

Transport Infrastructure Ireland

Climate Adaptation Strategy



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Glossary and abbreviations

Term	Definition
Climate	Long-term weather conditions in an area.
Climate adaptation	Anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause or taking advantage of opportunities that may arise. ⁽¹⁾
Climate change	The United Nations Framework Convention on Climate Change defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. ⁽²⁾
Climate hazards	Any identified climate-related event or long-term change to which Transport Infrastructure Ireland (TII) assets can be vulnerable.
Climate mitigation	The Intergovernmental Panel on Climate Change defines mitigation of climate change as “a human intervention to reduce emissions or enhance the sinks of greenhouse gases. Note that this encompasses carbon dioxide removal (CDR) options. Mitigation measures include technologies, processes, or practices that contribute to mitigation”. ⁽³⁾
Climate-proofing	A process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects. ⁽⁴⁾
Climate risk	How climate hazards translate to a detrimental impact on TII’s vulnerable assets.

Term	Definition
Climate variables	Physical, chemical, and biological properties of the atmosphere, the ocean, and the land surface, which are observed and monitored for a better understanding of the climate and its changes. Climate variables in the atmosphere include temperature, precipitation, humidity, and wind.
dTIMS	TII’s asset management system.
Exposure	The extent (frequency and severity) to which a location experiences a climate hazard in question.
Greenway	A cycleway that caters for people walking, wheeling, and cycling in a mainly recreational environment.
Climate mitigation	The Intergovernmental Panel on Climate Change defines mitigation of climate change as “a human intervention to reduce emissions or enhance the sinks of greenhouse gases. Note that this encompasses carbon dioxide removal (CDR) options. Mitigation measures include technologies, processes, or practices that contribute to mitigation”. ⁽³⁾
Interdependencies	How a single hazard can have knock-on impacts across a range of sectors, amplifying the resulting risk. Similarly, risks can interact across very different sectors; impacts on infrastructure can cascade through to the built environment and natural environment, and vice versa. ⁽⁵⁾
Likelihood	How likely the hazard is to occur up to 2050 (or further for infrastructure assets where the life span exceeds the year 2050).

Term	Definition
Maladaptation	Adaptation activities that result in increased vulnerability to climate variability and change, directly or indirectly, and/or significantly undermine capacities or opportunities for present and future adaptation.
Radiative forcing	The perturbation to the energy balance of the Earth-atmosphere system following, for example, a change in the concentration of carbon dioxide or a change in the output of the sun; the climate system responds to the radiative forcing so as to re-establish the energy balance. A positive radiative forcing tends to warm the surface and a negative radiative forcing tends to cool the surface.
Representative Concentration Pathways (RCPs)	Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs), aerosols, and chemically active gases, as well as land use/land cover. The word 'representative' signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term 'pathway' emphasises that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. ⁽³⁾

Term	Definition
Shared Socioeconomic Pathways (SSPs)	Scenarios that examine how global society, demographics, and economics might change over the next century. The SSPs are based on five narratives describing broad socioeconomic trends that could shape future society. These are intended to span the range of plausible futures and include: a world of sustainability-focused growth and equality (SSP1); a 'middle of the road' world where trends broadly follow their historical patterns (SSP2); a fragmented world of 'resurgent nationalism' (SSP3); a world of ever-increasing inequality (SSP4); and a world of rapid and unconstrained growth in economic output and energy use (SSP5). ⁽⁶⁾
Sensitivity	The extent to which a climate hazard may affect an asset, irrespective of location.
Soft landscaping	Nature-based elements such as trees, plants, and shrubs.
Vulnerability	A function of sensitivity and exposure, to capture the extent to which an asset is at risk to a climate hazard.
Weather	The state of the atmosphere at a particular place and time. Elements include temperature, precipitation, storminess, and cloudiness.

Abbreviation	Definition
BMS	building management system
BSI	British Standards Institution
CAP21	Climate Action Plan 2021
CAROs	Climate Action Regional Offices
CCMA	County and City Management Association
CDR	carbon dioxide removal
CEDR	Conference of European Directors of Roads
CFRAM	Catchment-based Flood Risk Assessment and Management
CIVIC	Critical Infrastructure Vulnerability to Climate Change
CMIP	Coupled Model Intercomparison Project
COP	Conference of the Parties
DoT	Department of Transport
DTTAS	Department of Transport, Tourism and Sport
EPA	Environmental Protection Agency
ERTRAC	European Road Transport Research Advisory Council
EU	European Union
FEHRL	Forum of European National Highway Research Laboratories
GHG	greenhouse gas
GIS	geographic information system
Ha	hectares
HEFS	high-end future scenario
IAPDM	Irish Analytical Pavement Design Method

Abbreviation	Definition
ICHEC	Irish Centre for High-End Computing
ICPSS	Irish Coastal Protection Strategy Study
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ITS	intelligent transport systems
km	kilometres
LED	light-emitting diode
m	metres
MMaRC	Motorway Maintenance and Renewals Contract
MRFS	mid-range future scenario
NAF	National Adaptation Framework
NCCAF	National Climate Change Adaptation Framework
NFCS	National Framework for Climate Services
NIFTI	National Investment Framework for Transport in Ireland
NSO	National Strategic Outcome
NTA	National Transport Authority
PAMS	Pavement Asset Management System
PAS	Publicly Available Standard
PIARC	World Road Association
PPP	public-private partnership
RCP	Representative Concentration Pathway
REM	Road Emissions Model

