.[44] • Minimum precipitation-evapotranspiration index of -0.4 expected. An index of -0.5 indicates slight water deficit, -1.0 indicates moderate drought, so long term risk for Louth is mild to moderate.[45] • Water scarcity for drinking, sanitation, agriculture, resulting crop failures and livestock loss, and increased cost of maintenance to vital infrastructure services. • Habitat degradation along rivers and wetlands, extinction of flora, reduced topsoil fertility due to soil erosion.
Snow/Cold Spells	• Expected number of frost days (days where the minimum temperature is below 0°C to drop from 34 days/year to 17.9 days/year.[46] • Snow and cold spells have cut off rural areas, disrupted healthcare access, and affected vulnerable people in older or poorly insulated homes through property damage and health issues. • Cold events have damaged roads, pipes, and strained utilities. The 2010 "Big Freeze" [47] led to major repair costs and service delays due to icy conditions. • LCC has winter response plans, updated emergency procedures, and is investing in climate resilience through infrastructure, planning, and community engagement. But primarily, the risks associated with snow and cold spells are expected to reduce significantly.
Wildfire	• Median average surface thermal radiation expected to reach 320.1 W/m^2, which while not a direct contributor to wildfires, the increase in surface thermal radiation amplifies the underlying conditions that make them more impactful.[48] • Expected global increase in 30% in wildfires, while not a direct projection for Louth, highlight a clear risk of wildfire increase and Ireland's wildfire "hazard zone" is expected to expand.[49] • Increased risk to households, particularly in rural areas near woodlands, or dwellings impacted by ember storms. • Increased likelihood of fires damaging power lines, roads, or railways near wooded or upland areas. • Peatlands and woodlands at most risk, loss of carbon and biodiversity, creating a negative feedback loop for future fire risk.

Prioritised Hazards

All of the hazards outlined above were initially considered before the analysis focused on the hazards of heavy rainfall, flooding, and windstorms, based on several key factors. Local and national assessments played a major role in this choice, with these hazards identified as priorities in LACAS (2019–2024) and LACAP (2024–2029) due to their severity and vulnerability.

---

[44] Copernicus Interactive Climate Atlas – Median of maximum consecutive dry days: Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[45] Copernicus Interactive Climate Atlas – Minimum of Standardised Precipitation – Evapotranspiration Index: Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[46] Copernicus Interactive Climate Atlas – Median of Frost days (minimum temperature below 0°C): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[47] The Extreme Cold Spell of November – December 2010 - ColdSpell10.pdf
[48] Copernicus Interactive Climate Atlas – Median of Mean surface thermal radiation (W/m^2): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[49] Number of wildfires forecast to rise by 50% by 2100 - World Meteorological Organization, 2022

Observed and expected impacts were also important considerations. These three hazards have already affected, or are expected to affect, communities and businesses in Louth, mainly through damage to infrastructure. Past severe weather events, like Storm Emma and Storm Debi, caused significant flooding, and the increasing frequency of extreme weather highlights the ongoing threat.

The severity and consequences of these hazards influenced their prioritisation. Flooding has historically caused the highest costs for LCC, with €1 million spent in 2023 alone on road repairs due to flood damage. Windstorms are also a major risk, known for causing significant damage and even fatalities.[50]

Vulnerability was another critical factor. The assessment targets groups and areas most at risk, including low-income households in flood-prone zones, residents of social housing, rural and car-less households vulnerable during evacuations, and coastal tourism businesses exposed to property damage. The project also considers Louth's built heritage, a valuable but fragile asset threatened by storms and winds.

Finally, strategic planning and adaptation efforts were reviewed. LCC integrates flood risk and climate adaptation into spatial planning, supporting effective strategies and emergency response plans. This includes ongoing flood relief projects and updated measures to manage windstorm risks.

Available Data and Knowledge

To ensure the CRA reflects both regional context and scientific best practices, existing data and knowledge sources were reviewed, and key gaps identified. This helps prioritise future data collection efforts and improve the accuracy of risk characterisation and adaptation planning.

Available Data

- Copernicus Atlas - web-based tool which uses key datasets from the Climate Data Store (CDS).
- CLIMAAX Handbook datasets on hazards, exposure, and vulnerability (pan-European scope).
- LCC planning documents (LACAS, LACAP, Emergency Management Plan) with local risk registers and historical events.
- OPW flood risk data, including CFRAM and Flood Risk Assessment maps.
- Geological Survey Ireland (GSI) data on groundwater, bedrock, geohazards, and geochemistry.
- Environmental Protection Agency (EPA) and Marine Institute datasets, including Water Framework Directive (WFD) and ocean climate projections.
- CORINE (Co-Ordination of Information on the Environment) Land Cover, Ireland's Marine Atlas, and Central Statistics Office (CSO) for land use, tourism, and socio-economic analysis.
- Geographic Information System (GIS) layers and mapping tools for environmental sensitivity and risk visualisation.

[50] https://www.gov.ie/en/department-of-housing-local-government-and-heritage/publications/louth-county-council-statutory-audit-report-2023/

- Localised flood studies (e.g. Carlingford, 2023) and stakeholder insights gathered through workshops.

Data Gaps

- No national downscaled projections for key variables exist (e.g., sea level rise, extreme wind, fire weather, drought).
- Inconsistent formats and time horizons across datasets limit integration.
- Spatial data gaps on asset locations and critical infrastructure functions.
- No clear thresholds for impact (e.g., temperature limits for systems or ecosystems).
- Limited vulnerability data, especially socio-economic and adaptive capacity indicators.
- Local data issues, such as short time series, low resolution, or mismatched spatial scales.

2.2.2 Workflow selection

The workflows were selected by prioritising the hazards of heavy rainfall, flooding, and windstorms, guided by both local and national assessments such as LACAS (2019–2024) and LACAP (2024–2029). These hazards were chosen due to their severity, historical and projected impacts, and the vulnerability of affected communities in Louth.

A collaborative workshop was held with key LCC subject matter experts to help identify which workflows were the most impactful to take forward. This approach of evidence-based prioritisation and risk ranking, along with expert opinion, produced the most robust selection.

2.2.2.1 Workflow #1 Flooding

The flood risk workflow has been identified as relevant to the CRA. The exposed areas for flooding include areas surrounding the Rivers Dee, Glyde and Fane, which are prone to overflowing during periods of intense rainfall. Heavy rainfall overwhelms drainage systems in the urban areas of Dundalk and Drogheda, along with the coastal urban area of Blackrock.[51] Five areas in Louth have been prioritised by the County Council for flood relief measures, LCC are working with the OPW to deliver these Flood Schemes (Dundalk, Drogheda, Carlingford, Baltray and Ardee).

Flooding in Louth poses significant risks to ecosystems, infrastructure, and vulnerable communities. Coastal and riverbank erosion threatens habitats in areas like Carlingford Lough and the Boyne estuary, while runoff degrades water quality, impacting both biodiversity and public health.[52] Flood events have isolated rural communities, disrupted emergency services, and damaged built heritage sites. Urban centres such as Dundalk, Drogheda, and Ardee face development pressures in flood-prone zones, complicating land-use planning. Vulnerable groups including low-income households, social housing residents, and tourism-dependent businesses, are disproportionately affected by flood events.[53] While LCC and the OPW are actively implementing flood relief schemes, high capital costs and land-use conflicts remain key barriers to long-term resilience.[54]

---

[51] https://www.gov.ie/en/office-of-public-works/consultations/consultation-of-the-proposed-maintenance-works-on-the-glyde-and-dee-arterial-drainage-scheme-2023/
[52] https://www.gov.ie/en/office-of-public-works/publications/coastal-change-management-strategy-report/
[53] https://www.gov.ie/en/office-of-public-works/frm-pages/assessment-of-flood-risk-management/
[54] https://www.gov.ie/en/office-of-public-works/policy-information/budgeting-for-major-flood-projects/

2.2.2.2 Workflow #2 Windstorms

The windstorm workflow has been identified as relevant to the climate risks assessment, with consideration that windstorms are listed as a priority risk in the NCCRA. The entire county of Louth can be exposed to windstorms, and due to its small size (826 km²) when windstorms occur they typically cover the entire county. Some of the rural areas in Louth can be the most affected by windstorms, due to the vast number of trees surrounding roads and electricity lines.[55] 2025 saw Storm Éowyn bring gusts up to 148km, which particularly affected the Kilowen area.[56] 2023 Storm Debi brought power outages in Dundalk, along with fallen trees in Dundalk, rural Drogheda and the Ardee area.[57]

Windstorms in Louth result in adverse effects to ecosystems, infrastructure, and vulnerable communities, with coastal areas like Carlingford and Baltray facing erosion and habitat loss due to storm surges and high winds.[58]

Severe wind events have disrupted communities and services in Louth, damaging infrastructure, threatening heritage sites, and exposing vulnerable groups to greater risk.

While wind has been identified as a major national risk, adaptation efforts in Louth are still developing, with emergency plans being updated and tree management strategies underway. However, barriers such as uncertain projections and public resistance to interventions like tree felling continue to hinder progress.

2.2.2.3 Workflow #3 Heavy Rainfall

The heavy rainfall workflow has been identified as a key part of the CRA for Louth. Due to its small size (826 km²), heavy rainfall can affect the entire county at once. The areas most impacted by heavy rainfall often overlap with flood-prone zones, especially around the Rivers Dee, Glyde, and Fane, which frequently overflow during intense rain.[59] Urban drainage systems in Dundalk, Drogheda, and the coastal area of Blackrock are also overwhelmed during heavy rainfall. The LCC has prioritised five main areas (Dundalk, Drogheda, Carlingford, Baltray, and Ardee) for flood relief efforts.[60]

Heavy rainfall in Louth contributes to ecological damage, particularly in sensitive areas like Carlingford Lough and the River Boyne estuary, causing erosion and habitat loss.[61] It can also lead to polluted runoff degrading water quality, affecting ecosystems and water supply. In rural areas like Cooley and Mansfieldtown-Castlebellingham, heavy rainfall has led to blocked roads, whilst in urban centres like Drogheda, Dundalk, and Ardee, there are challenges in managing future growth while mitigating drainage issues.[62] The county's archaeological sites and older homes are

---

[55] https://opendata.agriculture.gov.ie/dataset/private-forest-wind-damage-assessment-spatial-database-may-2025
[56] https://www.gov.ie/en/office-of-public-works/news/weather-warnings-and-advisories-associated-with-storm-%C3%A9owyn/
[57] https://www.met.ie/climate/storm-centre
[58] https://www.gov.ie/en/department-of-agriculture-food-and-the-marine/press-releases/minister-healy-rae-confirms-that-over-26000-hectares-of-forests-have-suffered-wind-damage/
[59] https://www.gov.ie/en/office-of-public-works/policy-information/flood-mapping-and-data-resources/
[60] https://consult.louthcoco.ie/en/consultation/proposed-variation-no-3-louth-county-development-plan-2021-2027-0
[61] https://www.gov.ie/en/office-of-public-works/collections/catchment-wide-appropriate-assessments-of-arterial-drainage-scheme-maintenance/
[62] https://www.gov.ie/en/department-of-housing-local-government-and-heritage/policy-information/river-basin-management-plan-2022-2027/

vulnerable to damp-related damage, and agriculture suffers from waterlogging and crop losses, underscoring the broad socio-economic impacts of intense rainfall.[63]

2.2.3 Scenario Selection

GHG emissions are widely recognised as the primary driver of climate change. Therefore, when assessing the potential impact of climate change, the estimated future GHG emission levels are important. The various estimated future emission levels are referred to as scenario assumptions, with each scenario representing different projected emission levels. RCP 4.5 (moderate emission levels) and RCP 8.5 (high emissions) are examples of these scenarios. The scenarios rely on assumptions about future socioeconomic development, technological advancements, and climate policies to project potential climate outcomes. When assessing the chosen workflows, flooding, windstorms and heavy rainfall, differing scenario assumptions have been taken into consideration.

As part of the CRA a combination of climate change and socio-economic scenario assumptions are used to understand future risks and guide adaptation planning. RCP 4.5 is the primary scenario used by LACAP (2041–2060), aligning with national assessments. RCP 8.5 is used for stress testing high-impact, low-likelihood events, particularly for mid-to late-century projections (approximately 2050 to 2100). Global Warming Levels (GWLs) like +1.5°C and +2°C are used to communicate risk across temperature thresholds. Hazards assessed include sea level rise, heavy rainfall, temperature increases, drought, and extreme wind, all of which are expected to intensify under higher emission scenarios.[64]

Shared Socioeconomic Pathways (SSPs) are scenarios describing potential future developments of global society, demographics, and economics, influencing greenhouse gas emissions and climate change. SSPs provide context for exposure and vulnerability. SSP2-4.5, "Middle of the Road", is paired with RCP4.5 and is used in national assessments. SSP3-7.0 and SSP5-8.5 represent higher vulnerability futures with fragmented governance and greater dependence on fossil fuels. Key non-climatic drivers considered include population growth, urbanisation, land use change, and infrastructure demands. These are important for understanding how adaptive capacity and exposure may evolve in the near term (to 2030), mid-century (2041 to 2060), and late century (2081 to 2100).

CLIMAAX Scenarios

The CLIMAAX Framework gives access to a wide range of climate scenarios that can help assess future risks in Louth. These scenarios come from global climate models simulations, Coupled Model Intercomparison Project 6 (CMIP6) and Coupled Model Intercomparison Project 5 (CMIP5)[65]. CMIP6 and CMIP5 show how the climate might change depending on different levels of greenhouse gas emissions. For example, they include low-emission futures like SSP1-1.9 and RCP2.6, as well as high-emission ones such as SSP5-8.5 and RCP8.5.

