TII Climate Adaptation Strategy

Appendix

A.1 Policy and guidance
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A.3 Summary of the CIViC study

December 2022

A.1 Policy and guidance

The following sections summarise some of the key policies associated with climate change and adaptation. Figure 8 and Figure 9, presented in Section 2 of the main Climate Adaptation Strategy, show a comprehensive list of relevant international, national, and Transport Infrastructure Ireland (TII) policies over the past fifteen years.

A.1.1 National policies on climate change

A.1.1.1 Climate Action and Low Carbon Development Acts

The Climate Action and Low Carbon Development Act was passed in 2015, and later amended with the Climate Action and Low Carbon Development (Amendment) Act 2021. [35] [37] The Amendment strengthened the 2015 Act's remit and enacted national climate objectives into law. This provides the legally binding framework, with goals and commitments, to ensure that climate targets and obligations are met at European Union (EU) and national level.

The Acts legally commit Ireland to move to a climate resilient and climate neutral economy by 2050, in alignment with the European Green Deal, [10] and includes the following elements:

- Establishment of a net zero emissions target for the year 2050, and
- Introduction of a requirement to annually revise the Climate Action Plan (see Section A.1.1.2) and prepare a National Long-Term Climate Action Strategy at least every decade.

A.1.1.2 Climate Action Plan 2021

Ireland's Climate Action Plan 2021 (CAP21) [7] provides the implementation plan to deliver on the commitments laid out in the Climate Action and Low Carbon Development (Amendment) Act 2021.

CAP21 sets out numerous climate adaptation actions. The key actions that relate to TII's Climate Adaptation Strategy are presented in Table 16, overleaf.

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Table 16 Key actions from CAP21 that are relevant to TII's Climate Adaptation Strategy [8]

Action Number	Action
Transport Adaptation	
296	Identify opportunities for collaborative research in the area of climate adaptation for the transport sector
297	Improve climate resilience and adapt to climate change on the Light rail and National Road Network
298	Collaborate and share best practice on adaptation in the transport sector with relevant stakeholders
299	Define a set of metrics to accurately quantify the cost of extreme weather events to the State in terms of both revenues lost and the cost of repairs
300	Commission research on adaptation in the Transport sector to fill existing knowledge gaps
302	Review further linkages between accessibility and climate action

Action Number	Action
National Adaptation	
453	Deliver Climate Ireland as the national platform for data, information and decision supports on climate impacts and adaptation
456	Commence pilot project to identify a suitable approach for the use of climate change adaptation indicators at national level
457	Further develop Ireland's national climate change risk assessment capacity to identify the priority physical risks of climate change to Ireland
466	Maintain and further develop national landslide mapping related to climate change and land use
467	Develop and publish coastal vulnerability mapping and coastal erosion databases for the east and south coasts of Ireland
474	Develop interim guidance on best practice for Solutions to the Management of Rainwater and Surface Water Runoff in Urban Areas
482	Conduct a major survey of health infrastructure resilience to severe weather events: wind events, heat waves, flooding, and extreme cold snaps
487	Undertake climate change adaptation research in the electricity and gas networks sector
490	Harmonise the collection of baseline data on the costs to business and the public arising from past extreme weather events in the electricity and gas networks sector
491	Identify areas vulnerable to impacts of climate change in the electricity and gas networks sector
492	Identify measures required to adapt to climate change impacts on vulnerable infrastructure in the electricity and gas networks sector

A.1.1.3 Project Ireland 2040

Project Ireland 2040 is the Government's long-term strategy to make Ireland a better country for all and to build a more resilient and sustainable future. [50] Project Ireland 2040 is composed of two parts:

1. *The Project Ireland 2040 National Planning Framework* [38]
2. *The National Development Plan 2021-2030* [75]

The National Planning Framework is a high-level framework supported by a series of National Policy Objectives and National Strategic Outcomes which promote coordinated spatial planning, sustainable use of resources, and protection of the environment. The National Development Plan translates the policy objectives set out in the National Planning Framework, providing a significant programme for investment.

A notable part of Project Ireland 2040 is the development of an environmentally sustainable transport system in Ireland. Additionally, the NPF directly calls for the mainstreaming of climate change adaptation measures into the spatial planning and infrastructure development process, as covered in the following National Policy Objectives:

- **"National Policy Objective 41b:** in line with the collective aims of national policy regarding climate adaptation, to address the effects of sea level changes and coastal flooding and erosion and to support the implementation of adaptation responses in vulnerable areas."
- **"National Policy Objective 54:** reduce our carbon footprint by integrating climate action into the planning system in support of national targets for climate policy mitigation and adaptation objectives, as well as targets for GHG emissions reductions."
- **"National Policy Objective 57:** ensuring flood risk management informs place-making by avoiding inappropriate development in areas at risk of flooding in accordance with The Planning System and Flood Risk Management Guidelines for Planning Authorities."

A.1.2 Department of Transport policies on climate adaptation

A.1.2.1 *National Investment Framework for Transport in Ireland*

The *National Investment Framework for Transport in Ireland* (NIFTI) was published by the Department of Transport in December 2021. [44] It outlines the Department's approach to Project Ireland 2040 and is a strategic framework that demonstrates the Department's priority future investment in land transport across the country.