Abbreviation	Definition
SIP	<i>Sustainability Implementation Plan – Our Future</i>
SO	strategic objective
SSP	Shared Socioeconomic Pathway
SuDS	Sustainable Drainage Systems
TII	Transport Infrastructure Ireland
TRAN	European Union Committee on Transport and Tourism
UCC	University College Cork
UITP	International Association of Public Transport (Union Internationale des Transports Publics)
UN	United Nations
UTRAP	Urban Transport-Related Air Pollution
VMS	Variable Message Signs



TII Climate Adaptation Strategy

Executive Summary

Executive Summary

Introduction & context

In 2019, Ireland declared that the nation is in a climate and biodiversity emergency, with the impacts of climate change being increasingly felt across the country. To address this, in 2021, the Irish Government developed the Climate Action Plan 2021 (CAP21).⁽⁷⁾ CAP21 set a requirement for Transport Infrastructure Ireland (TII) to publish an updated strategy on how it will adapt the light rail and National Road networks in the face of a changing climate. This Climate Adaptation Strategy is TII's response to CAP21 Action 297, "Improve climate resilience and adapt to climate change on the Light rail and National Road Network".⁽⁸⁾

This Climate Adaptation Strategy builds on TII's previous climate adaptation strategy, *Strategy for Adapting to Climate Change on Ireland's Light Rail and National Road Network*, published in 2017.⁽⁹⁾ Since the original strategy was published there have been significant developments in climate adaptation. For example, there has been a global call for action on climate, with the launch of The European Green Deal in 2019.⁽¹⁰⁾ Moreover, TII has developed a better understanding of how climate change may affect its networks due to improved guidance on adaptation planning processes, as well as advancements in climate science and sectoral awareness of climate risks across Ireland.

Climate change is causing extreme weather events to become more frequent and severe, as well as contributing to sea level rise and coastal erosion. TII's assets and activities are vulnerable to weather events; flooding, storms, and heatwaves can damage assets and cause service disruption, which can result in significant safety, financial, and reputational impacts. TII must continue to adopt a proactive approach to managing the impacts of climate change in order to prevent the worst of these impacts and avoid relying on costly reactive measures. Taking this proactive approach means TII will be prepared for the increasingly frequent and extreme weather events that are projected to occur in the future.

TII's approach to climate adaptation

TII is adapting to the impacts of climate change alongside taking mitigation actions to reduce its carbon emissions. This Climate Adaptation Strategy addresses the first of those challenges, with the TII Climate Action Roadmap detailing TII's approach to reducing its emissions.⁽¹¹⁾ This Climate Adaptation Strategy outlines seven strategic objectives for climate adaptation (see Table 1), which align with the six principles from TII's overarching *Sustainability Implementation Plan – Our Future* (SIP).⁽¹²⁾

Table 1 TII's seven strategic objectives for climate adaptation

TII's seven climate adaptation strategic objectives	
1	Observe fewer network disruptions during climate-related events.
2	Rapidly recover from any climate-related events.
3	Have a robust, flexible, and equitable organisation that responds effectively during climate events.
4	Enhance the climate resilience of lifeline roads in order to maintain community accessibility.
5	Engage with the wider adaptation efforts across Ireland through partnerships and wider research.
6	Embed climate adaptation within TII's operations, policies, and procedures in order to ensure a safe and resilient network.
7	Adopt a low-carbon approach in TII's designs, standards, and processes when considering climate adaptation, while also considering wider social and environmental benefits.

Key actions

TII is not complacent about the scale of the challenge that climate change risks pose to its networks and activities. There is much to do, and continued action is required in terms of understanding climate risks, building capacity to adapt to climate change, and investing in current and future levels of resilience to climate impacts. The publication of recent standards, for example Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline and Greenways) – Overarching Technical Document. (24) highlights TII's commitment to ensure that the design of new infrastructure is resilient to future climate change.

Several actions have therefore emerged to support the implementation of this Climate Adaptation Strategy within TII and are summarised in Table 2. Facilitating these actions and ensuring that TII's networks are adapted to future climate change will require significant resources and investment. Going forward, work will be undertaken to obtain a better understanding of the climate risks and costs of the climate adaptation actions that will form a fundamental part of climate adaptation implementation planning (Stage 5 of TII's climate adaptation approach). This understanding will assist TII to create climate adaptation budgets that are subject to appropriate due diligence, subject to the receipt of funding, and assign sufficient funds to implement planned actions. However, ultimately delivering on these planned actions will enable TII to achieve its aim of being an organisation that is adaptive to the impacts of climate change while maintaining its commitment to sustainability.