To make these global models more useful locally, the project uses Coordinated Regional Climate Downscaling Experiment for Europe (EURO-CORDEX)[66] datasets. These are adjusted and zoomed in to give more detailed information for smaller areas in Louth, such as Dundalk, which is especially helpful for assessing floodings.

63 https://data.gov.ie/dataset/co-louth-record-of-protected-structures
64 https://atlas.climate.copernicus.eu/atlas
65 CMIP - Coupled Model Intercomparison Project
66 http://cordex.org/

The project will use these scenarios to estimate future risks and understand how different parts of the county, such as infrastructure, natural areas, and communities, might be affected by climate change.

2.3 Risk Analysis

The CLIMAAX Handbook workflows have been applied through a structured, multi-step approach to assess coastal and river flooding, windstorm, and heavy rainfall risks in Louth. The workflows follow the CLIMAAX CRA methodology, including hazard, exposure, and vulnerability assessments, and are implemented using Jupyter Notebooks provided in the Handbook. The hazard, vulnerability and exposure data has been outlined for each workflow, for example Table 2-5 for flooding. During Phase 1, EU-wide datasets are analysed to quantitatively assess the key climate risks, serving as a foundation for the more detailed analysis and implementation strategies to follow in Phase 2. Local level data and stakeholder engagements will be utilised in Phase 2 to ensure the results are locally tailored and as impactful as possible.

2.3.1 Workflow #1 Flooding

Table 2-5 Overview of data used for workflow #1 Flooding.

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
(GTSMv3.0) – Deltares	Joint Research Centre (JRC) Depth-Damage Curves	CORINE Land Cover - Copernicus	Flood inundation maps; Flood depth and extent maps; Comparison of flood depth maps
NASA/IPCC AR6 Sea Level Projection Tool	LUISA Damage Curves	LUISA Land Use Data	Building flood exposure maps; Building damage maps; Critical infrastructure map
Deltares Global Flood Maps		OpenStreetMap	Maps of exposed population; Maps of displaced population
JRC River Flood Hazard Maps		GHS-POP R2023A	Plots of water level timeseries; Estimates for extreme water levels
Aqueduct Floods - World Resources Institute			

The assessment follows a structured approach to flood hazard and risk assessment. The methodology is divided into hazard and risk assessments for each flood type of coastal and river flooding. The approach integrates advanced modelling tools, historical data, and socio-economic indicators. These assessments aim to identify vulnerable areas, estimate potential impacts, and support informed decision-making for climate adaptation and flood resilience planning.

2.3.1.1 Hazard assessment

Sub-workflow 1: Coastal Flood Hazard Assessment

The Global Tide and Surge Model v3.0 (GTSMv3.0) is used to understand what the typical water level timeseries in Louth looks like. The water level is composed of mean sea water level, tidal water levels and surge levels. Surge levels are caused by the effect of the atmospheric conditions and can change depending on the weather conditions. The hazard assessment for coastal flooding in Louth leverages flood hazard maps from the Deltares Global Flood Maps. It identifies and quantifies flood hazards under present (2018) and future (2050) conditions, aligned with the RCP 8.5 scenario.

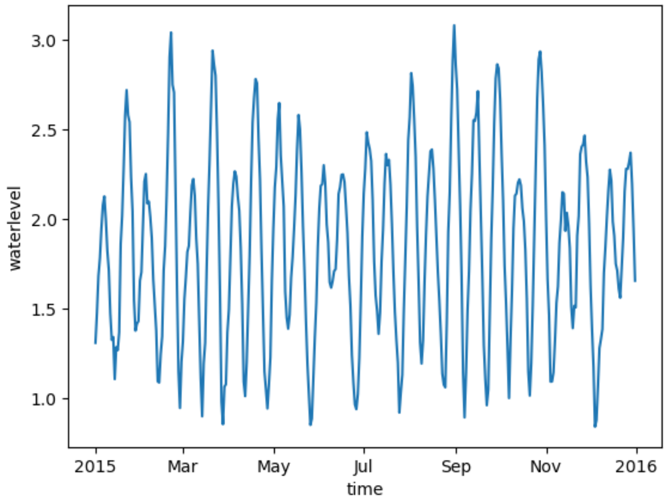

Figure 2-2 Historical Water Level Time Series (2015). Timeseries of daily maximum water levels for one year (2015).

A timeseries of daily maximum water levels and daily maximum surge levels for one year (2015) are plotted, showing the upper values of the water levels for each day of the year. This timeseries also already includes sea level rise. The water levels are defined relative to mean sea level in 1986-2005.

Future projections for flood events are analysed across various return periods. Return periods are an estimate of the likelihood of a flood of certain magnitude occurring in any given year. For example, 1-in-2-year events have 50% chance of occurring in any given year, 1-in-100-year events have 1% of occurring in any given year, and 1-in-250 year events have 0.4% chance of occurring in any given year.

From Copernicus CDS we can also access a related dataset with water level statistics, computed over the period of 1979-2018. This dataset allows for an estimate the extreme water levels over a longer period of time. Extreme water levels for the 1-in-5-year return period are estimated to be 3.3 m above mean sea level, and extreme water levels for the 1-in-100 year return period are estimated to be 3.9 m above mean sea level. However, the Copernicus CDS statistics are limited, as these water levels do not include the effect of sea level rise. [67]

[67] Copernicus Interactive Climate Atlas – Mean of daily accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

The NASA (National Aeronautics and Space Administration) Sea Level Projection Tool[68] is utilised to access localised sea level rise projections based on multiple climate models and emission scenarios. It accounts for factors such as thermal expansion, ice sheet melt, and land subsidence, giving a nuanced picture of future sea level changes.

- For Louth, using SSP5-8.5, projected mean sea-level for 2050 is 3.23 m (range: 3.14–3.33 m), based on historical (2015) maximum observed water level of approximately 3.0 m above mean sea level. Projected sea-level rise increment is 0.23 m (range: 0.14–0.33 m).
- By 2100, projected global mean sea-level rise is as follows 3.70 m (range: 3.48–4.00 m), based on historical (2015) maximum observed water level of approximately 3.0 m above mean sea level. Projected sea-level rise increment is 0.70 m (range: 0.48–1.00 m).
-

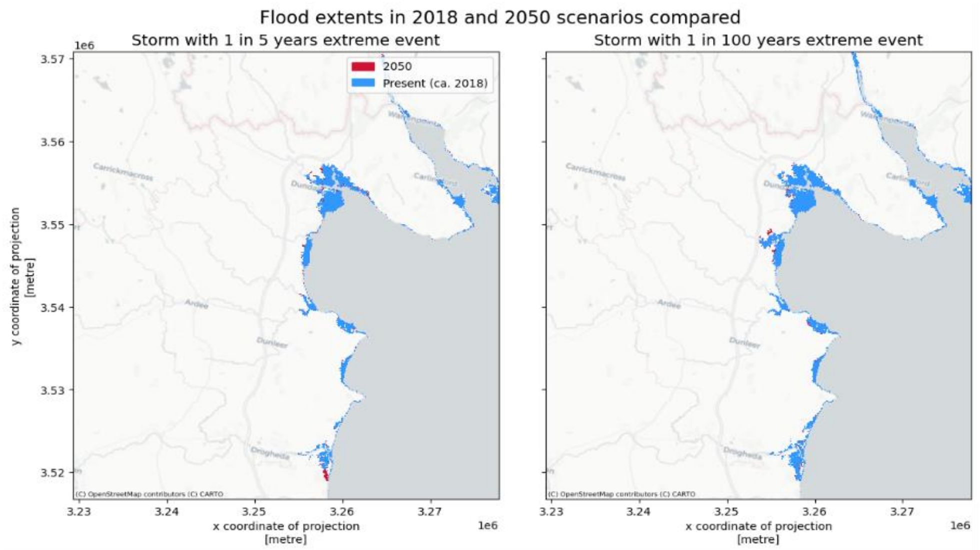

Figure 2-3 Flood Events in 2018 and 2050. The two maps show both 2018 and 2050 extreme coastal flood events. One for an extreme event with return period 1-in-5 years, and a much rarer extreme event with return period of 1-in-100 years. The areas marked red on the map indicate the most significantly impacted by flood events.

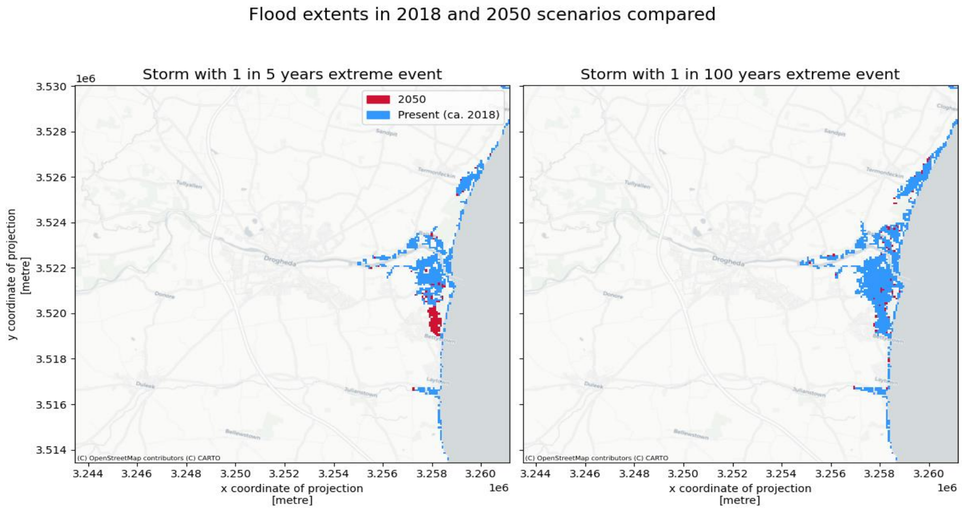

Figure 2-44 Flood Events in 2018 and 2050 Drogheda. The two maps show both 2018 and 2050 extreme coastal flood events in Drogheda.

[68] NASA Sea Level Projection Tool

Flood map Figure 2-3 illustrates the flood extents for scenarios in the years 2018 and 2050, and two different return periods are compared. This flood map highlights coastal areas projected to experience expanded flooding by 2050. Regions marked in red demonstrate significant increases in flood extents. Figure 2-4 indicates these low-lying coastal areas near Dundalk and Drogheda are estimated to be highly exposed even under relatively frequent flood events, with inundation depths reaching up to 5.0 m.

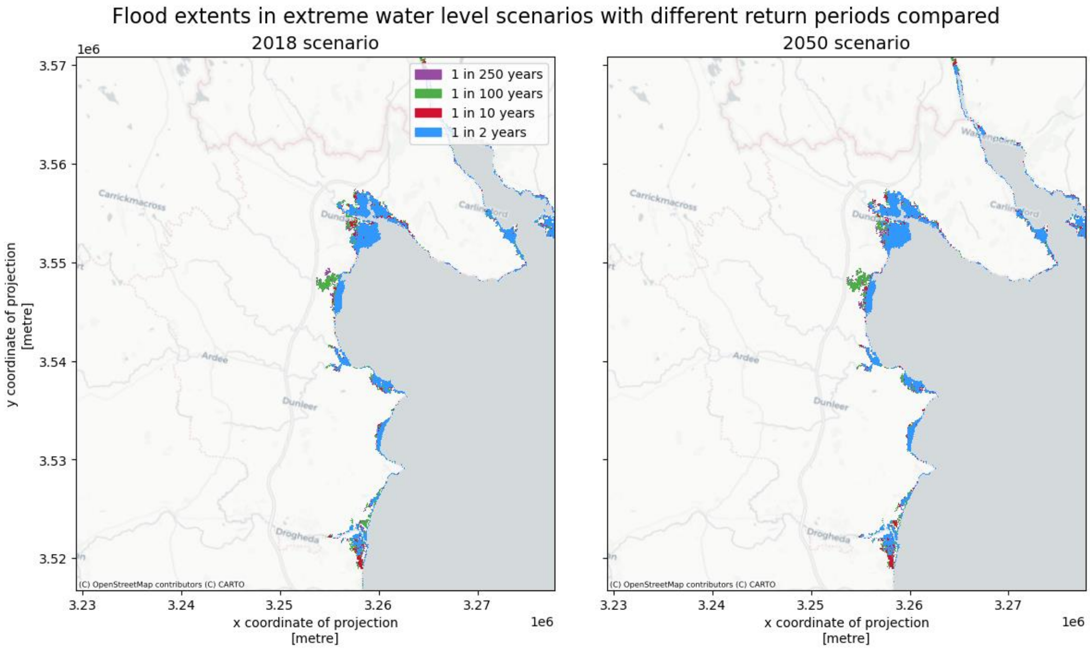

Figure 2-55 Flood Events in 2018 and 2050. The two maps show both 2018 and 2050 extreme coastal flood events, across four different return periods. The areas marked red on the map indicate how the coastal areas are projected to experience expanded flooding by 2050.

To understand the differences between the potential coastal flood extents corresponding to different return periods, the flood extents for four return periods are plotted on top of each other. Across all return periods, flood-prone areas widen noticeably by 2050. The most frequent events (1-in-2 year, blue) already cover a broader coastal strip, while rarer events (1-in-100 year, green, and 1-in-250-year, purple) push further inland, especially near Dundalk Bay and the southern coastline. The pattern indicates that what is currently a moderate hazard could become a routine occurrence, and extreme floods will threaten new areas by mid-century.