NIFTI notes that expenditure is required during winter months to maintain and repair transport infrastructure caused by extreme weather events. This cost is anticipated to rise under a warming climate given the projected increase in frequency and magnitude of extreme weather events, with even localised issues having widespread impacts. The framework therefore makes the case that the cost of not implementing adaptation measures as part of an effective strategy is expected to be far greater than taking early action. These adaptation measures are expected to include considerable construction to amend or alter the infrastructure and surrounding environment. NIFTI supports the 21 adaptation actions documented in the *Transport Climate Change Sectoral Adaptation Plan* (see below for further detail), spanning knowledge development, stakeholder engagement, and upskilling, as well as the implementation of adaptation measures.

NIFTI also identifies the budget reductions seen since the financial crisis as a challenge for asset protection and renewal, and that this has led to the degradation of some assets. Considering both challenges, the framework emphasises that the focus over the coming years will be on improving the resilience of the most strategically important parts and lifeline links of the transport network.

NIFTI commits the Department of Transport to continue to analyse, develop policy, and build the evidence base in nine priority areas, one of which is "identifying priority assets and infrastructure for protection and renewal investment in the context of climate adaptation and evolving infrastructure uses." This Climate Adaptation Strategy should create a process for TII to support this priority area by highlighting key infrastructure assets that are vulnerable to the impacts of ongoing climate change and increasingly extreme weather events.

A.1.2.2 National Adaptation Framework

The first non-statutory National Adaptation Framework (NAF) was created in 2012. The NAF aims to reduce national vulnerability to the negative impacts of climate change. It sets out the national Government and societal approach to climate adaptation, and how the Government aims to improve the enabling environment to drive wider adaptation. [41] This was later updated in 2018, whereby it mandated that Government Departments must produce their first sectoral adaptation plans by 2019, with updates expected on a 5-year cycle. This includes the transport sector, with these plans produced by the Department of Transport.

A.1.2.3 The sectoral adaptation planning process

The *Sectoral Planning Guidelines for Climate Change Adaptation* were published by the Department of Communications, Climate Action and Environment in 2018 to support the different Government Departments to produce their own sectoral adaptation plans and enable a consistent approach. [13] While aimed at Government Departments, much of the guidance on how to plan for adaptation is applicable to different organisations.

A.1.2.4 Transport Climate Change Sectoral Adaptation Plan

An initial high-level transport sectoral adaptation plan was first published in 2017, titled *Developing Resilience to Climate Change in the Irish Transport Sector.* [42] Following this, a final version of the *Transport Climate Change Sectoral Adaptation Plan* was approved by Government in October 2019. [43]

The implementation objectives set out in the plan are as follows:

1. Improve understanding of the impacts of climate change on transport infrastructure, including cross-sectoral cascading impacts, and close knowledge gaps.
2. Assist transport stakeholders in identifying and prioritising climate risks to existing and planned infrastructural assets and enable them to implement adaptation measures accordingly.
3. Ensure that resilience to weather extremes and longer-term adaptation needs are considered in investment programmes for planned future transport infrastructure.

The Transport Climate Change Sectoral Adaptation Plan is a high-level plan that seeks to identify vulnerabilities at a national level across the transport system. The plan, which aims to set policy on adaptation strategies for transport, will contribute to building adaptive capacity within the sector's administrative structures and assist organisations to better understand the implications of climate change for Ireland and how it may impact on transport infrastructure and services at a national, regional, and local level.

As well as identifying the key sectoral risks and priorities, the *Transport Climate Change Sectoral Adaptation Plan* recommends 21 adaptation actions, as presented in Table 17, overleaf.

These are designed to increase knowledge and understanding of the likely impacts of climate change on the sector, support stakeholders in identifying and prioritising risks, and assist in the implementation of adaptation measures to improve resilience across the sector.

Table 17 Climate adaptation actions in the *Transport Climate Change Sectoral Adaptation Plan*

Action Number	Action	Type
Proposed Adaptation Actions under Implementation Objective No. 1		
1	Extend Adaptation Planning Team to include representation from transport system users i.e. freight sector; tourism sector; active travel etc. in line with NSOs in *Project Ireland 2040* to encourage stakeholder engagement with climate adaptation needs and resilience building.	Soft
2	Co-ordinate with the Climate Action Regional Offices (CAROs) to ensure that national and regional policies align and to ensure that infrastructure managed by [local authorities] is considered within the Sectoral Adaptation Team.	Soft
3	Establish cross-sectoral Critical Infrastructure Working Group to complement the work of the Sectoral Adaptation Team.	Soft
4	Disseminate Progress Report on the Implementation of Transport Adaptation Measures to representatives or advocates for accessibility, the health sector, cultural and natural heritage (biodiversity) sector as appropriate.	Soft
5	Commission a study to develop appropriate monitoring indicators to evaluate the efficacy of adaptation measures.	Soft
6	Commence a review of the effectiveness of current quantitative data collection procedures for the impacts of extreme weather events and longer-term climate change with a view to developing a cross-sectoral reporting mechanism.	Soft
7	Continue collaboration with the EPA, Climate Ireland and Met Éireann to ensure sectoral understanding of up to date climate information, including a watching brief of longer term climate modelling outputs to 2100.	Soft
8	Commission a study to identify common criteria to define critical assets within the transport; communications and energy sectors.	Soft
9	Commission concise comparative study between output of the EPA CIViC project and other resources such as CFRAMS and IPCSS maps; and the mapping exercise developed for this plan.	Soft
10	Perform a midterm review of the statutory critical infrastructure adaptation plans with potential input from relevant actors such as local authorities and CCMA.	Soft

Table 17 Climate adaptation actions in the *Transport Climate Change Sectoral Adaptation Plan*