Table 2 Upcoming climate adaptation actions

Action No.	Action	Indicative Dates
0	Publish TII's <i>Climate Adaptation Strategy</i> .	December 2022
1	1.1 Develop governance and resourcing requirements.	Commence in Q1 2023
	1.2 Complete climate screening (see Stage 2 of TII's climate adaptation approach in Section 5.2) for National Roads, light rail, greenways and cycleways, land, buildings, and people.	In progress Complete by Q1 2023
	1.3 Identify priority climate hazards through climate screening (see Stage 3 of TII's climate adaptation approach in Section 5.3) for National Roads, light rail, greenways and cycleways, land, buildings, and people.	In progress Complete by Q2 2023
2	Undertake a more detailed climate risk assessment for all climate hazards identified as priorities (see Stage 4 of TII's climate adaptation approach in Section 5.4).	Dependent on completion of Action 1 Complete flood risk assessment for National Roads Complete by Q4 2024
3	Develop and implement climate adaptation implementation plans (see Stage 5 of TII's climate adaptation approach in Section 5.5). These plans will include estimates of resourcing, time frames, measurement, and monitoring of proposed adaptation measures.	Dependent on completion of Action 2 Commence in Q1 2025
Partnerships & Research		
4	Provide support to the Department of Transport with its upcoming Transport Climate Change Sectoral Adaptation Plan.	Ongoing
5	Continue TII's working relationship with Climate Ireland and University College Cork (UCC) to support the definition of a final list of climate resilience indicators. This will support Action 3.	To commence in 2023
6	Continue engagement with Met Éireann's TRANSLATE project. ⁽¹⁴⁾	Commenced in Q3 2022 and due to be complete by Q2 2023
7	Continue TII's working relationship with climate-focused groups, including, but not limited to, the Conference of European Directors of Roads (CEDR), the Urban Transport-Related Air Pollution (UTRAP) Working Group, the European Union Committee on Transport and Tourism (TRAN), and the International Association of Public Transport (<i>Union Internationale des Transports Publics</i> ; UITP).	Ongoing

Report overview and structure

This Climate Adaptation Strategy is structured as follows:

Section 1

Introduction introduces the Climate Adaptation Strategy's aims and objectives, and includes a summary of the organisation's network and remit, defining what adaptation means for TII.

Section 2

The policy context for climate adaptation summarises existing policies, programmes, and plans that influenced the development of TII's Climate Adaptation Strategy.

Section 3

Strategic objectives for adapting to climate change links TII's Climate Adaptation Strategy to the overarching SIP in order to ensure that the climate adaptation approach aligns with the guiding principles for sustainability.

Section 4

TII's understanding of climate risks presents TII's current understanding of climate risks, how they will change in the future, and how they affect its networks, systems, and services.

Section 5

TII's approach to climate adaptation summarises TII's approach to adapting to ongoing and future climate change.

Section 6

TII's progress on climate adaptation outlines TII's progress to date on adapting to climate change and addressing the challenges of extreme weather events.

Section 7

TII's governance of climate adaptation outlines TII's approach to the governance of climate adaptation in the organisation.

Section 8

Next steps sets out actions to deliver on TII's Climate Adaptation Strategy.



TII Climate Adaptation Strategy

Section 1. Introduction



1. Introduction

1.1 Context

Safe and resilient transport infrastructure is vital for the movement of people, goods, and services.

“Our purpose is to provide sustainable transport infrastructure and services, delivering a better quality of life, supporting economic growth and respecting the environment.”

TII Statement of Strategy 2021 to 2025 ⁽¹⁵⁾

Despite global commitments and efforts to reduce greenhouse gas (GHG) emissions in order to minimise future climate change impacts, climate change is causing extreme weather events to become more frequent and severe, as well as contributing to sea level rise and coastal erosion. Transport Infrastructure Ireland’s (TII’s) assets and activities are vulnerable to these climate-related events, and any climate-related issues that affect its assets could compromise their value. Additionally, failure to address the climate vulnerability associated with assets could lead to increased financial costs through damage to infrastructure, alongside disruptions to society, the economy, and the environment. It is therefore essential that TII continue to adapt to the changing climate.

What is climate adaptation?

“Anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause or taking advantage of opportunities that may arise.” ⁽¹⁾

This Climate Adaptation Strategy sets out TII’s approach for adapting to climate change and is a direct response to Ireland’s Climate Action Plan 2021: Securing Our Future (CAP21). CAP21 includes an Annex with almost 500 actions which organisations across the country must deliver. ⁽⁷⁾ This Climate Adaptation Strategy:

- Delivers on the requirements under CAP21 Action 297, “Improve climate resilience and adapt to climate change on the Light rail and National Road Network” ⁽⁸⁾
- Builds on TII’s first Climate Adaptation Strategy – *Strategy for Adapting to Climate Change on Ireland’s Light Rail and National Road Network*, published in 2017 – which focused mainly on the effects of climate change on TII’s National Road and light rail networks, specifically intense rainfall and increased levels of groundwater, and what measures needed to be taken in order to minimise the incidence of road closures due to flooding, ⁽⁹⁾ and

- Aligns with TII’s overarching *Sustainability Implementation Plan – Our Future* (SIP) ⁽¹²⁾ and the corporate *TII Statement of Strategy 2021 to 2025*. ⁽¹⁵⁾

1.2 About TII’s assets

In this Climate Adaptation Strategy, TII refers to assets across six categories: road; light rail; rural cycleways and greenways; land; buildings; and people (see Figure 2).