Sub-workflow 2: River Flood Hazard Assessment

The hazard assessment for river flooding uses two complementary datasets. The JRC Historical Flood Maps depict past flood events across Europe and beyond. They provide spatial footprints of historical floods, helping to understand patterns, frequency, and severity of river flooding over time. The Aqueduct Floods Projections, provided by the World Resources Institute, project estimates of future flood risks under various climate and socio-economic scenarios.

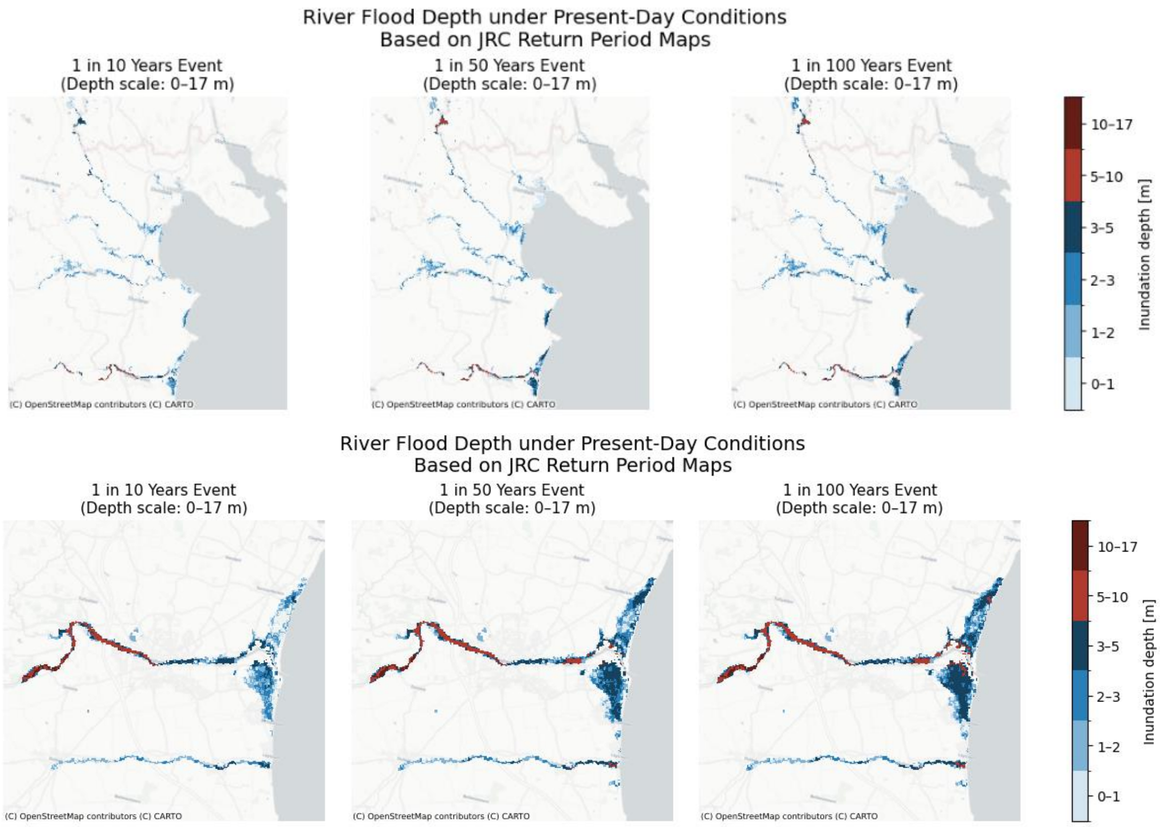

Figure 2-66 River Flood Depth for JRC Return Periods under 2018 conditions. Based on flood event data from circa 2018, the projected 1-in-10 year, 1-in-50 year and 1-in-100-year flood events are estimated. As the return period increases and the frequency of the event grows, both the depth and spread of flooding rise, with the deep red colour for higher depths becoming clearer.

Table 2-6 River Flood Depth Values for JRC Return Periods under 2018 conditions. Based on flood event data from circa 2018, the projected 1-in-10 year, 1-in-50 year and 1-in-100-year flood events are estimated.

Return Period (yrs)	Max Depth (m)	Mean Depth (m)	Median Depth (m)	Flooded Area (km^2)
10	15.67	1.605	1.133	55.159
50	16.43	1.860	1.394	69.694
100	16.70	1.980	1.474	73.620

The flood hazard maps for present day climate conditions illustrate how river flood depth and spatial extent increase with the severity of return period events in Louth. For a 1-in-10-year flood, the average inundation depth is approximately 1.6 m across a flooded area of 55 km^2. This increases to nearly 2.0 m and 73.6 km^2 for a 1-in-100-year event, reflecting both deeper and more widespread flooding as the rarity of the event grows. The progressive rise in mean and median depths, alongside expanding flood coverage, indicates escalating exposure to river flood risk even under present-day climate conditions.

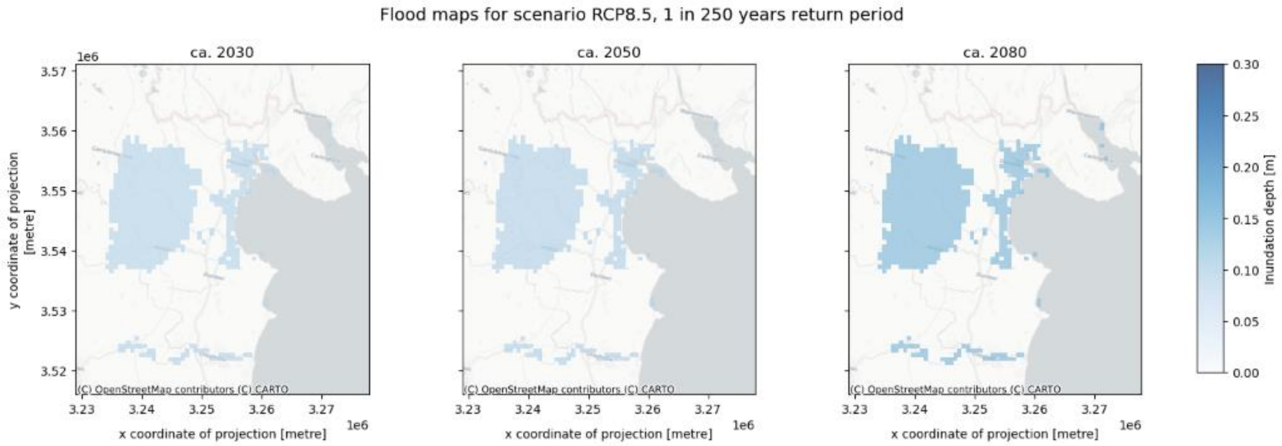

Figure 2-7 Flood Maps for Scenario RCP 8.5, 1-in-250 years Return Period. These images illustrate the inundation depth of rare extreme events (1-in-250-years), across 2030 – 2080 for the RCP 8.5 scenario. The scale indicates that there is an increase in expected inundation depth from 2030 to 2080, with the map for 2080 coloured in a darker blue.

The mapping of projected river flooding for RCP 8.5 for a 1-in-250-year return period rare event, shows the additional flood plain at the inland areas of Louth. The use of the Aqueduct Flood data allows this flood plain to be visualised, which was not possible in the coastal flood hazard assessment using the JRC flood maps alone. The flood maps indicate a moderate increase over time, maximum flood depths increase from 0.100 m in 2030 to 0.182 m in 2080 under RCP8.5.

2.3.1.2 Risk assessment

Coastal and River Flood Risk assessment.

The risk assessment quantifies both the coastal and river flood risk in Louth by integrating historical flood hazard maps with land use, vulnerability, and economic value datasets. It estimates potential economic damages for different flood return periods under current and projected future conditions, highlighting the areas most exposed to flooding. CORINE and LUISA Land Cover data is used to classify land use across flood-prone areas. This classification helps identify which areas are most exposed and what types of assets are at risk. JRC vulnerability curves are then utilised to estimate damages, these curves relate flood depth to expected damage levels.

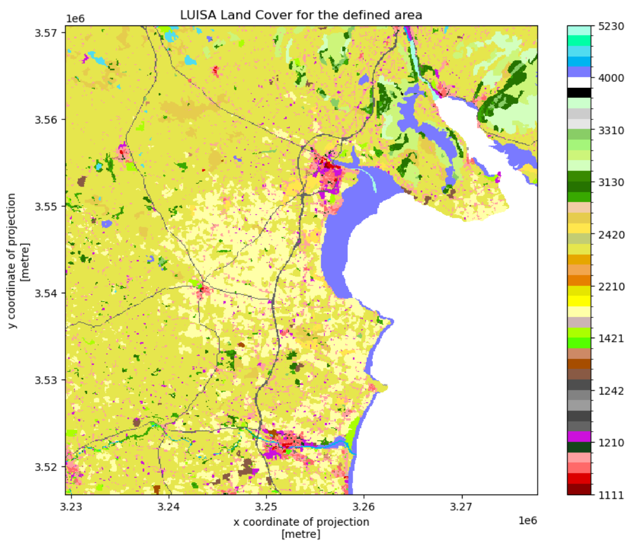

Figure 2-8 LUISA land cover classification. This graph his map provides a foundational layer for assessing climate or flood risk exposure by linking land use to potential hazard impact zones. Each colour pixel assigned a specific LUISA code corresponding to land use types such as urban, agricultural areas, or industrial zones.

The graph represents the LUISA land cover classification for Louth, with each pixel assigned a specific LUISA code corresponding to land use types such as urban, agricultural areas, or industrial zones. Dominant land cover types along the coast include pastures (2310), wetlands (4000), and industrial/commercial areas (1210). Urban clusters in Dundalk and Drogheda show significant exposure.

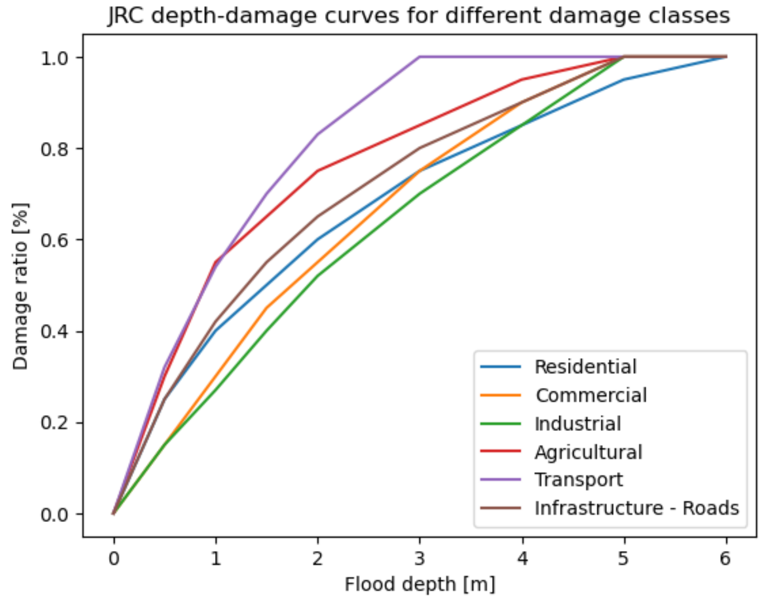

Figure 2-9 JRC Vulnerability Curve. The vulnerability curves estimate the exposure of infrastructure and economic assets to coastal floods.

To assess how different types of land and infrastructure respond to flooding, vulnerability curves are produced, these curves relate flood depth to expected damage levels. The curves are tailored to various asset types and construction standards, allowing for a more accurate estimation of losses. Transport and agricultural assets show the steepest damage increase relative to water depth. Infrastructure roads reach full damage potential at 3m inundation.

Table 2-7 Estimated Economic Damages by Land Use Category Across Flood Return Periods (County Louth). Values are represented in millions.

LUSIA Code	Description	RP10	RP50	RP100	RP200	RP500
		Millions				
2310	Pastures	554.3	747.1	814.9	883.4	965.4
2110	Non irrigated arable land	310.2	442.9	488.9	536.9	595
1210	Industrial or commercial units	115.6	156.2	168.2	182.7	211.8
1123	Isolated or very low-density urban fabric	83.6	119.7	132.9	146.4	162.5
1421	Sport and leisure green	47.3	88.4	101	113.2	126.1
1122	Low density urban fabric	48.7	72.2	81.9	90.3	111.8
4000	Wetlands	51.6	71.4	77.6	83	89.5
2430	Land principally occupied by agriculture	24.9	34.7	39.2	42.9	48.3
1330	Construction sites	10	24.3	29.6	34.7	39.9
2420	Complex cultivation patterns	8.6	14.5	19.9	25.4	33.3
1121	Medium density urban fabric	16.9	18.3	18.8	19.3	19.1

1221	Road and rail networks and associated land	10.4	12.9	14.1	15	17.4
1130	Urban vegetation	11.7	12.8	13.2	13.1	16.1
1422	Sport and leisure built-up	4.4	7.9	10.2	11.4	13.2
1410	Green urban areas	5.2	5.9	6.1	6.3	6.5
1230	Port areas	0.4	1.2	1.4	1.6	1.8
3240	Transitional woodland shrub	0.1	0.8	1.1	1.3	1.6
1310	Mineral extraction sites	0.2	0.3	0.3	0.3	0.4
3220	Moors and heathland	0.2	0.2	0.2	0.2	0.2
1320	Dump sites	0.2	0.2	0.2	0.2	0.2

The economic damage analysis shows that flood-related economic damages in Louth increase significantly with return period, particularly affecting pastures, non-irrigated arable land, and industrial or commercial units. Pastures are the most impacted category, with damages rising from €554 million for 1-in-10-year events (RP10) to over €965 million for 1-in-500 year events (RP500). Urban areas and infrastructure also face rising damages, indicating growing exposure and highlighting the need for risk-informed planning.