Action Number	Action	Type
Proposed Adaptation Actions under Implementation Objective No. 2		
11	Disseminate geospatial distribution impact maps to transport stakeholders.	Soft
12	Develop online repository host transport adaptation resources on the departmental website www.dttas.gov.ie to encourage stakeholders to review network vulnerabilities and conduct risk assessments.	Soft
13	Support transport stakeholders to avail of adaptation funding opportunities by providing information on potential EU funding sources.	Soft
14	Following from Action 7, develop guidance for sectoral stakeholders to inform identification of critical transport assets, taking account of cross-sectoral interdependencies.	Soft
15	Under the *NAF*, consider the need to put in place arrangements at a national level to define critical infrastructure from a climate resilience perspective for the standardisation and prioritisation of resources.	Soft
Proposed Adaptation Actions under Implementation Objective No. 3		
16	Continue engagement with disaster risk management for transport through active participation with the Office for Emergency Planning and the National Directorate for Fire and Emergency Management to ensure operational continuity and service delivery during acute weather events.	Soft
17	Strengthen sectoral adaptation responses by ensuring that climate resilience is considered in appraisal guidance, including in the update to the *Common Appraisal Framework*, for all future transport infrastructure projects over appropriate timescales.	Soft
18	Consider adaptation needs in contracts; performance delivery agreements; and service level agreements between [Department of Transport, Tourism and Sport (DTTAS)], transport infrastructure agencies, public transport service agencies and constituent operators as relevant.	Soft
19	Consider the inclusion of adaptation needs as a criterion in projects relating to future transport energy (recharging and refuelling) infrastructure networks, under any relevant further calls of the *Climate Action Fund.*	Soft
20	Ensure that adaptation needs are considered in EU-funded projects relating to future transport and energy infrastructure networks where DTTAS has a role in project validation.	Soft
21	Support implementation of remote working initiatives, including expansion of effective broadband connectivity, to facilitate remote working when travel is inhibited during extreme weather events.	Soft

A.1.3 External drivers of climate adaptation

A.1.3.1 European Commission: Climate-proofing infrastructure

In 2021, the European Commission published *Technical guidance on the climate proofing of infrastructure in the period 2021-2027*. [4] The guidance considers climate-proofing to mean both resilience to climate change while also reducing carbon emissions, as shown in Figure 21.

As shown in Figure 22, the climate adaptation process follows a two-phase assessment approach:

1. **Screening:** The sensitivity, exposure, and vulnerability of projects to the impacts of climate change should be considered. Any significant climate risks that require further analysis should be taken forward to Phase 2.
2. **Detailed analysis:** Climate risk assessment, based on the likelihood and impact of climate change-related hazards, should be undertaken. The detailed climate vulnerability and risk assessment process is the basis for identifying, appraising, and implementing climate change adaptation measures to address the outstanding climate risks. There may be a need to implement regular monitoring or evaluation, for example to assess the progress or impact of the adaptation measures, or to consider any new developments in climate science that may affect original assumptions about the future climate.

While this European Commission's guidance has been written from the perspective of new infrastructure projects, rather than at an organisational level, the same approach can be adapted. For example, where the sensitivity analysis suggests four themes to focus on (on-site assets, inputs, outputs, and transport links), these could be adapted to TII's different assets (e.g. road surfaces, embankments, light rail tracks, staff).

The guidance makes reference to International Organization for Standardization (ISO) 14091:2021, which is the international standard for climate change adaptation guidelines on vulnerability, impacts, and risk assessment. [48] These guidelines use the concept of 'impact chains', which can be a useful tool to understand, visualise, systemise, and prioritise the factors that drive systematic risk.

Impact chains are useful throughout the adaptation planning process, as follows:

- **Risk assessment:** a useful tool to understand, visualise, systemise, and prioritise the factors that drive systematic risk, and to determine which hazards cause direct or indirect climate impacts
- **Communicating the risk:** impact chains clearly show the cause and effect of different climate hazards, and
- **Identifying adaptation actions:** a good understanding of all the impacts resulting from climate hazards and trends makes it easier to define appropriate climate adaptation measures.

The European Commission's guidance also notes that any adaptation plans should align with national strategies, as well as other relevant strategic and planning documents.