Figure 2 Categorisation of assets



1.2.1 National Road network

TII operates, maintains, and improves the national primary and secondary road network in Ireland shown in Figure 3. ⁽¹⁶⁾ The network is 5,206 kilometres (km) long and is formed of motorways, dual carriageways, and single-lane roads that carry approximately 45% of the country's total road traffic; additionally, most of Ireland's freight is distributed by road. TII operates and manages the National Road network in partnership with local authorities and through public-private partnership (PPP) contracts. Approximately 50% of the national primary network is managed directly by TII. TII oversees the operations and maintenance of roughly 500 km of the motorway network through PPP contracts, with the balance of the network maintained by three regional Motorway Maintenance and Renewals Contracts (MMaRCs). Local authorities are the road authorities for many of the National Roads' functions in their respective administrative areas. TII works in partnership with local authorities to operate, maintain, and improve the National Roads.

As shown in Figure 4, the National Road network comprises a diverse range of assets. This includes over 1000 km of footpaths and over 200 km of cycleways, which facilitate active travel.

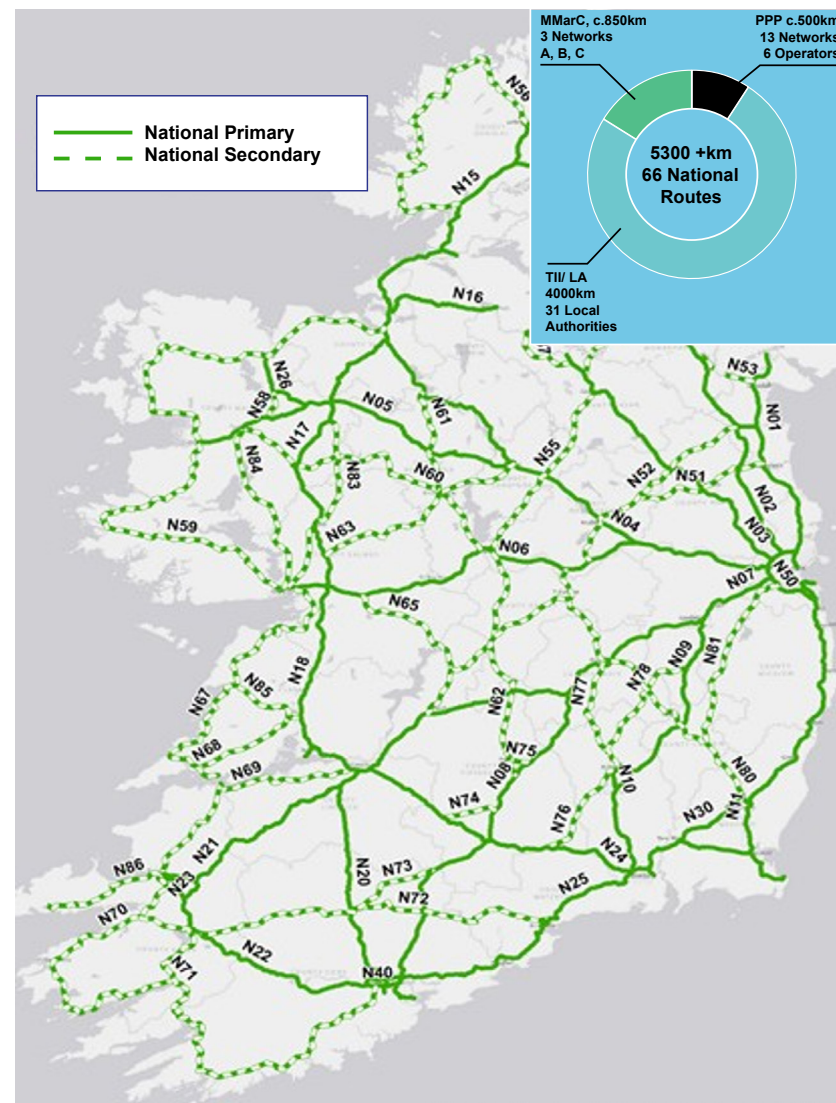


Figure 3 TII's National Road network ⁽¹⁶⁾ ⁽¹⁷⁾

1.2.2 Light rail network

TII's light rail network (Luas) is made up of 2 tram lines (Figure 5), with a total of 67 stops and a fleet of 81 trams. Since Luas services commenced in 2004, over 430 million passengers have been recorded.⁽¹⁸⁾ Working with the National Transport Authority (NTA), TII manages the Luas through a series of operating and maintenance (vehicle and infrastructure) contracts.

The Luas Red Line extends from Tallaght in the southwest of Dublin, through the city centre, to The Point in Dublin's Docklands. The line consists of twin tracks and is 20.5 km in total length. The Luas Green Line extends from Brides Glen in the southeast of Dublin to Broombridge in the northwest of the city. The line comprises single and twin tracks with a total length of 21.9 km. There are three Luas depots which support the maintenance of the tram fleet. Depot facilities are located at Red Cow for the Red Line, and at Sandyford and Broombridge for the Green Line.⁽¹⁹⁾

TII is responsible for the life cycle asset management of all Luas infrastructure and rolling stock. More detail about the assets on TII's light rail network is presented in Figure 6.