Flood Damage and Population Exposure:

Assessing flood risk to populations involves analysing river flood impacts using spatial and statistical methods. The assessment considers exposure of critical infrastructure and estimates population exposure and displacement using gridded datasets and flood depth thresholds. The outputs support understanding of spatial risk distribution and help identify areas requiring adaptation planning.

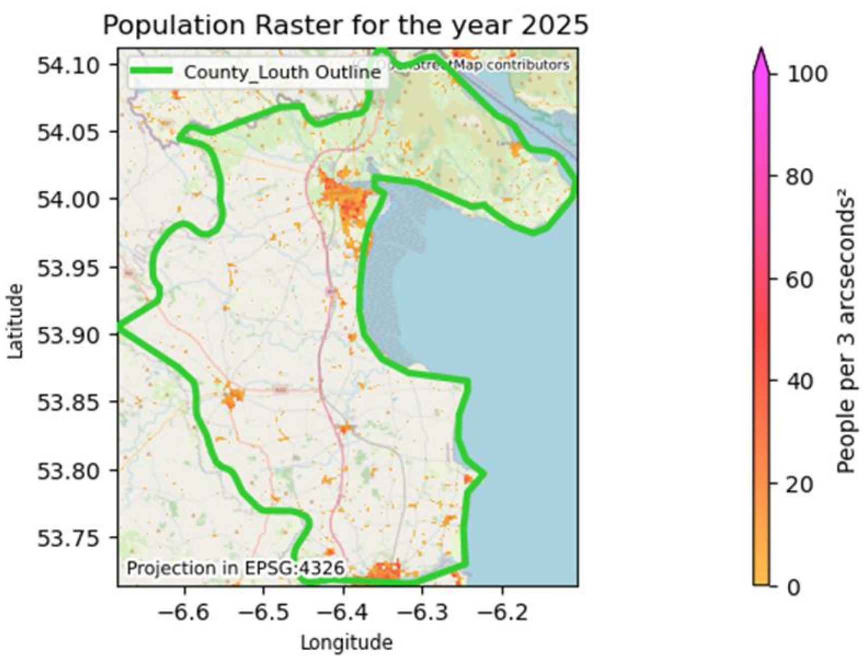

Figure 2-10 Estimated population distribution across County Louth in 2025.

The population distribution across Louth in 2025 is predominantly low-density, with a total population of approximately 159,888 residents spread over 746.4 km² of populated area. The average population density is 214.2 people/km², though over 95 % of the land area records densities below 50 people/km². Concentrated population clusters are visible around Dundalk, Drogheda, and smaller coastal settlements. While most of the county is sparsely populated, these localised clusters may still be at risk, especially if they intersect with flood-prone zones.

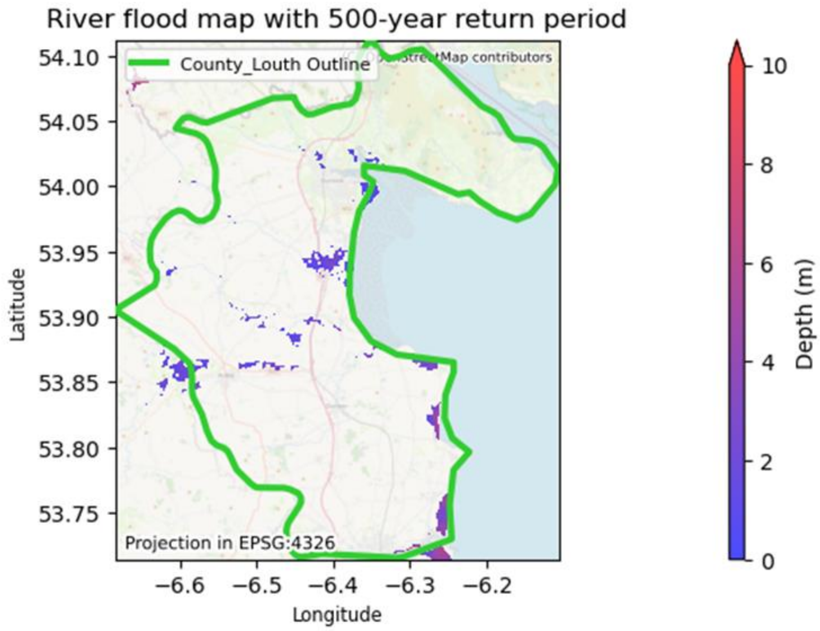

Figure 2-11 Estimated flood risk areas across County Louth.

Under the 500-year return period scenario, the modelled flooded area impacts the highest densely populated areas in Louth. These flood zones pose a substantial risk to critical infrastructure and built-up areas, particularly in estuarine and riverine floodplains that would otherwise remain dry under more frequent flood scenarios.

2.3.2 Workflow #2 Windstorms

Table 2-8 Overview of data used for workflow #1 Windstorms.

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
Historical and synthetic windstorm footprints (maximum 3-second gusts) from Copernicus CDS	Six vulnerability curves (Feuerstein et al., 2011) for different asset types	LUISA Land Cover data (JRC, 2018); JRC Maximum Damage Estimates (adjusted for local GDP)	Absolute and relative damage estimates per asset class; Spatially explicit economic damage maps

The assessment of windstorms focuses on both the strength of the hazard and the possible damage it could cause. The process includes analysing past and simulated storm events to understand wind patterns and evaluating how different types of land and buildings might be affected. By combining these elements, the assessment helps estimate the economic cost of storm damage and supports better planning for future extreme weather events.

2.3.2.1 Hazard assessment

A wind hazard is defined through the CLIMAAX framework as the maximum 3-second wind gust during a storm. The assessment uses Historical storm footprints (1979–2021) and Synthetic storm footprints (1986–2011) from the Copernicus CDS. These datasets provide maps of wind gust intensity over a 72-hour period. Historical data shows what has happened in the past, while synthetic storms are physically realistic and plausible events that could happen in the present day. These synthetic storms are useful for creating a larger picture of possible events that could affect a certain area.

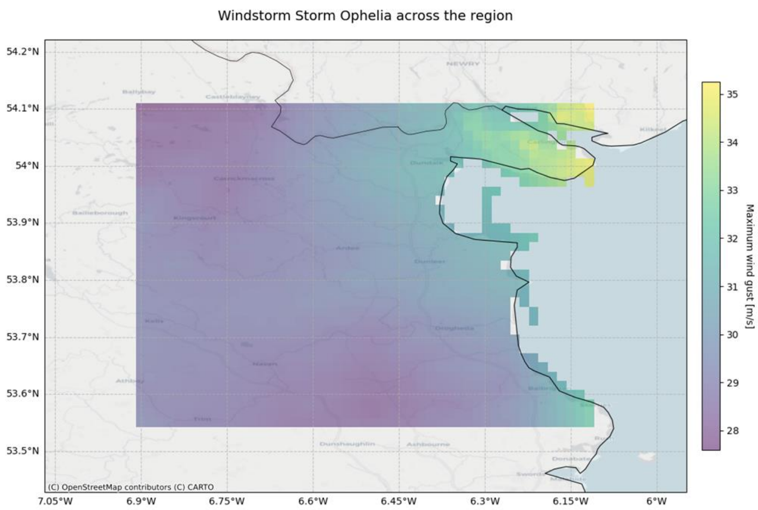

Figure 2-12 Windstorm Storm Ophelia 2017 across the region This map explains the maximum wind gust speeds generated by Storm Ophelia in a specific region. The colours on the map show the wind speed in meters per second (m/s). The yellow and lighter areas indicate the strongest winds, while the purple and darker areas show where the winds were not as powerful.

The hazard assesment allows for the view of the historical storm Ophelia across the Louth region, wind speed data from Storm Ophelia is visualised on the map, which shows maximum wind gusts exceeding 31 m/s. [69]

2.3.2.2 Risk assessment

The risk assessment combines hazard, exposure, and vulnerability to estimate damages from a windstorm. By integrating these three components, the workflow can generate detailed damage maps and cost estimates for a storm event.

However, this analysis is subject to various limitations. Vulnerability curves are generalised representations of building types and may not fully capture the diversity of the local building stock. Economic damage estimates are derived from maximum damage values adjusted at the national GDP level, which may not reflect actual replacement or repair costs in specific communities. The results have not been validated against insurance claims or observed loss data, which would provide a more robust benchmark for accuracy. In addition, the scope of the assessment is limited to structural damages, excluding potential losses to infrastructure, agriculture, or indirect economic impacts. Finally, as the analysis is based on a single event, Storm Ophelia, the results may not represent the full range of possible storm impacts.

[69] Output of the windstorm CLIMAAX workflow

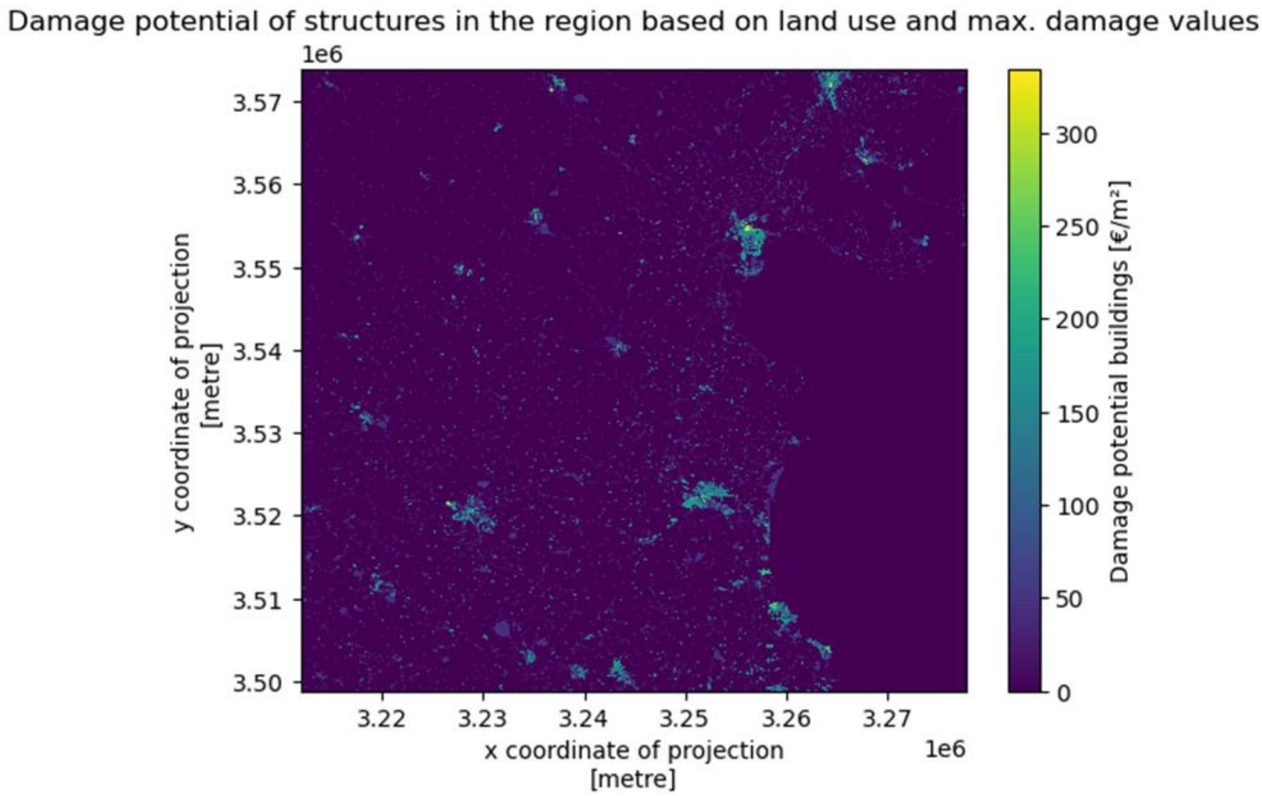

Figure 2-13 Spatial distribution of maximum potential damage values (€ per m²) across County Louth, derived from LUISA land cover classes. High exposure is concentrated in Dundalk and Drogheda, where industrial and commercial assets dominate.

As described in the flooding risk assessment, LUISA land cover classification has been applied to Louth. With each pixel in the map of Louth assigned a specific LUISA code corresponding to land use types such as urban, agricultural areas, or industrial zones. Each land cover type is also associated with a maximum damage per square meter, allowing the exposure of the area to be assessed. By mapping the damage potential of structures in the region based on land use and max damage values, it is identified there is high exposure in Dundalk and Drogheda, where industrial and commercial assets dominate.