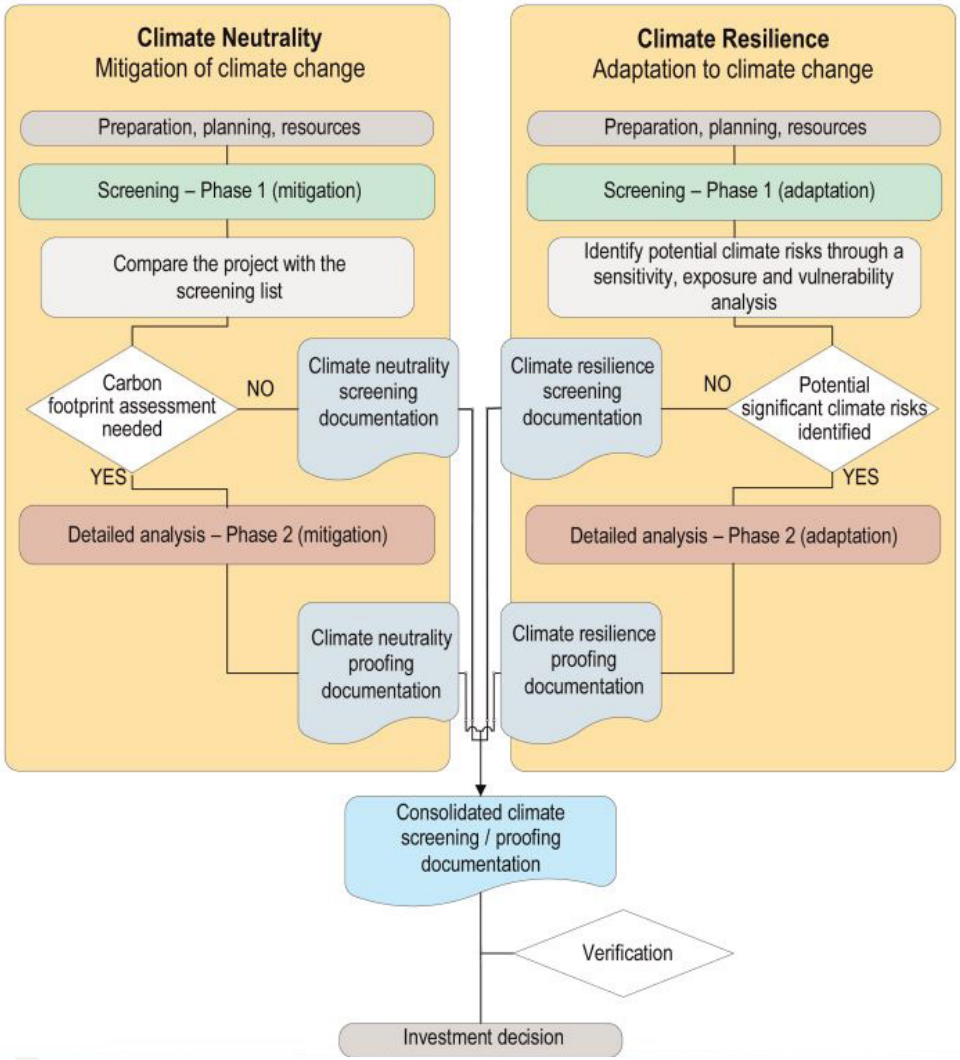

Figure 21 Workflow for developing climate-proof infrastructure projects [4]

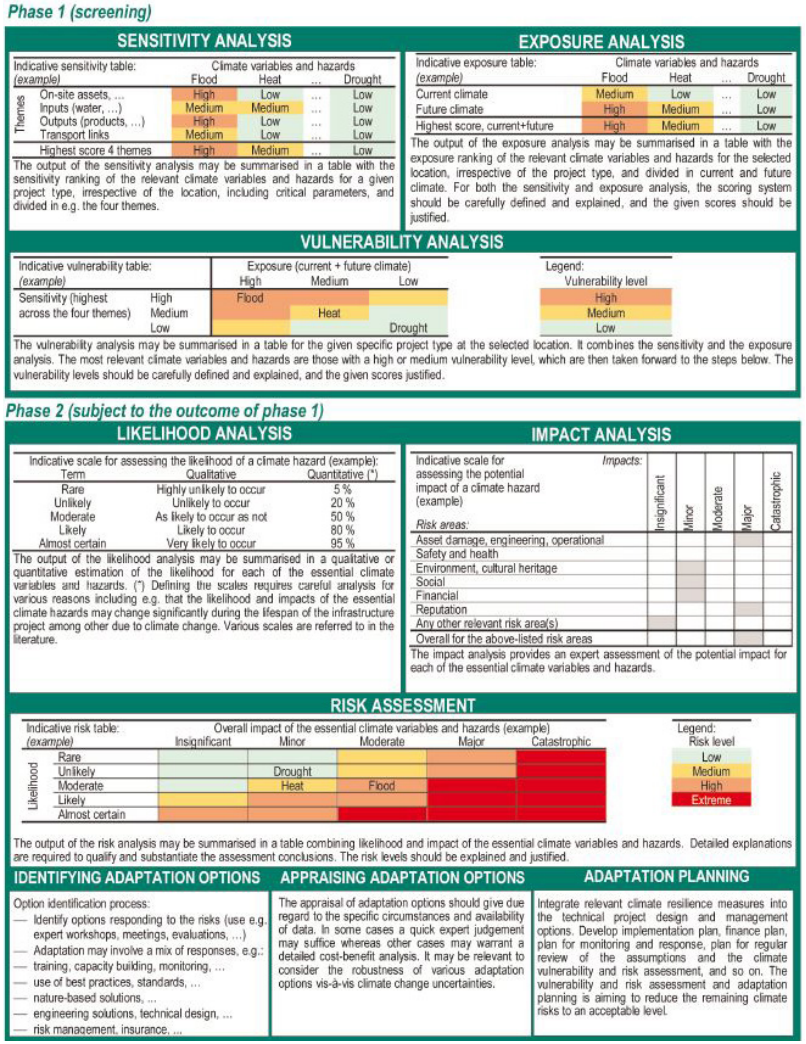

Figure 22 Overview of the EU guidance approach to climate adaptation for infrastructure projects [4]

A.2 Case studies of past extreme weather events

Case Study 1: Flooding of a Luas substation

Event summary and impact

Following severe weather in 2011, a Luas substation was flooded by a nearby overspilling river. The water exceeded the capacity of the water pumps and it took approximately 1 week for the site to be fully drained. This made undertaking ordinary maintenance on the Luas Green Line difficult for the following 18 months until the substation was restored.