Snapshot of our road network assets

The road network represents a very substantial level of investment by the people of Ireland



Carriageway and earthworks

5314 km roads. 1200 km is high-quality motorway and dual carriageway.



Drainage and ducting

600 km urban positive drainage. 1200+ km designed drainage (filter, carrier, kerb, and gully).



Bridges, walls, and Structures

3,400 structures, 700 gantries



Land

14,000 hectares



Tunnels and major Structures

3 x tunnels
(1 x bored
2 x cut and cover)



Traffic systems, signs, and markings

600 traffic signals
130,000 road signs



Street lighting

42,000 streetlights



Footpaths and cycleways

1,000+ km of footpaths, 200+ km of cycleways

Figure 4 TII's road network assets⁽¹⁷⁾

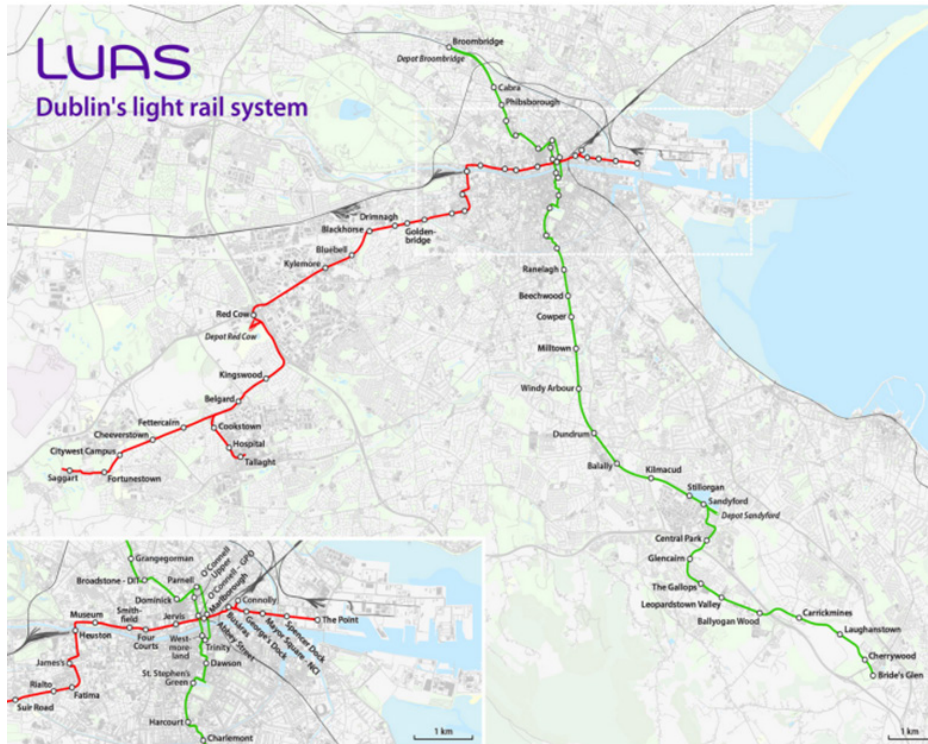


Figure 5 TII's light rail network ⁽¹⁷⁾

Snapshot of our light rail network

The light rail network provides an essential service to connect communities in the Greater Dublin Area



2

lines



43

km



67

stops



3

depots



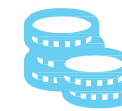
81

trams



48

million passenger
journey's per year



€87

million revenue 2019



3.7

million km per year

Figure 6 TII's light rail network assets ⁽¹⁷⁾

1.2.3 Rural cycleways and national and regional greenways

As part of the *Strategy for the Future Development of National and Regional Greenways*,⁽²⁰⁾ TII was given a remit from the Minister for Transport to take over delivery responsibilities for the national and regional greenway programme in September 2021. This national and regional greenway programme is being delivered in partnership with local authorities. This Climate Adaptation Strategy will refer to greenways as the national and regional greenways under TII's remit.

1.2.4 Land

TII manages large sections of soft landscaping adjacent to motorways, National Roads, and alongside the Luas lines and their stops. Most soft landscaping near to the Luas lines is managed by TII. Maintenance agreements are in place with local authorities setting out agreed protocols and lines of demarcation. TII currently maintains approximately 3,500 hectares (ha) of transport corridor and roadside landscapes.⁽²¹⁾ TII is developing a landscape management strategy to sustainably manage transport corridors and roadside landscapes.⁽²²⁾

1.2.5 Buildings

TII has a diverse range of building assets that are typically associated with its National Road and light rail networks and fall under the responsibility of various entities. TII is responsible for its headquarter offices at Parkgate Street, Dublin. TII's light rail transport operator (Transdev), MMarCs and PPPs are responsible for their own building assets which are located strategically in Dublin and across the country. The building assets for which third parties are responsible are significant to the provision of sustainable transport services and operate all year round. These include:

- Operational control centres
- Motorway maintenance depots
- Tram depots, and
- Light rail electrical substation buildings and systems, and communications buildings.