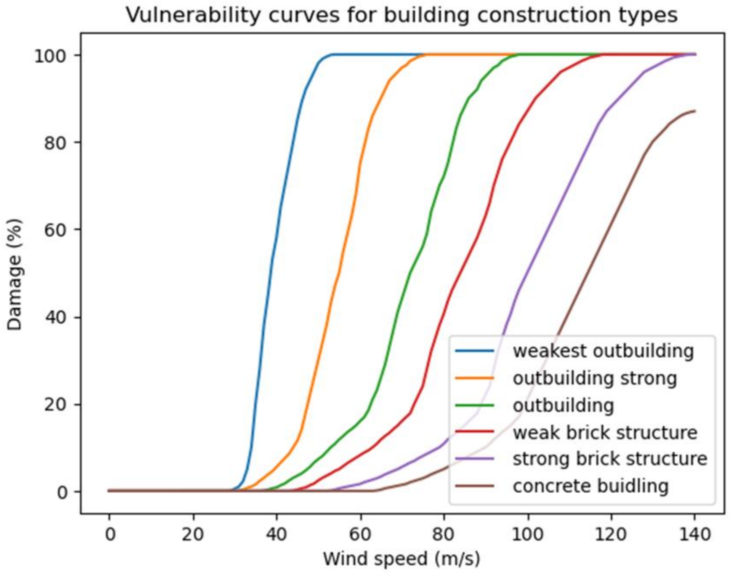

Figure 2-14 Vulnerability curves for LUISA land cover classes, showing percentage damage as a function of wind speed. Industrial and commercial buildings show steep increases in damage at lower thresholds, while stronger building types demonstrate greater resistance to wind loads.

The vulnerability assessment then determines how easily assets are damaged by wind. This is done using vulnerability curves, which show the percentage of damage to an asset at different wind speeds. Plotting the vulnerability curves shows the windspeed associated with a construction class and a fraction of the building of a specific class that is destroyed at that wind speed. The vulnerability curves revealed limited losses below 20 m/s but rapidly increasing damage at higher gust speeds, especially for industrial and commercial buildings compared to residential ones. The vulnerability in Figure 2-6 shows that over 90% of weak outbuildings could be damaged by a wind of 47 m/s, but less than 90% of strong concrete buildings could be damaged even in a much stronger wind of 134 m/s. [70]

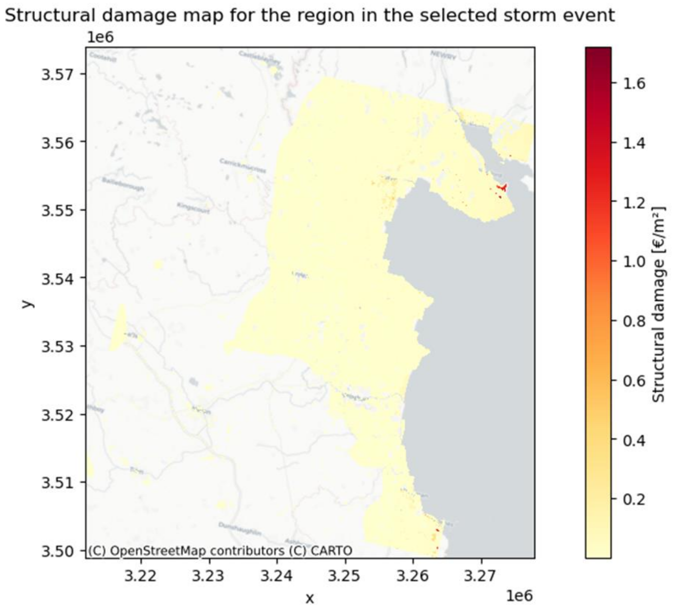

Figure 2-15 Estimated absolute structural damages (€ per m²) from Storm Ophelia. Losses are concentrated in urban and industrial zones, particularly Dundalk and Drogheda, with rural areas showing limited damage due to lower wind speeds and asset values.

[70] Output of the windstorm CLIMAAX workflow

The potential impact and estimated structural damage of further windstorms in Louth is assessed by utilising historical windstorm events, the wind speeds measured during a historical storm are applied to a model which calculates damage, to estimate the impact of a storm with similar wind speeds. The hazard, exposure, and vulnerability assessments as aforementioned are utilised to model this damage estimate. Modelling potential storm wind speeds based on Storm Ophelia, it is estimated that a windstorm event in Louth could occur with max wind speeds of over 31 m/s. With these windspeeds, the total structural damage could be up to approximately €11.45 million[71] for a high impact event, with the largest contributions from pastures (€2.91million), industrial/commercial units (€2.44 million), and sport and leisure green areas (€1.50 million), highlighting the concentration of risk in coastal and urban areas alongside vulnerabilities in rural regions. The damages are plotted on a map to gain more insight where the storm could cause the most damage.

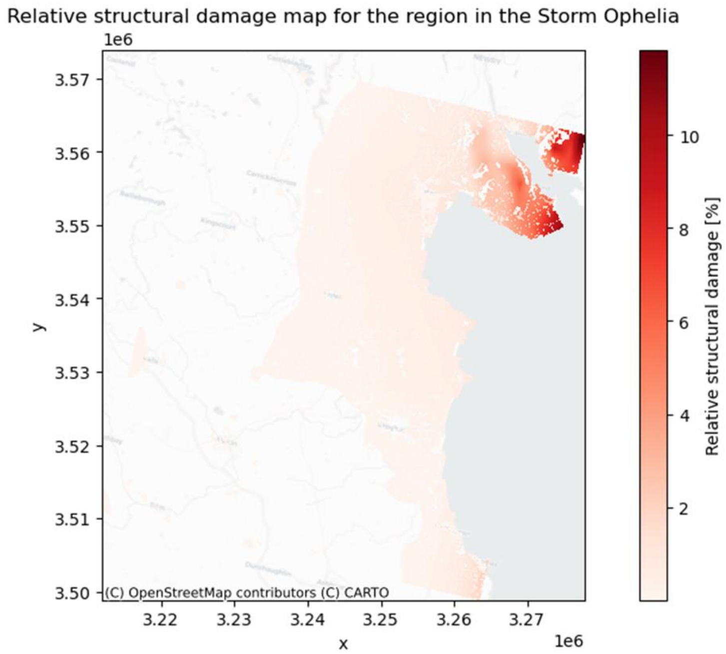

Figure 2-16 Relative structural damage (%) from Storm Ophelia, showing the proportion of maximum potential damage. The highest impacts are observed in coastal areas around Dundalk Bay, while inland regions experience lower but still significant relative losses.

Plotting the relative structural damage across Louth indicates that the highest impacts are observed in coastal areas around Dundalk, inland regions experience lower but still significant relative losses.

2.3.3 Workflow #3 Rainfall

Table 2-9 Overview of data used for workflow #1 Rainfall.

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
EURO-CORDEX Climate Projections:	RP_Louth_threshold_100mm.tif is used to define critical	OpenStreetMap Data to represents elements	Future return period of current 100 mm/24h event; Future rainfall amount for fixed return period; Future rainfall amount for fixed return period; %

[71] Output of the windstorm CLIMAAX workflow

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Precipitation data from Climate Data Store at 3-hour and 24-hour duration	impact-based rainfall thresholds.	exposed to the hazards	change in rainfall magnitude for fixed return period; Map of return period changes for 100 mm/24h; Map of relative rainfall change for fixed frequency

2.3.3.1 Hazard assessment

The hazard assessment uses climate model data for two time periods: the past (1976–2005) and the future (2041–2070) under a high-emissions scenario. The data focuses on Louth, and rainfall is tracked in 3-hour and 24-hour periods. For each year, the highest value is selected to build a time series of extreme events. These yearly peaks are then used to make graphs, maps, and calculate return period estimates, which indicate how often extreme rainfall is likely to occur. Then a final dataset is created to explain how rainfall intensity, frequency, and location could change and are used to evaluate future flood risk.

While the heavy rainfall workflow provides useful insights, it has limitations such as relying on only one climate model and one emissions pathway, which may not capture the full range of possible outcomes. In addition, using a 12 km grid, or coarse resolution, can miss local storms that may drive flash flooding.

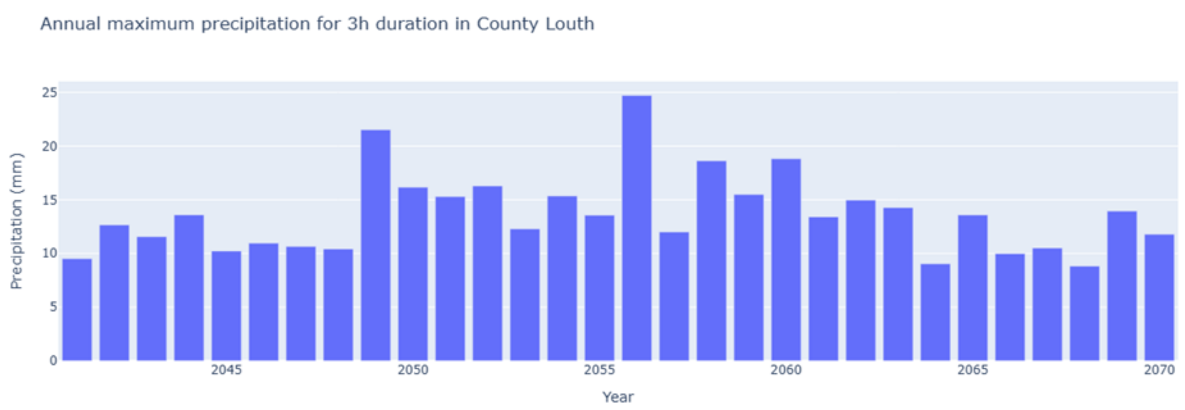

Figure 2-177 Annual Maximum 3-Hour Precipitation for 2041–2070 in County Louth. This chart illustrates the projected maximum short-duration rainfall event for each year under RCP 8.5.

The projection of annual maximum 3-hour rainfall for 2041–2070 shows strong year-to-year variability, with events ranging from ~9 mm to nearly 25 mm. Peaks in 2049 and 2056 highlight the risk of short, intense storms that may overwhelm drainage systems, increase flash flooding, and put added pressure on local infrastructure and communities in Louth.

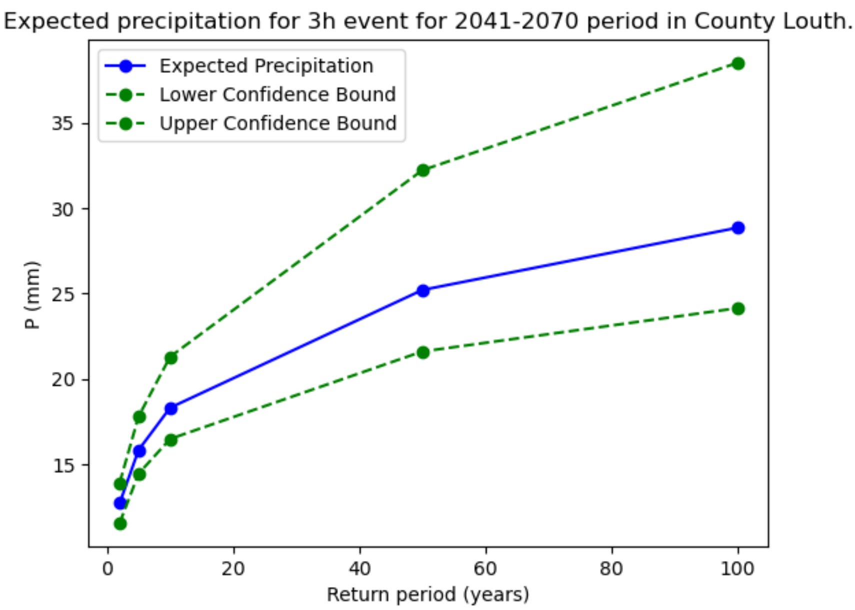

Figure 2-1818 Expected Precipitation for 3-Hour Events Across Return Periods (2041–2070, RCP 8.5). This return-period curve shows how projected rainfall intensity increases Return periods.

The second plot shows projected precipitation intensities for 3-hour storms across different return periods in Louth. The central estimate suggests that rainfall increases from around 13 mm for frequent events (2–5 years) to nearly 30 mm for rarer, 100-year events. The green confidence bounds highlight the range of possible outcomes, indicating substantial uncertainty but confirming a clear upward trend in intensity with return period.

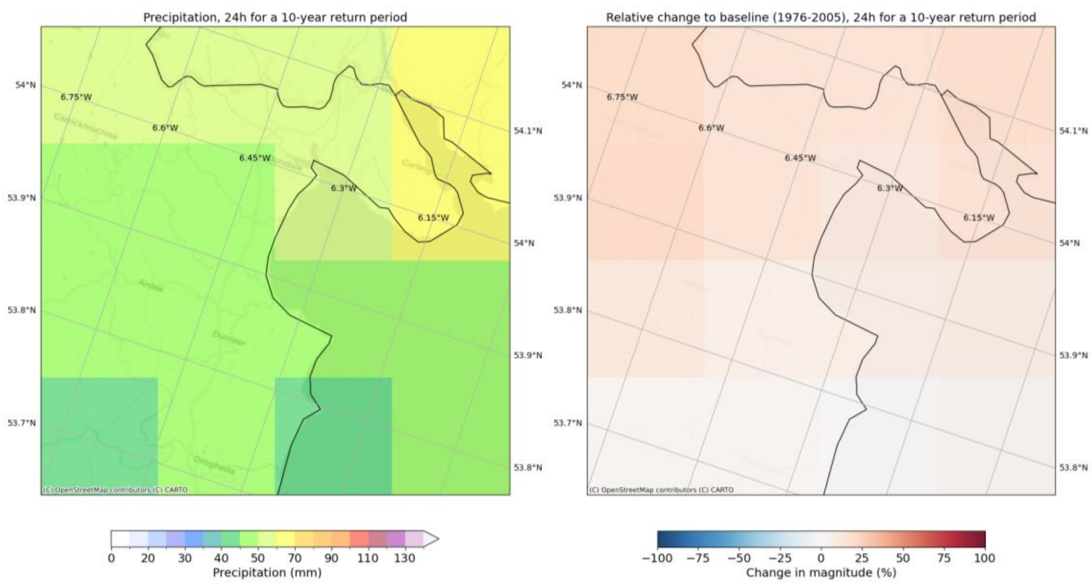

Figure 2-1919 Projected 24-Hour Precipitation for a 10-Year Return Period (2041–2070, RCP 8.5). The map illustrates expected rainfall intensities across County Louth, with values reaching 50–65 mm. These levels exceed historical design thresholds, signalling increased strain on local drainage and flood management.