This event highlighted some key issues:

- The substation flooded despite existing mitigation measures. This was reportedly because the flood event was more severe than previously experienced (a '100-year flood'). Water was also channelled along the tracks and into the vicinity of the substation.
- Underground substations are particularly vulnerable to flooding.
- Flood events at substations have the potential to cause cascading impacts and disrupt the entire Luas line.
- There was a lack of suitable pumps to discharge such a large amount of water.

Lessons learned

In response, measures were put in place to prevent a similar event occurring again. These included the following:

- Standards for substations were changed in order to ensure that substations are designed for other such 100-year events and that they can survive a 300-year flood event.
- At the substation, flood protection walls were installed, and pumping capabilities have been improved.
- The event highlighted the importance of engaging across organisations. The pump capacity issue was quickly addressed when TII engaged with the Office of Public Works.

Since this event occurred, no similar flooding of a Luas substation has taken place, despite flood events of a similar magnitude having occurred in Dublin.

Figure 23 Flooded Luas substation

Case Study 2: TII pavement design and material performance requirements for climate adaptation

TII manages National Road pavements using its Pavement Asset Management System (PAMS). PAMS monitors the National Road network pavement conditions using automated machinery to monitor and measure both the pavement's structural condition and surface course characteristics and functionality. TII also operates weather stations that monitor both environmental conditions and pavement temperatures. The pavement network is surveyed on an annual basis, and the resulting analysis is used to target sections of the network that may be in distress and to identify the interventions required in order to maintain the network in a safe, serviceable, and resilient condition.

The climatic conditions in which a pavement structure and its surfacing operate can have significant negative impacts on its functionality and the long-term performance it provides to the road user. This can result in eroded surfaces, uneven and rutted surfaces, and compromised structural capacity.

To facilitate efficient and sustainable design and to maintain the resilience of National Road pavements, TII has developed a suite of analytic road pavement design methodologies and software, supported by TII design and specification publications, to assist designers in selecting the most suitable material types, pavement depths and surfacing types for a particular design scenario. This ensures road users experience road smoothness, comfort and safety throughout the lifespan of the pavement assets. High quality pavements and road user experience is furthermore ensured through the implementation of the TII PAMS which continuously monitors pavement condition and proactively schedules road pavement maintenance activities.

These analytic methods include the Irish Analytical Pavement Design Method [68] and the TII Surface Dressing Design Method. A design scenario is characterised by the existing pavement conditions – in other words, the conditions in which the road pavement will operate, including existing ground conditions, traffic loading, and the climatic conditions in which the pavement structure will function throughout its expected life span.

To achieve this, the climate within which the pavement operates is modelled within the chosen analytical design method by considering the mechanical properties of the materials and their constituents (e.g. resistance to cracking, resistance to deformation, etc.) and their expected long-term performance in the field.

TII's road pavements' resilience to climate change is achieved through the ability to adjust and model design parameters and material types to account for changing climate conditions. In addition, where negative pavement material performance is identified due to climatic conditions, the design and material performance requirements may be adjusted to mitigate poor performance due to changes in climatic conditions.

Figure 24 Maintenance of TII road pavement [17]

Case Study 3: Erosion on N11 along the river Dargle

Event summary and impact

In September 2016, a river embankment on the N11 at Silverbridge in Bray, County Wicklow was subject to erosion and scour from the river Dargle. The river Dargle (at Silverbridge) is a high-energy river which has numerous scour pockets along the channel. The slope failure that occurred threatened the stability of the hard shoulder/verge of the N11 dual carriageway.

A walkover survey was conducted at the site and revealed that the embankment slip extended approximately 65 metres (m) along the western bank of the river Dargle and reached the edge of the existing N11 crash barrier and services chambers, which had fallen into the river.

The N11 Silverbridge retaining wall scheme involved the design of remedial works for the slope failure which was informed by background information from remedial/strengthening works that were undertaken in 2014 downstream of the slope failure on a section of the river embankment. The primary function of the retaining wall was to support the N11 road embankment. The retaining wall proposed was a piled, gravity-type wall to be situated between the mainline and the river Dargle.

The retaining structure was required to minimise the impact of scour and erosion to the bank of the river Dargle on the N11 mainline and the access road which was running parallel to the mainline. A holistic approach was taken in the design of the retaining wall to develop a cost-effective and sustainable solution which minimised the impact on the surrounding environment.

Lessons learned

This case warranted scope for immediate response to similar situations in the future, which has since been incorporated in the Motorway Maintenance and Renewals Contract Gen 2 contract.

Figure 25 Erosion on N11 along the river Dargle

Case Study 4: Severe winter weather in the early 2010s and the creation of the Severe Weather Management Plan and National Salt Management System

Event summary and impact

Several severe winters affected Ireland in the early 2010s.

At that time, local authorities were responsible for the storage, supply, and distribution of salt. There was a limited supply, but 30–40 customers needed salt simultaneously when severe weather occurred. This caused major disruption, as many roads were unable to be salted.

Lessons learned

In the 2-3 years following 2010, TII officially took responsibility of the salt supply across all local authorities. TII developed the National Salt Management System to allocate salt stocks every year to each local authority. This allows targeting of resources to areas that are severely impacted and avoids stockpiling large amounts of salt in an uncoordinated manner. In addition, there are ongoing improvements regarding salt spreading, with an expanded fleet of 350 vehicles nationally.

In 2018, Storm Emma demonstrated the success of these activities. No motorways were closed and there was no shortage of salt supplies. TII was able to target supplies to where they were needed.