1.2.6 People

TII recognises that its people are a key component of its organisation. It is through their hard work, commitment, and innovation that TII can deliver its services across Ireland. TII aims to maintain, enhance, and harness the capability of its workforce, promoting the values of collaboration, innovation, and integrity in the spirit of public service.

1.2.7 Policies and standards

TII publishes technical and guidance documentation in relation to the functions and services provided by the organisation for its National Road, light rail, and rural cycleway and greenway schemes.⁽²³⁾ These standards include mandatory requirements and guidance documents for road, light rail, and regional greenway operations. TII's standards are a core part of its approach to climate adaptation and act as a way of ensuring the delivery of TII's climate adaptation principles across its networks. For example, TII has recently developed *Climate Guidance for National Roads, Light Rail, and Rural Cycleways* (Offline and Greenways) – Overarching Technical Document.⁽²⁴⁾

1.3 Ensuring alignment with TII's SIP

TII's SIP forms the basis of all climate-proofing activities within the organisation, including corporate programmes and projects. TII is taking an integrated approach towards climate-proofing the organisation through implementing climate adaptation and mitigation measures, as outlined in Figure 7. Mitigation activities are being addressed through the development of TII's Climate Action Roadmap. The SIP underlines the importance of taking a holistic approach to climate adaptation. This Climate Adaptation Strategy will support TII to achieve its environmental and social objectives, as well as support the national adaptation effort, while ensuring that it enables the transition to net zero.

Towards climate-proofing TII: linking climate adaptation with mitigation

The European Commission's 2021 publication *Technical guidance on the climate proofing of infrastructure in the period 2021-2027* defines climate-proofing as "A process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects". ⁽⁴⁾

TII is applying this definition of climate-proofing to its organisation through both the SIP and the *TII Statement of Strategy 2021 to 2025*, ensuring an integrated approach to both climate mitigation and adaptation. For example, TII will consider the carbon emissions associated with adaptation measures and prioritise low-carbon measures, where appropriate, in order to play its part in supporting the national requirement to achieve net zero by 2050.

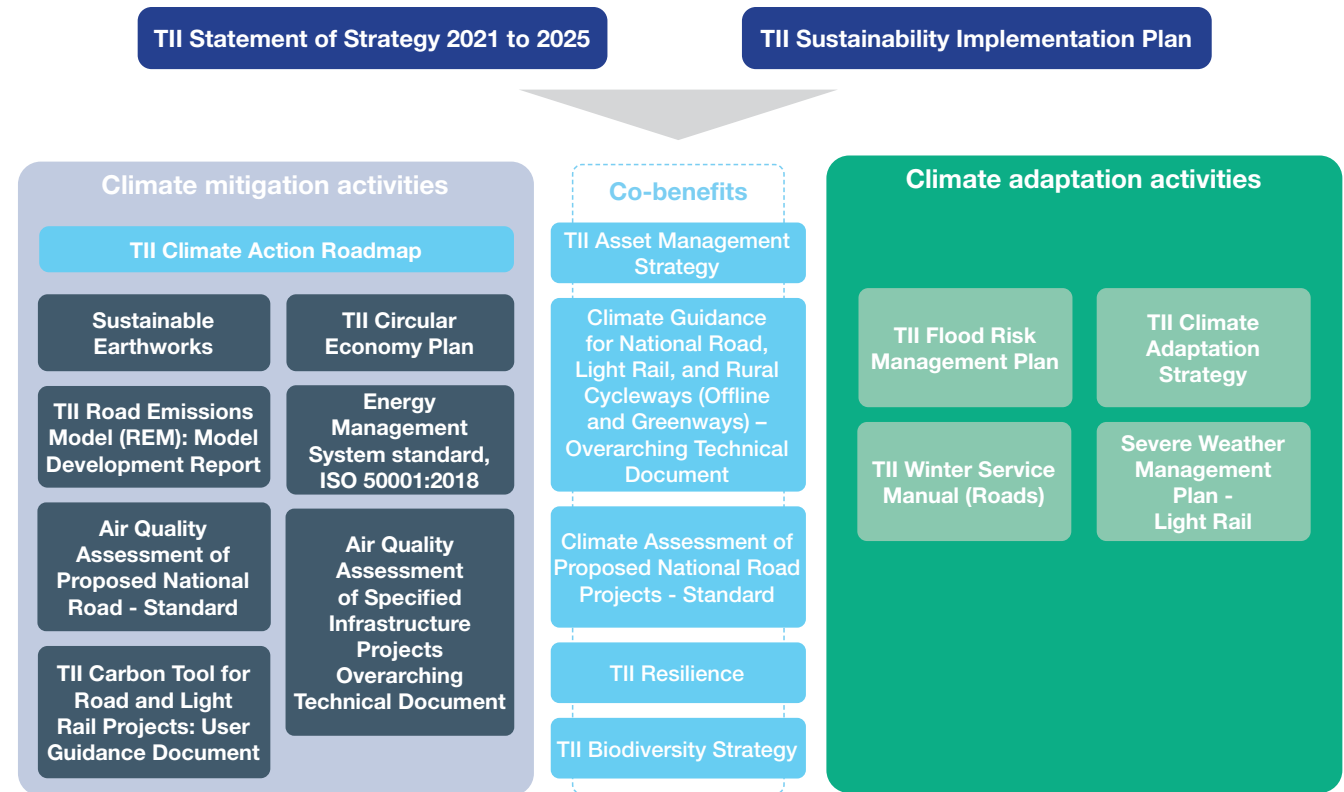


Figure 7 Diagram of TII's process to climate-proofing the organisation

References: ⁽¹⁾ (12) (15) (17) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33) (34)

TII Climate Adaptation Strategy

Section 2.