To understand how frequent extreme heavy rainfall can occur, the analysis looks at 24-hour rainfall. This is the total amount of rain that falls in a single day, showing how intense one-day storms can be. The map shows that future storms in Louth (2041–2070, RCP 8.5) bring about 50–65 mm of rain in one day, with the most extreme events projected to be nearly 12% stronger than in the past. These storms, often used to design drains and flood systems, are likely to go over past limits more often, meaning today's infrastructure may not be enough. This points to the need for stronger flood planning and upgrades in the future.

2.3.3.2 Risk assessment

The risk assessment for extreme rainfall in Louth looks at a critical rainfall threshold, the level of rain in one day that could cause serious impacts like flooding. For this study, the threshold is set at 63.3 mm in 24 hours, which in the past only happened about once every 50 years. Using past climate data (1976–2005) as a baseline and comparing it to future projections (2041–2070) under a high-emissions pathway (RCP 8.5), the analysis shows how often this level of rainfall may happen in the future. The main result is a return period shift map, which explains how the chance of hitting this rainfall threshold changes over time. Instead of just showing how much rainfall might increase, the map shows how often extreme events may occur, giving a clearer picture of future flood risk.

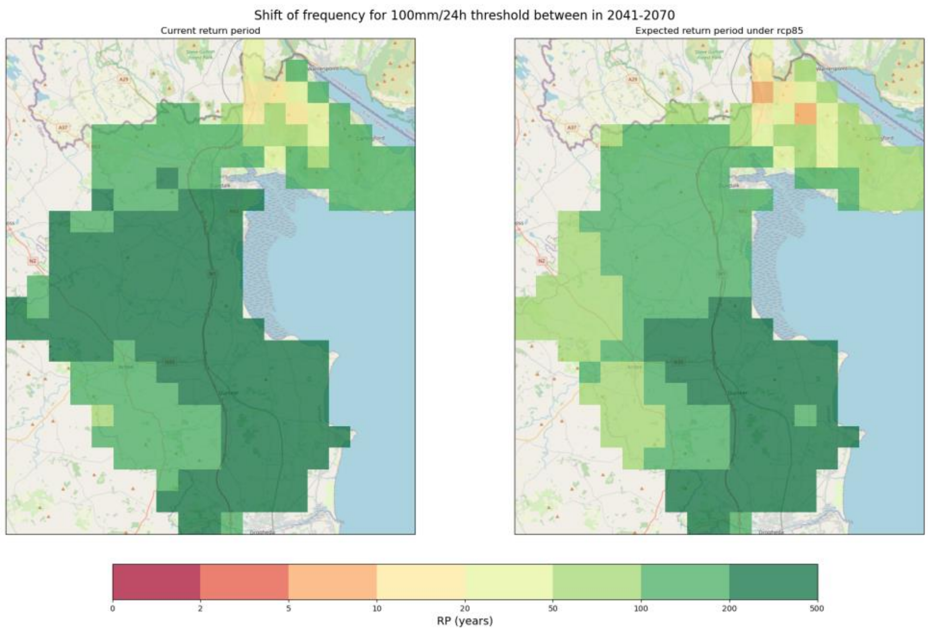

Figure 2-2020 Projected Return Periods for 100 mm/24h Rainfall (2041–2070, RCP 8.5). The maps compare historical and future return periods across County Louth, showing that events previously expected once every 100 years may occur every 50–70 years. This shortening of return periods indicates more frequent exceedance of critical thresholds leading to increased pluvial flood risk.

For Louth, the graph shows that extreme rainfall events which were once considered rare, such as those historically occurring every 50–100 years, are projected to become much more frequent. The 63.3 mm in 24 hours event, which aligned with a 50-year return period in the past, is projected to recur about every 43 years by mid-century, raising its annual probability from 2.0% to 2.3%. More severe thresholds also shift, with a 100-year event expected to shorten to around 60–70 years, effectively doubling the chance of occurrence within a single lifetime. In practice, this means that extreme one-day storms move from being exceptional events to ones that are relatively common within a generation.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

Flooding:
Both coastal and river flooding in Louth are severe and growing threats, particularly under the high-emissions RCP 8.5 scenario. Historical data shows that maximum coastal water levels reached approximately 3.0 m above mean sea level in 2015. For future projections across all return periods flood-prone areas widen noticeably by 2050. The most frequent projected events already cover a broader coastal strip, while rarer events push further inland, especially near Dundalk Bay and the southern coastline. Low-lying coastal areas near Dundalk and Drogheda are estimated to be highly exposed even under relatively frequent flood events, with inundation depths reaching up to 5.0 m.

River flooding in Louth already poses a significant threat, based on flood event data from circa 2018, with projected 1-in-100-year flood events estimated to inundate up to 74 km² and reaching depths of 16.7 m. As the return period increases and the frequency of the event grows, both the depth and spread of flooding rise, with the 1-in-500-year scenario showing the most widespread and deepest inundation. The mean depth grows from approximately 1.6 m for a 10-year event to over 2.0 m for a 1-in-100-year event, while flooded area also increases significantly. The progressive rise in mean and median depths, alongside expanding flood coverage, indicates escalating exposure to river flood risk even under present-day climatic conditions.[72]

These changes pose substantial risks to residential, commercial, and transport infrastructure. Economic losses across the region are expected to rise by 30-60% by mid-century.[73] Vulnerability assessments show that even moderate flood depths can cause significant damage, for instance, a 2-metre inundation could result in around 60% damage to residential buildings.[74] The combination of increasing flood frequency, expanding exposure zones, and high-value assets at risk underscores the urgent need for updated coastal defences, land-use planning, and climate adaptation strategies. Flooding has the potential for irreversible impacts such as permanent loss of coastal land and ecosystems, along with the destruction of infrastructure and economic zones. Historically flooding has had cascading effects on Louth with potential for this to increase in the future. This has included the displacement of communities, disruption of transport and supply chains, and the potential for public health crises such as water contamination and disease outbreaks.[75]

Wind:
Historical windstorm events such as Storm Ophelia, and more recently Storm Éowyn, showcase the extensive damage that storm events can cause in Louth. The assessment of windstorms is an example of an acute risk which focuses on a single, sudden event. The potential impact of further

[72] https://www.floodinfo.ie/
[73] Projections from flooding CLIMAAX workflow.
[74] https://www.epa.ie/news-releases/news-releases-2025/major-new-epa-report-assesses-irelands-vulnerability-to-climate-change-impacts.php
[75] https://consult.louthcoco.ie/en/system/files/materials/259/DRAFT%20Louth%20County%20Council%20Climate%20Action%20Plan%202024-2029.pdf

windstorms in Louth is assessed by utilising historical windstorm events. The wind speeds measured during a historical storm are applied to a model which calculates potential damage, to estimate the impact of a storm with similar wind speeds. Based on Storm Ophelia, it is estimated that a windstorm event in Louth could occur with max wind speeds of over 31 m/s. With these windspeeds, the total structural damage could be up to approximately €11.45 million[76] for a high impact event. The areas that suffer the highest damages are pastures (€2.91million), industrial/commercial units (€2.44 million), and sport and leisure green areas (€1.50 million), highlighting the concentration of risk in coastal and urban areas alongside vulnerabilities in rural regions. The vulnerability curves show that over 90% of weak outbuildings could be damaged by a wind of 47 m/s, but less than 90% of strong concrete buildings could be damaged even in a much stronger wind of 134 m/s.

Windstorms have the potential to cause irreversible damage in Louth, with historic high winds already causing one fatality during Storm Ophelia. The Copernicus Atlas analysis estimates that windstorms are not projected to be high in frequency, but extreme storm events with higher wind speeds are projected to be more frequent. Extreme storms are projected to occur up to 3.6 times more frequently by 2060-2081 than during the 1981-2000 baseline under an RCP 8.5 scenario.[77]

Rainfall:

Heavy rainfall in Louth is projected to become more severe, with events delivering higher volumes of water in shorter timeframes. The intensity of annual heavy 24-hour rainfall is expected to increase by about 12% between the historical baseline (1976–2005) and mid-century (2041–2070) under a high-emissions scenario (RCP 8.5). Short-duration storms will also intensify, with 3-hour events potentially reaching 20–25 mm at single locations, volumes that can overwhelm urban drainage and trigger flash and surface water flooding. In parallel, average 24-hour rainfall is projected to rise by 10–20% across much of the county, leaving soils more saturated and rivers more prone to overtopping. These changes suggest a greater likelihood of cascading impacts, including transport disruption, strain on healthcare access, damage to water supply and treatment systems, and interruption of business operations. Infrastructure and flood defences designed using historical records may not withstand such higher magnitudes of rainfall.

2.4.2 Urgency

Flooding:

The analysis shows that both coastal and river flood hazards will worsen significantly in the near future, especially under RCP 8.5, with major impacts from both coastal and river flooding projected to occur by 2050. With early signs of increased flood frequency and severity already observable in recent data (e.g. 2015 storm surges and rising water levels, and 2023 extreme rainfall).

Sea-level rise of up to 0.23 m by 2050 will increase baseline water levels, making extreme events more frequent and severe. For river flooding, the spatial extent remains relatively stable (~36 km²). Impacts can be seen in 2050, but projections from the Copernicus Atlas predict that by

[76] Output of the windstorm CLIMAAX workflow

[77] https://www.gov.ie/en/department-of-transport/publications/transport-sectoral-adaptation-plan-t-sap-ii-implementation-and-governance/

2100 the impacts will have grown exponentially. By 2100 extreme rainfall peaks could be at +6.5 to +11.6 mm/day, with sea level rise of up to 1 m.[78]

This indicates that Louth's flood hazards involve both sudden and slow-onset processes, which heighten the urgency for action. Sudden events in Louth such as storm surges, heavy rainfall, and river floods have historically caused immediate and severe damage to infrastructure, homes, and communities. Slow onset processes such as sea level rise is gradual but persistent, leading to permanent changes in flood risk and reducing the effectiveness of existing defences.
The 2001/42/European Commission (EC)[79] level rise combined with flood triggering events such as heavy rain, which are projected to become more frequent, could overwhelm defences and cause deep inland flooding.

Urgency addressing flood risks is high due to the immediate threat posed by sudden flood events. Prompt action is recommended to minimise damages and build resilience, particularly to upgrade coastal defences as existing infrastructure may not withstand future flood depths and extents. High-priority action is also recommended to enhance emergency preparedness. Measures should be taken as soon as possible to adapt land use planning to reflect future flood risk zones, particularly in urban areas like Dundalk and Drogheda. Flood risk in Louth is predicted to be persistent and long term. Sea level rise is irreversible on human timescales, meaning elevated flood risks will continue for decades or centuries. Flood risks will grow without sustained mitigation and adaptation, affecting more people, properties, and ecosystems over time.[80]

Timely action is likely to help reduce damage and improve resilience, especially by strengthening coastal defences, as current infrastructure may struggle to cope with future flood levels. Flood risk in Louth is expected to remain a long-term concern. Since sea level rise is effectively permanent on human timescales, elevated flood risks are likely to persist for decades or even centuries. Phase 2 of the project will incorporate more localised data to gain deeper insight into the actions required in Louth, this will include more insight on which geographical areas, certain infrastructure and communities will need the most immediate defence and adaptation measures.

Wind:
Based on the modelled projections from Storm Ophelia, the risk is severe and warrants prompt action. High-impact events of this nature are associated with estimated structural losses of €11.45 million. A windstorm is a sudden-onset hazard that can escalate rapidly, leaving a very limited window for response. This fundamentally differs from a chronic hazard, such as a gradual rise in sea level, which permits phased, long-term planning. Given the sudden-onset nature of windstorms, it is important to implement proactive and preventative measures to minimise damages, as reactive actions are largely ineffective once a high-impact event begins. While this specific analysis did not employ future climate scenarios such as RCP or SSP to project if storms will worsen, the fact that a historical storm has the potential to cause such significant damage

[78] Copernicus Interactive Climate Atlas – Mean of daily accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.
[79] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment.
[80] https://www.climateireland.ie/impact-on-ireland/climate-hazards/coastal-flooding/

demonstrates that this type of hazard is a persistent and urgent concern that requires immediate attention.