The implementation of severe weather response operations for the majority of Ireland's road network is dependent on the actions of the local authorities. TII uses its position to support and influence local authority decision-making. The *Winter Service Manual* published by TII in 2022 [33] sets out standards for the local authorities, including:

- The preparation of a winter service plan
- Key winter service roles, responsibilities, and performance levels
- Salt management, and
- Procedures for liaison with emergency services, the supply chain, and other relevant organisations.

TII also participates in collaborative capacity building activities such as the 'winter-ready day' and the annual TII winter conference. This approach will support TII in considering how to collaborate for other similar climate events.

Figure 26 Slow-moving motorway traffic, winter 2009–2010

Case Study 5: Variable Message Sign warnings of hail to road users

Summary

TII's Network Management division is using artificial intelligence to detect certain types of climate conditions and linking the information to advanced Variable Message Signs (VMS) on the road network to warn road users to drive cautiously during hail.

Impacts

TII uses intelligent transport systems (ITS) technology and equipment on its National Road and light rail networks. VMS are an example of ITS equipment used to inform road users of road and traffic conditions, such as severe weather events, on the National Road network. ITS create a safer, more coordinated, and smarter environment for road users.

TII uses data obtained from roadside weather stations which are situated around the country to plan winter maintenance operations and to inform road users of weather events impacting the National Road network through VMS. Prior to advancements in technology, the sensors used to detect climate conditions had difficulty differentiating between types of rainfall, such as hail, snow, sleet, freezing rain, and fog. Such climatic conditions create dangerous driving conditions for road users.

Lessons learned

ITS technology and equipment are improving the accuracy and reliability of detecting climate conditions. Ireland's weather stations have trigger sensors which can be set up to monitor different climate conditions. In this case, a process is being set up that combines computer vision artificial intelligence working through existing camera technology with a multi-parameter weather sensor to detect types of precipitation and trigger a hail warning. The detection of hail triggers a link to advanced VMS to warn road users to slow down, and also links to road operations decision-makers.

This system could be set up in problematic areas on the road network and has the potential to improve winter maintenance operations and to enhance safety for road users and reduce road accidents on the road network. The detection and communication to road users of extreme climate conditions can reduce risks to infrastructure and road users, both significant assets of TII, while minimising disruptions to the National Road network.

Figure 27 VMS displaying travel time message

A.3 Summary of the CIViC study

This appendix presents a potential approach for undertaking the priority impact assessment, Stage 4 of the TII climate adaptation approach. This approach uses spatial information to capture how climate risks and asset vulnerability can vary across Ireland.

The CIViC study is a research project led by the Environmental Protection Agency. [56] This project includes a geographic information system (GIS)-based climate change risk assessment for the transport sector, combining climate data and asset data in a mapped format. This is a potential method for identifying climate risk hot spots across large networks and prioritising future adaptation investment in specific locations.

The study refers to a number of future scenarios. Broadly, these align with two scenarios:

- Representative Concentration Pathway 4.5 (RCP4.5), referred to throughout the study as the 'medium to low emissions scenario' or the 'mid-range future scenario' (MRFS)), and
- RCP8.5, referred to throughout the study as the 'high-emissions scenario' or the 'high-end future scenario' (HEFS)).

Figure 28 to Figure 31 show some of the maps presented in a subsequent paper related to the initial study. [65]