Policy Context



2. The policy context for climate adaptation

This Climate Adaptation Strategy forms TII's response to Ireland's CAP21. ⁽⁷⁾ A timeline of this and other important climate policies that influence TII's Climate Adaptation Strategy is summarised in Figure 8. TII's past, ongoing, and future climate adaptation activities and collaborative engagements with research partners are shown in Figure 9. Further detail regarding the policy context of this Climate Adaptation Strategy is contained in Appendix A.1.



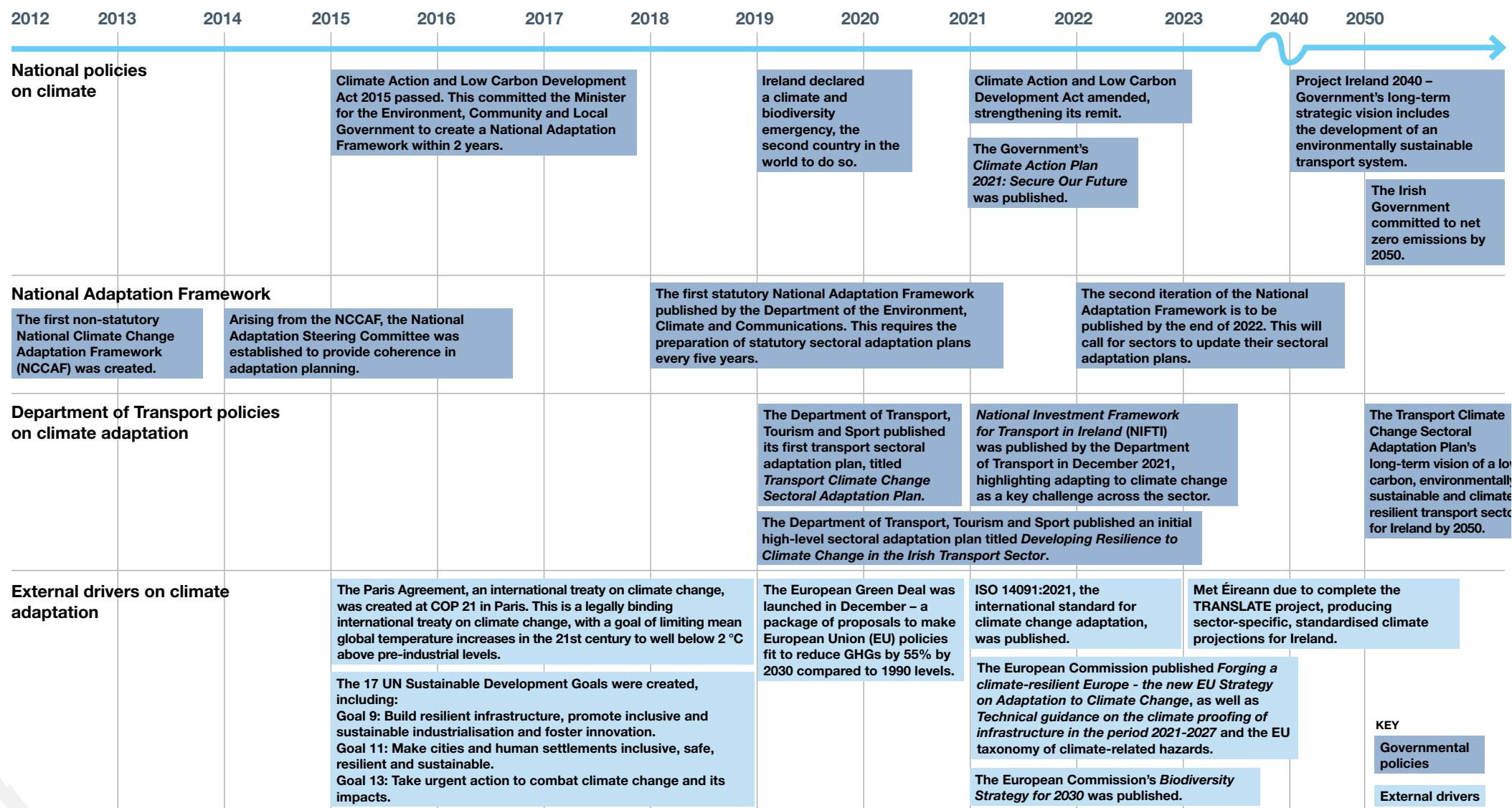


Figure 8 Timeline of climate adaptation policy in Ireland and other external drivers of TII's Climate Adaptation Strategy (4) (7) (10) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (48) (49) (50)