Rainfall:
The urgency concerning heavy rainfall events for Louth stems from projected increases in both the intensity and frequency of extreme precipitation. Analysis for Louth indicates an average increase of 12%[81] in the intensity of annual heavy 24-hour rainfall events by 2041-2070 under a high-emissions scenario (RCP 8.5). This means that events previously considered rare will occur more often; for example, a historical 1-in-50-year rainfall event of 63.3mm is projected to become a 1-in-43-year event, significantly increasing risk. Such changes imply that existing critical impact thresholds for infrastructure and safety will be crossed more frequently, leading to a heightened potential for flash, riverine, and surface water flooding. Consequently, there is a need to re-evaluate design standards, emergency response plans, and long-term water management and flood defence strategies, as current measures may no longer be adequate to protect against future risks. The broader NCCRA identifies risks related to healthcare services and facilities and water supplies due to extreme precipitation and flooding as requiring "More Action Needed".[82]

2.4.3 Capacity

Louth's risk register as part of LCAS, has helped prioritise adaptation actions and inform planning decisions. In terms of specific hazards, Louth has addressed flood and heavy rainfall risk through multiple channels. The Sectoral Adaptation Plan for Flood Risk Management (2019) provided a comprehensive risk assessment of river, coastal, pluvial, and groundwater flooding, and outlined strategic priorities and adaptation actions. Additionally, Flood Risk Assessments for new developments have incorporated future climate scenarios, recommending elevated flood levels and SuDS to manage runoff and reduce pluvial flood risk. Nature-based solutions have also played a role in Louth's climate resilience efforts. The Louth Local Biodiversity Action Plan 2021–2026 promotes the restoration of wetlands, peatlands, and native woodlands, ecosystems that naturally absorb carbon and mitigate flood risk, highlighting the county's commitment to integrating biodiversity and climate adaptation.

The OPW study has identified that there are 5 areas in Louth to be prioritised for flood relief measures and LCC are working with OPW to deliver these Flood Schemes. These are located in Dundalk, Drogheda, Carlingford, and Baltray and Ardee. Some of the measures already in place for extreme flood and rainfall events include maintenance of road river and stream drainage systems, provision of warning signage and sandbags as needed by outdoor staff, implementation of severe weather plan and engaging contractors to carry out minor works on site to open channels to alleviate flooding and remove debris.

Louth have capacity to address the climate risks of heavy rainfall and floods, as local flood and rainfall data is rich and readily available due to the work carried out by the OPW. This means the insight into flood risk is strong and puts LCC in a good position to plan further adaptation measures.

---

[81] Comparison of average annual maximum 24-hour precipitation between 1976–2005 and 2041–2070 under RCP 8.5 for County Louth.
[82] https://www.climateireland.ie/media/epa-2020/monitoring-amp-assessment/climate-change/climate-ireland/EPA_NCCRA_Main-Report_Published_June_2025.pdf

Measures for windstorm risk include implementation of severe weather plans, appropriate emergency response training for outdoor staff, engagement of local contractors, and contact with ESB and communication service providers. Wind related climate risks have not been addressed to a large extent throughout Louth, however, the capacity to address wind related climate risks has increased in recent years.

Windstorms have been highlighted on a national level as a key climate risk. The support on a national level provides justification for local windstorm adaptation measures in Louth, along with having a positive effect on the available resources. With a history of severe wind events, resulting in fatality, Louth will have community support on adaptation measures.

Phase 2 of the project will allow for more local insight which can be the basis of a concentrated strategy for climate risk adaptation and mitigation. The use of localised data and further stakeholder feedback will provide further insight into Louth's capacity for climate risk measures.

2.5 Preliminary Monitoring and Evaluation

The first phase of the CRA revealed that Louth faces significant and evolving risks from heavy rainfall, flooding, and windstorms. The CLIMAAX framework enabled a structured approach for identifying vulnerable areas, sectors, and communities.

Holding workshops involving stakeholders of LCC, proved to be insightful in terms of identifying priority risks to bring forward into Phase 2. The climate risks and their effects on different sectors and communities in Louth were discussed, such as the impacts on the GAA community and the vulnerable lower income communities. The workshops also served to assess the capacity LCC has to address these risks.

During this phase of the project, the limited availability of local data was identified. Phase 2 of the project will focus more on the integration of local data, therefore these difficulties identified in Phase 1 will allow for timely addressing and preparing for this issue before commencing the next stage. Limitations included inconsistent formats, short time series, and mismatched spatial scales, which constrained the integration of datasets and the precision of risk modelling. Steps have been taken already to request data from additional authorities and organisations.

While some new data sources were accessed, such as Copernicus Atlas projections and updated OPW flood maps, some key gaps remain. These include the lack of national downscaled projections for hazards like extreme wind, fire weather, and drought. To improve understanding of risks, the project requires enhanced spatial data on asset locations and infrastructure functions, clear impact thresholds, more detailed vulnerability indicators, especially socio-economic and adaptive capacity metrics.

Phase 1 highlighted the need for more inclusive and extensive stakeholder involvement in future phases, particularly to capture the perspectives of vulnerable and underrepresented groups. There is a recognised need to broaden participation to include additional community representatives, local businesses, and sectoral experts to refine risk prioritisation and adaptation planning. Additional resources and competencies in data integration, scenario modelling, and stakeholder facilitation are required to complete an optimal analysis in Phase 2.

2.6 Work plan

The upcoming phases of the CLIMAAX project will build on the initial assessment by expanding and localising the analysis of climate risks in Louth. Phase 2 will focus on refining the understanding of exposure and vulnerability to the three priority hazards, flooding, heavy rainfall, and windstorms, using more detailed local data and stakeholder input. Activities will include developing GIS-based overlays, conducting site-specific profiling, and facilitating workshops to co-design locally relevant adaptation measures. Phase 3 will use these insights to create a structured adaptation strategy, including governance models, implementation pathways, and targeted risk management plans for critical assets such as public infrastructure, heritage sites, and vulnerable communities. Hazards like drought, wildfire, and snow/cold spells will not be studied further due to limited data availability and their lower projected impact, allowing the project to concentrate efforts where the risks are most urgent

3 Conclusions Phase 1- Climate Risk Assessment

Phase 1 of the CRA for Louth successfully identified and prioritised the region's most pressing climate hazards, with a particular focus on:

- Flooding,
- Heavy rainfall
- Windstorms

These hazards were selected based on a combination of historical impact data, projected future severity, and vulnerability assessments. The methodology incorporated not only statistical datasets which were sourced specific to the region (e.g., polygon alignment for the Copernicus Atlas and regional datasets from CSO), but also featured stakeholder input, ensuring that the findings were relevant and grounded in the specific context of Louth.

The assessment revealed that flooding is the most prevalent and financially burdensome hazard, with projections indicating a 25% increase in very wet days and heightened exposure in urban and coastal areas. Heavy rainfall is found to exacerbate flood risk and place additional strain on infrastructure, with increasing precipitation intensity expected in the coming decades. Windstorms were also identified as a significant threat, posing risks to public safety, critical infrastructure, and heritage assets. Recent events, such as Storm Éowyn, have demonstrated the disruptive potential of such hazards. Vulnerable groups, including low-income households, rural communities, and coastal businesses, are disproportionately affected by these climate risks.

Existing measures to address these hazards include the implementation of flood relief schemes, emergency response planning, and nature-based solutions. However, notable gaps remain, particularly in windstorm preparedness and the integration of socio-economic vulnerability data.

Despite these successes, several challenges persist. These include the limited availability of downscaled data for hazards such as drought and fire, public resistance to certain adaptation measures, and funding constraints that hinder the implementation of large-scale infrastructure projects. Additionally, there is a need for improved integration of socio-economic indicators to better capture community-level vulnerability.

In conclusion, Phase 1 has established a robust foundation for climate resilience planning in Louth. The insights and methodologies developed during this phase will inform subsequent stages of the project, including detailed risk profiling, the formulation of adaptation strategies, and the planning of implementation pathways.

4 Progress evaluation and contribution to future phases

Phase 1 of the CLIMAAX project has laid the groundwork for the next stages by delivering a regional focused CRA for Louth. The outputs such as the risk assessment, prioritised hazards, and initial vulnerability analysis will directly guide the activities planned for Phases 2 and 3. These upcoming phases will involve refining the risk assessments using more detailed local data and engaging with stakeholders from the communities to ensure the community is accurately represented. Key performance indicators achieved include the completion of a multi-hazard screening, stakeholder engagement sessions, and the application of CLIMAAX workflows to the selected hazards. Milestones reached include the submission of the Phase 1 report, confirmation of priority risks, and integration with planning frameworks such as the Louth Climate Action Plan.

Table 4-1 Overview key performance indicators

Key performance indicators	***Progress***
Stakeholder engagement and workshops	Conducted with LCC to validate risks and gather feedback.
Application of CLIMAAX workflows	Successfully applied to selected hazards using EU-wide datasets.
Integration with local and national climate strategies	Aligned with Louth Climate Action Plan and National Adaptation Framework.
Identification of vulnerable groups and sectors	Completed through socio-economic and spatial analysis.
Preliminary risk severity, urgency, and capacity assessment	Delivered for each selected hazard.

Table 4-2 Overview milestones

Milestones	***Progress***
Delivery of Phase 1 Climate Risk Assessment Report	Completed and submitted.
Selection of priority hazards for Phase 2	Finalised: flooding, heavy rainfall, and windstorms.
Alignment with planning frameworks (e.g., LDP)	Incorporated into CRA methodology.
Identification of data gaps and limitations	Documented for integration in Phase 2.
Preparation of Phase 2 work plan	Structured timeline and activities outlined.

5 Supporting documentation

List of outputs produced during this stage:

1. Main Report (PDF)

   Flood Workflow Outputs:
2. 1_1_LOUTH_FLOOD_coastal_flooding_jupyter_notebooks_hazard_assessment_flood_coastal_floodmaps.ipynb
3. 1_2_LOUTH_FLOOD_coastal_flooding_jupyter_notebooks_hazard_assessment_flood_coastal_waterlevel.ipynb
4. 1_3_LOUTH_FLOOD_coastal_flooding_jupyter_notebooks_risk_assessment_flood_coastal.ipynb
5. 1_4_LOUTH_FLOOD_coastal_flooding_plots_county_louth_floodmap_county_louth_compare_2050vs2018.png
6. 1_5_LOUTH_FLOOD_coastal_flooding_plots_county_louth_floodmap_county_louth_compare_return_periods.png
7. 1_6_LOUTH_FLOOD_coastal_flooding_plots_county_louth_floodmap_county_louth_overview.png
8. 1_7_LOUTH_FLOOD_coastal_flooding_plots_county_louth_result_map_county_louth_2050_rp0010.png
9. 1_8_LOUTH_FLOOD_coastal_flooding_plots_county_louth_result_map_county_louth_2050_rp0100.png
10. 1_9_LOUTH_FLOOD_coastal_flooding_plots_county_louth_result_map_county_louth_2050_rp0250.png
11. 1_10_LOUTH_FLOOD_coastal_flooding_plots_county_louth_result_map_county_louth_damages_overview.png
12. 1_11_LOUTH_FLOOD_coastal_flooding_plots_county_louth_result_map_county_louth_damages_overview_improved.png
13. 1_12_LOUTH_FLOOD_flood_population_damage_images_county_louth_building_damage_meandepth_10rp.png
14. 1_13_LOUTH_FLOOD_flood_population_damage_images_county_louth_building_damage_meandepth_500rp.png
15. 1_14_LOUTH_FLOOD_flood_population_damage_images_county_louth_building_floodepth_10rp.png
16. 1_15_LOUTH_FLOOD_flood_population_damage_images_county_louth_building_floodepth_500rp.png
17. 1_16_LOUTH_FLOOD_flood_population_damage_images_county_louth_buildingoutline_floodmap_10rp.png
18. 1_17_LOUTH_FLOOD_flood_population_damage_images_county_louth_buildingoutline_floodmap_500rp.png
19. 1_18_LOUTH_FLOOD_flood_population_damage_images_county_louth_criticalinfrastructure_10rp.png
20. 1_19_LOUTH_FLOOD_flood_population_damage_images_county_louth_criticalinfrastructure_500rp.png

21. 1_20_LOUTH_FLOOD_flood_population_damage_images_county_louth_damage_graph.png
22. 1_21_LOUTH_FLOOD_flood_population_damage_images_county_louth_floodmap_10rp.png
23. 1_22_LOUTH_FLOOD_flood_population_damage_images_county_louth_floodmap_500rp.png
24. 1_23_LOUTH_FLOOD_flood_population_damage_images_county_louth_osmbuilding_classified_simple.png
25. 1_24_LOUTH_FLOOD_flood_population_damage_images_county_louth_osmbuilding_preclassification.png
26. 1_25_LOUTH_FLOOD_flood_population_damage_images_county_louth_osmbuilding_unclassified_simple.png
27. 1_26_LOUTH_FLOOD_flood_population_damage_images_county_louth_popdisplaced_graph.png
28. 1_27_LOUTH_FLOOD_flood_population_damage_images_county_louth_popdisplaced_map_10rp.png
29. 1_28_LOUTH_FLOOD_flood_population_damage_images_county_louth_popdisplaced_map_500rp.png
30. 1_29_LOUTH_FLOOD_flood_population_damage_images_county_louth_popexposed_graph.png
31. 1_30_LOUTH_FLOOD_flood_population_damage_images_county_louth_popexposed_map_10rp.png
32. 1_31_LOUTH_FLOOD_flood_population_damage_images_county_louth_popexposed_map_500rp.png
33. 1_32_LOUTH_FLOOD_flood_population_damage_images_county_louth_populationmap_2025.png
34. 1_33_LOUTH_FLOOD_flood_population_damage_images_mylocation_building_damage_meandepth_10rp.png
35. 1_34_LOUTH_FLOOD_flood_population_damage_images_mylocation_building_damage_meandepth_500rp.png
36. 1_35_LOUTH_FLOOD_flood_population_damage_images_mylocation_building_flooddepth_10rp.png
37. 1_36_LOUTH_FLOOD_flood_population_damage_images_mylocation_building_flooddepth_500rp.png
38. 1_37_LOUTH_FLOOD_flood_population_damage_images_mylocation_buildingoutline_floodmap_10rp.png
39. 1_38_LOUTH_FLOOD_flood_population_damage_images_mylocation_buildingoutline_floodmap_500rp.png
40. 1_39_LOUTH_FLOOD_flood_population_damage_images_mylocation_criticalinfrastructure_10rp.png
41. 1_40_LOUTH_FLOOD_flood_population_damage_images_mylocation_criticalinfrastructure_500rp.png
42. 1_41_LOUTH_FLOOD_flood_population_damage_images_mylocation_damage_graph.png
43. 1_42_LOUTH_FLOOD_flood_population_damage_images_mylocation_floodmap_10rp.png