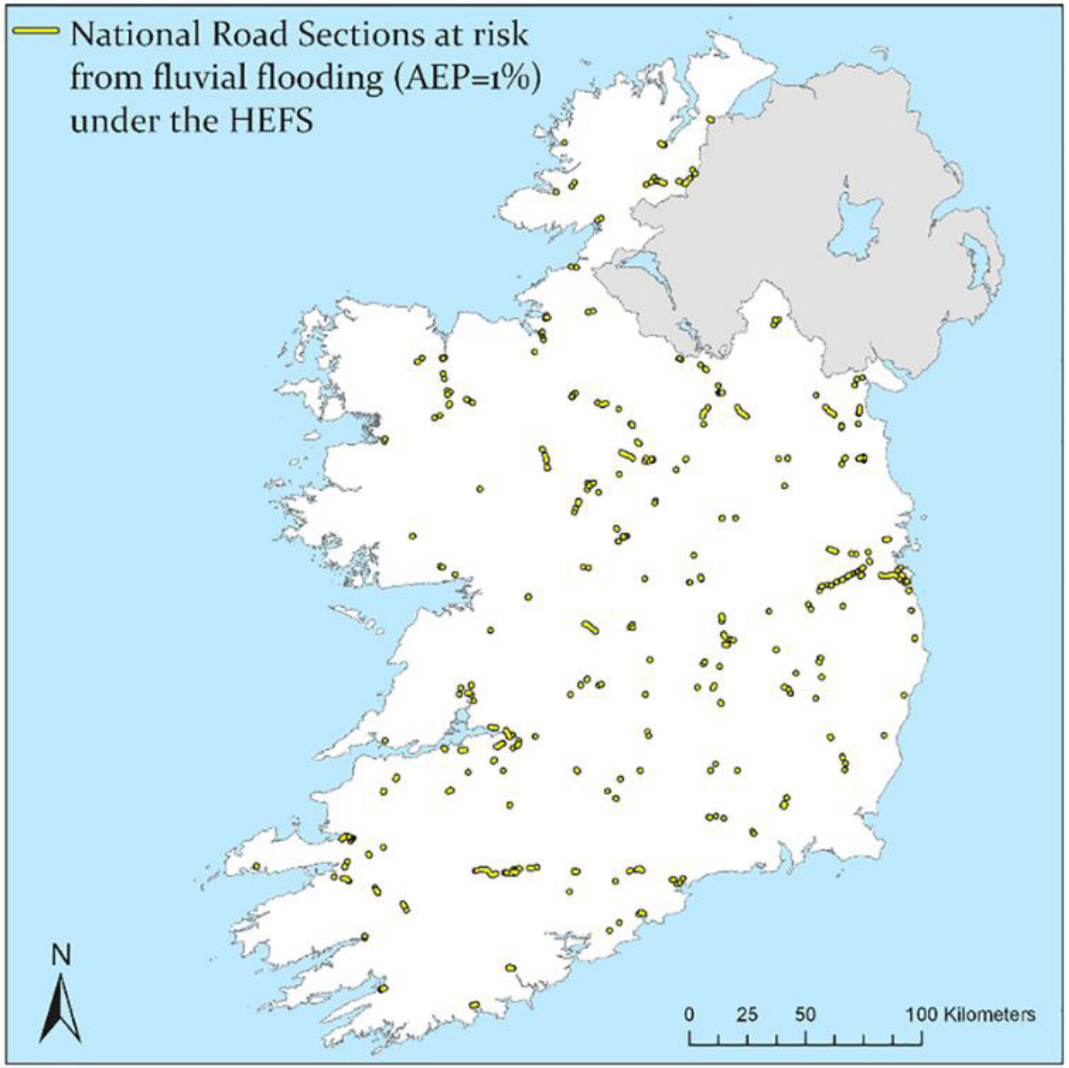

Figure 28 Location of National Roads sections exposed to risk from a 1-in-100-year fluvial flood event under the Office of Public Works HEFS [65]

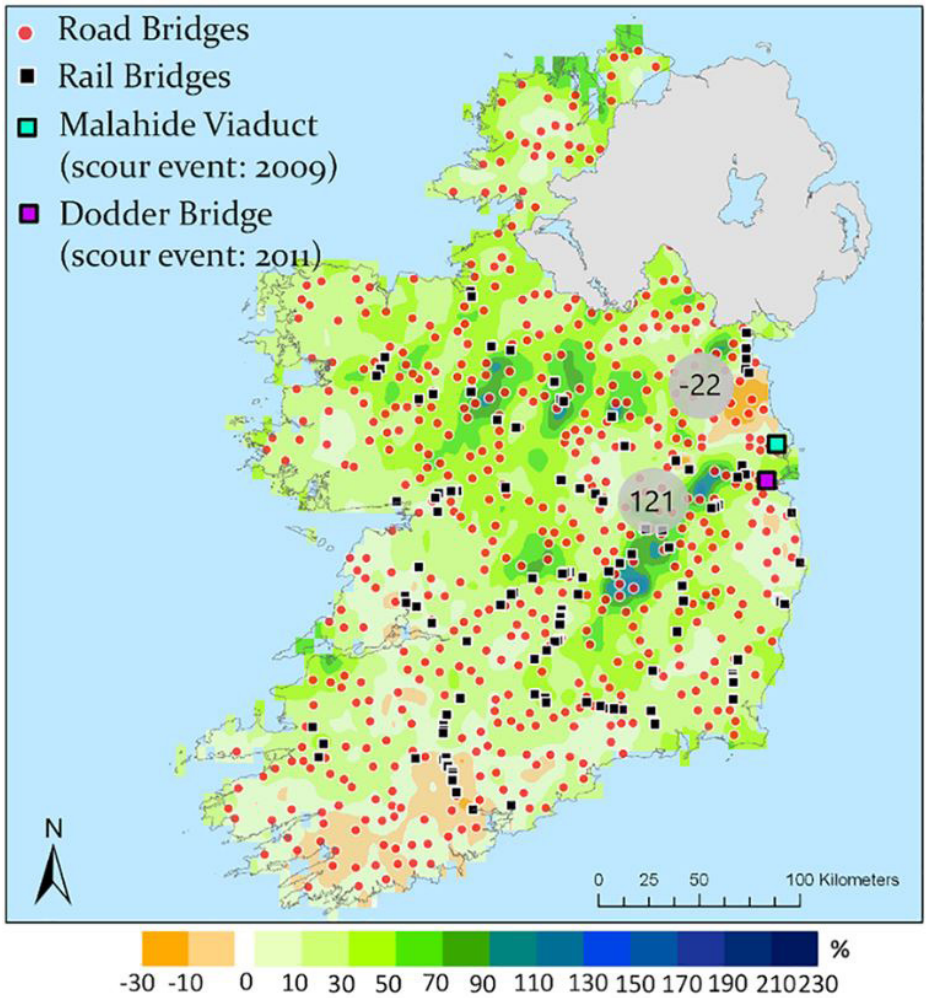

Figure 29 Location of road and rail river bridges in areas subjected to an increase in the number of very wet days in autumn, for the medium to low emissions scenario [65]