44. 1_43_LOUTH_FLOOD_flood_population_damage_images_mylocation_floodmap_500rp.png
45. 1_44_LOUTH_FLOOD_flood_population_damage_images_mylocation_osmbuilding_classified_simple.png
46. 1_45_LOUTH_FLOOD_flood_population_damage_images_mylocation_osmbuilding_preclassification.png
47. 1_46_LOUTH_FLOOD_flood_population_damage_images_mylocation_osmbuilding_unclassified_simple.png
48. 1_47_LOUTH_FLOOD_flood_population_damage_images_mylocation_popdisplaced_graph.png
49. 1_48_LOUTH_FLOOD_flood_population_damage_images_mylocation_popdisplaced_map_10rp.png
50. 1_49_LOUTH_FLOOD_flood_population_damage_images_mylocation_popdisplaced_map_500rp.png
51. 1_50_LOUTH_FLOOD_flood_population_damage_images_mylocation_popexposed_graph.png
52. 1_51_LOUTH_FLOOD_flood_population_damage_images_mylocation_popexposed_map_10rp.png
53. 1_52_LOUTH_FLOOD_flood_population_damage_images_mylocation_popexposed_map_500rp.png
54. 1_53_LOUTH_FLOOD_flood_population_damage_images_mylocation_populationmap_2025.png
55. 1_54_LOUTH_FLOOD_flood_population_damage_jupyter_notebooks_hazard_assessment_flood_building_population.ipynb
56. 1_55_LOUTH_FLOOD_flood_population_damage_jupyter_notebooks_risk_assessment_flood_building_population.ipynb
57. 1_56_LOUTH_FLOOD_input_files_jrc_damage_curves.csv
58. 1_57_LOUTH_FLOOD_input_files_luisa_damage_info_curves_template.xlsx
59. 1_58_LOUTH_FLOOD_river_flooding_jupyter_notebooks_hazard_assessment_flood_river.ipynb
60. 1_59_LOUTH_FLOOD_river_flooding_jupyter_notebooks_risk_assessment_flood_river.ipynb
61. 1_60_LOUTH_FLOOD_river_flooding_plots_county_louth_floodmap_overview_jrc_presentscenario_county_louth.png
62. 1_61_LOUTH_FLOOD_river_flooding_plots_county_louth_floodmaps_aqueductfloods_county_louth_rcp4_5.png
63. 1_62_LOUTH_FLOOD_river_flooding_plots_county_louth_floodmaps_aqueductfloods_county_louth_rcp8_5.png
64. 1_63_LOUTH_FLOOD_river_flooding_plots_county_louth_floodmaps_singlerow_county_louth_rcp4_5.png
65. 1_64_LOUTH_FLOOD_river_flooding_plots_county_louth_floodmaps_singlerow_county_louth_rcp8_5.png
66. 1_65_LOUTH_FLOOD_river_flooding_plots_county_louth_result_map_county_louth_damages_overview.png
67. 1_66_LOUTH_FLOOD_river_flooding_plots_county_louth_result_map_county_louth_rp100.png

Heavy Rainfall Workflow Outputs:

68. 2_1_LOUTH_HEAVY_RAINFALL_jupyter_notebooks_extreme_precipitation_hazard_assessment.ipynb
69. 2_2_LOUTH_HEAVY_RAINFALL_jupyter_notebooks_extreme_precipitation_risk_assessment.ipynb
70. 2_3_LOUTH_HEAVY_RAINFALL_plots_county_louth_expected_prec_3h_2041_2070_county_louth.png
71. 2_4_LOUTH_HEAVY_RAINFALL_plots_county_louth_mean_prec_ichec_ec_earth_knmi_racmo22e_rcp85_24h_1976_2005_2041_2070.png
72. 2_5_LOUTH_HEAVY_RAINFALL_plots_county_louth_pr_annualmax_3h_2041_2070_county_louth.png
73. 2_6_LOUTH_HEAVY_RAINFALL_plots_county_louth_prec_shift_threshold_2041_2070.png
74. 2_7_LOUTH_HEAVY_RAINFALL_plots_county_louth_rp_shift_threshold_2041_2070.png

Wind Workflow Outputs:

75. 3_1_LOUTH_WIND_input_files_luisa_damage_info_curves.xlsx
76. 3_2_LOUTH_WIND_jupyter_notebooks_hazard_assessment_storms.ipynb
77. 3_3_LOUTH_WIND_jupyter_notebooks_risk_assessment_storms.ipynb
78. 3_4_LOUTH_WIND_plots_county_louth_lusia_landcover.png
79. 3_5_LOUTH_WIND_plots_county_louth_potential_damage.png
80. 3_6_LOUTH_WIND_plots_county_louth_relative_structural_damage_map.png
81. 3_7_LOUTH_WIND_plots_county_louth_storm_ophelia_footprint.png
82. 3_8_LOUTH_WIND_plots_county_louth_strom_ophelia_footprint.png
83. 3_9_LOUTH_WIND_plots_county_louth_structural_damage_map.png
84. 3_10_LOUTH_WIND_plots_county_louth_vulnerability_curves.png
85. 3_11_LOUTH_WIND_plots_county_louth_vulnerablity_curves_for_wind_damages.png
86. 3_12_LOUTH_WIND_plots_county_louth_windstorm_and_landuse_2018.png
87. 3_13_LOUTH_WIND_plots_county_louth_windstorm_matched_to_landuse_data.png
88. 3_14_LOUTH_WIND_plots_county_louth_windstrom_footprint_in_france.png

Stakeholder Workshop:

89. 4_1_LOUTH_STAKEHOLDER_WORKSHOP_climaax_risk_scoring_21_07_25.pdf

Poster

90. 5_1_LOUTH_POSTER_2025_06_05_louth___a0_poster_vfinal.pdf

6 References

1 Census Data – Central Statistics Office, 2022.

2 Population Distribution and Movements – Central Statistics Office, 2016.

3 Storm Names – Met Éireann, 2024.

4 Warmest June on record, dry periods and intense thunderstorm activity – Met Éireann, 2023.

5 Storm Names 2018-19 Announced – Met Éireann, 2018.

6 Exceptional Weather Events – Met Éireann, 2010.

7 National Climate Change Risk Assessment: Main Report. Environmental Protection Agency, June 2025.

8 Louth County Council Climate Action Plan 2024-2029 – Louth County Council.

9 Climate Change Adaptation Strategy – Louth County Council, 2019.

10 Louth Local Authority Climate Action Plan 2024-2029 – Louth County Council, 2023.

11 Climate Action and Low Carbon Development (Amendment) Bill – Department of Climate, Energy, and the Environment, 2021.

12 GAA.

13 Community Climate Action Programme – Louth County Council, 2024.

14 Louth County Council and Energia 2023 partnership – SEAI, 2023.

15 25 Cross-Border Projects awarded funding under Shared Island Local Authority Development Funding Scheme – Department of the Taoiseach, 2022.

16 PEACEPLUS – European Union, Government of Ireland, UK Government, 2021.

17 Climate Change Adaptation Strategy – Louth County Council, 2019.

18 LEP – Louth County Council, 2025.

19 Copernicus Interactive Climate Atlas.

20 Flood and Erosion Mapping – Office of Public Works, 2016 & 2021.

21 Major Flood Relief Schemes, Office of Public Works, 2021 & 2024.

22 Capital Works Management Framework – Office of Government Procurement.

23 Copernicus Interactive Climate Atlas – Rate of change in Very Heavy precipitation days: Near Term, Medium Term, Long Term – RCP 8.5 scenario

24 Climate Change Adaptation Strategy – Louth County Council, 2019 & 2025.

25 Public Consultation on the draft Water Quality and Water Services Infrastructure Sectoral Adaptation Plan – Department of Housing, Local Government and Heritage, 2025.

26 Current Climate and Projected Climate Changes in Ireland (summary of Chapter 3) – Department of Transport, 2025.

27 Storm Centre: 2024/25 Storm Season – Met Éireann, 2024.

28 Name a Storm – Met Éireann, 2025.

29 Storm Éowyn has been named – Met Éireann, 2025.

30 Climate Statement for Autumn and November 2023 – Met Éireann, 2023.

31 Ophelia Report – Met Éireann, 2018.

32 Storm Emma – Met Éireann, 2018.

33 Current Climate and Projected Climate Changes in Ireland (summary of Chapter 3) – Department of Transport, 2025.

34 Copernicus Interactive Climate Atlas – Mean of daily accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

35 Copernicus Interactive Climate Atlas – Rate of change in Very Heavy precipitation days: Near Term, Medium Term, Long Term – RCP 8.5 scenario.

36 Regional Population Projections 2023-2042 – Central Statistics Office, 2025.

37 Population Distribution and Movements – Central Statistics Office, 2016.

38 Copernicus Interactive Climate Atlas – Median of Maximum of 1-day accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

39 Copernicus Interactive Climate Atlas – Rate of change of Maximum of 1-day accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

40 Copernicus Interactive Climate Atlas – Median of daily mean wind speed (m/s): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

41 Current Climate and Projected Climate Changes in Ireland (summary of Chapter 3) – Department of Transport, 2025.

42 Copernicus Interactive Climate Atlas – Median of maximum of daily maximum temperature (°C): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

43 Copernicus Interactive Climate Atlas – Mean of daily mean temperature (°C): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

44 Copernicus Interactive Climate Atlas – Median of maximum consecutive dry days: Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

45 Copernicus Interactive Climate Atlas – Minimum of Standardised Precipitation –

46 Copernicus Interactive Climate Atlas – Median of Frost days (minimum temperature below 0°C): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

47 The Extreme Cold Spell of November – December 2010

48 Copernicus Interactive Climate Atlas – Median of Mean surface thermal radiation (W/m^2): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

49 Number of wildfires forecast to rise by 50% by 2100 - World Meteorological Organization, 2022

50 Louth County Council Statutory Audit Report – Department of Housing, Local Government and Heritage, 2025.

51 Consultation of the proposed maintenance works on the Glyde and Dee Arterial Drainage Scheme 2023 – Office of Public Works, 2022 & 2025.

52 Coastal Change Management Strategy Report – Office of Public Works, 2023.

53 Assessment of Flood Risk Management – Office of Public Works, 2025.

54 Budgeting for Major Flood Projects – Office of Public Works, 2021 & 2022.

55 Private Forest Wind Damage Assessment Spatial Database – Department of Agriculture, Food and the Marine, 2025.

56 Weather Warnings and Advisories associated with Storm Éowyn – Office of Public Works, 2025.

57 Storm Centre: 2024/25 Storm Season – Met Éireann, 2024.

58 Minister Healy-Rae confirms that over 26,000 hectares of forests have suffered wind damage – Department of Agriculture, Food and the Marine, 2025.

59 Flood Mapping and Data Resources – Office of Public Works, 2021. 9 58

60 Proposed Variation No. 3 of the Louth County Development Plan 2021-2027 – Louth County Council, 2025.

61 Catchment wide Appropriate Assessments of Arterial Drainage Scheme Maintenance – Office of Public Works, 2020 & 2024.

62 River Basin Management Plan 2022-2027 – Department of Housing, Local Government and Heritage, 2024.

63 Co. Louth Record of Protected Structures – Louth County Council, 2009 & 2013.

64 Copernicus Interactive Climate Atlas.

65 Coupled Model Intercomparison Project.

66 Coordinated Regional Climate Downscaling Experiment – World Climate Research Programme.

67 Copernicus Interactive Climate Atlas – Mean of daily accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

68 NASA Sea Level Projection Tool (2023) NASA. Available at: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool.

69 Output of the windstorm CLIMAAX workflow

70 Output of the windstorm CLIMAAX workflow

71 Output of the windstorm CLIMAAX workflow

72 OPW FloodInfo.ie, Available at: Home - Floodinfo.ie

73 Projections from flooding CLIMAAX workflow.

74 Major new EPA report assesses Ireland’s vulnerability to climate change impacts – Environmental Protection Agency, 2025.

75 Louth Climate Action Plan – Louth County Council.

18 Output of the windstorm CLIMAAX workflow.

77 Transport Sectoral Adaptation Plan (T-SAP II): Implementation and Governance (summary of Chapter 7) – Department of Transport, 2025.

78 Copernicus Interactive Climate Atlas – Mean of daily accumulated precipitation (mm/day): Near Term, Medium Term, Long Term projections – RCP 8.5 scenario.

79 Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment. Published in *Official Journal of the European Communities* (OJ) L 197, 21 July 2001, p. 30–37

80 Coastal Flooding – Climate Ireland, 2023.

81 Comparison of average annual maximum 24-hour precipitation between 1976–2005 and 2041–2070 under RCP 8.5 for County Louth.

82 National Climate Change Risk Assessment: Main Report. Environmental Protection Agency, June 2025.