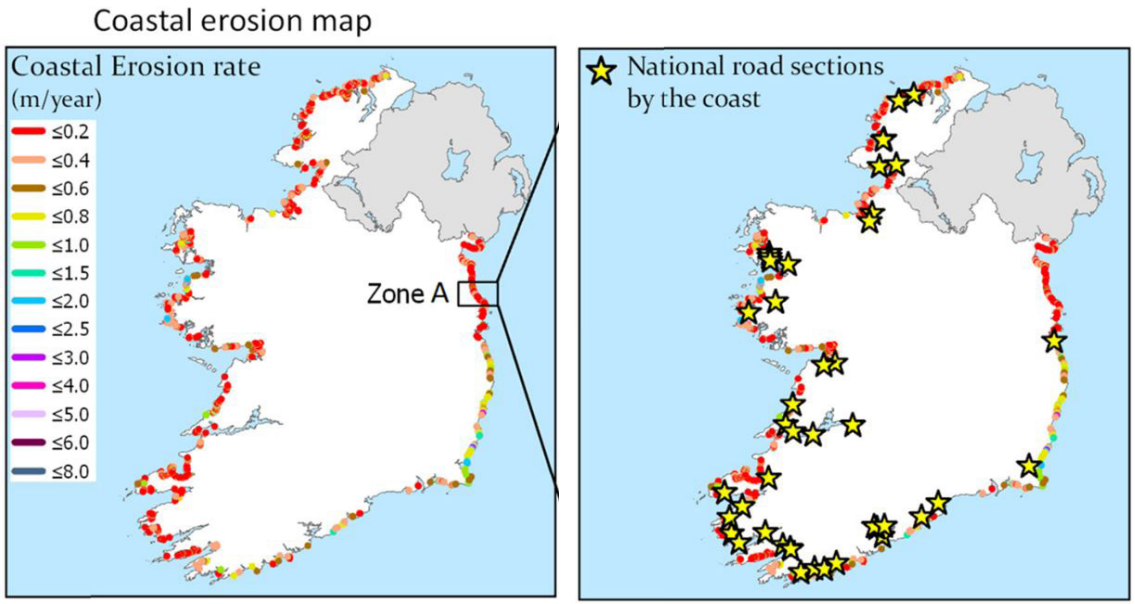

Figure 30 Assessment of the impact of coastal erosion and sea level rise on transport assets [65]

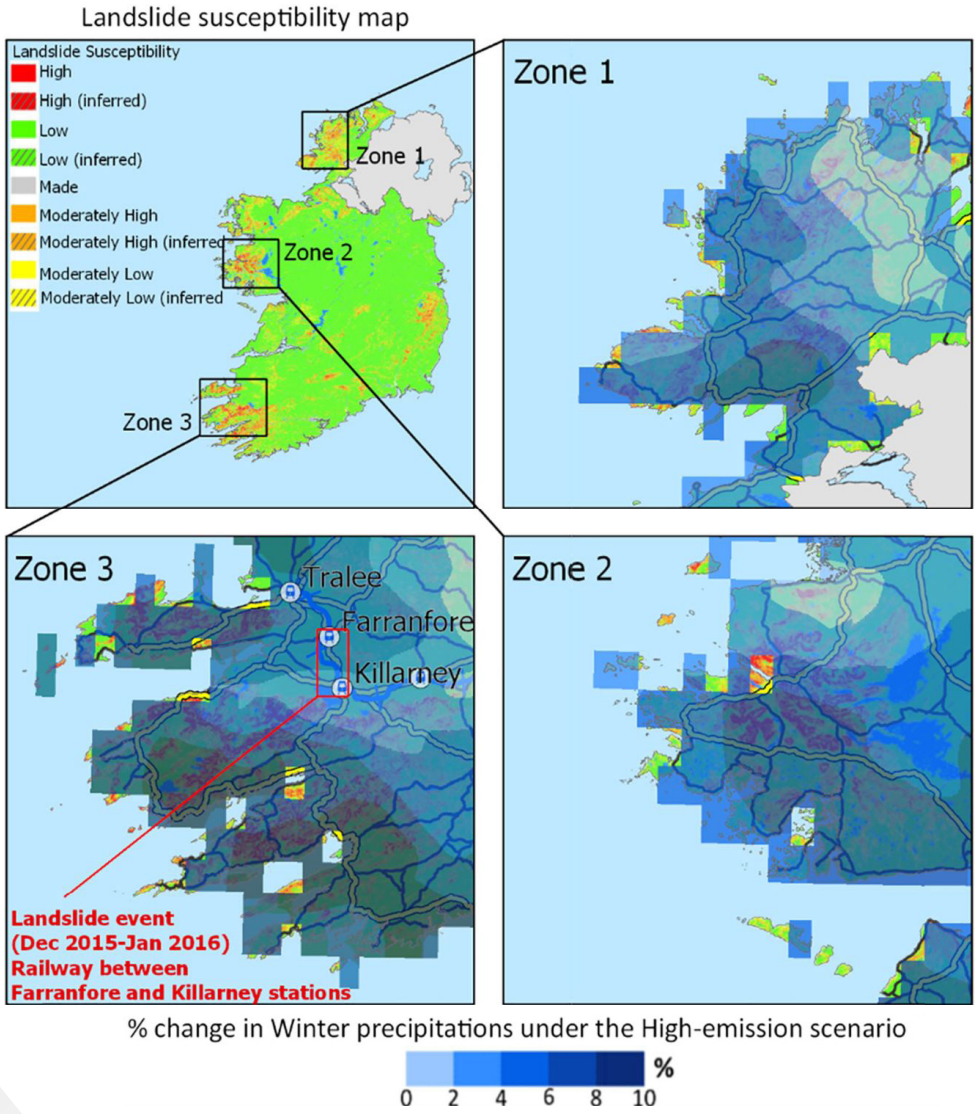

Figure 31 Assessment of the impact of climate change on the transport network's vulnerability to landslides [65]