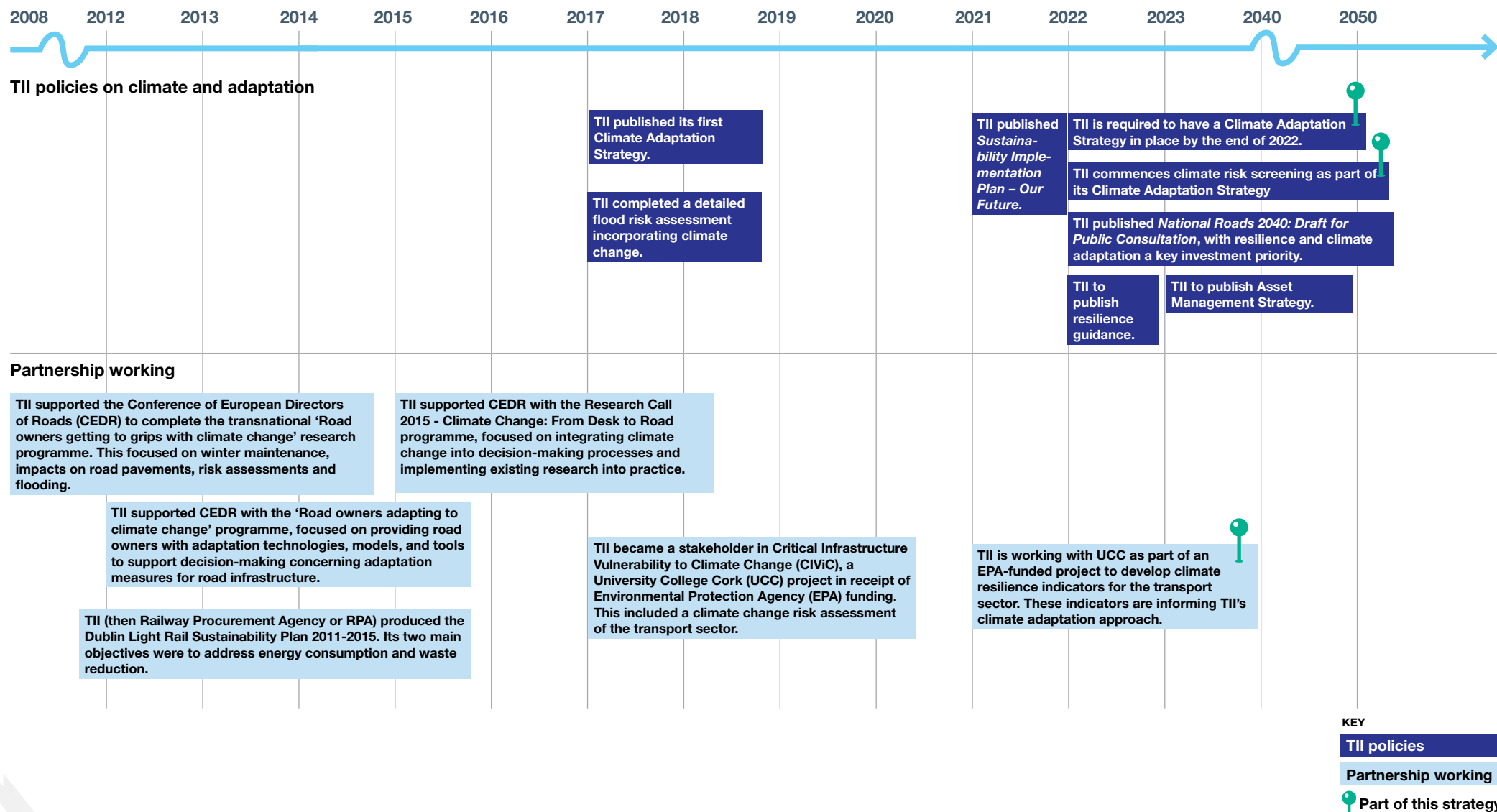


Figure 9 Timeline of TII's climate adaptation activities and external collaborations ^{(9) (12) (17) (32) (51) (52) (53) (54) (55) (56) (57)}

2.1 How policies and guidance are informing TII's approach to climate adaptation

TII's strategy for climate-proofing its assets is centred around TII's SIP ⁽¹²⁾ and the *TII Statement of Strategy 2021 to 2025*. ⁽¹⁵⁾ This Climate Adaptation Strategy is one element of TII's SIP; further details of how these align are outlined in Section 3 of this Climate Adaptation Strategy. Other existing policy and guidance has influenced TII's strategy and approach to climate adaptation, as detailed below:

- This Climate Adaptation Strategy is a direct response to Ireland's CAP21 ⁽⁷⁾ and specifically addresses Action 297, "Improve climate resilience and adapt to climate change on the Light rail and National Road Network". ⁽⁸⁾ This requires TII to publish a strategy on how Ireland's light rail and National Road networks will adapt to climate change.
- This Climate Adaptation Strategy supports the Ireland CAP21 target of facilitating 500,000 daily sustainable travel journeys by 2030 by working towards climate-proofing TII's light rail network, cycleways and greenways, and bus provision on TII's National Road network.

- TII is aligned with Ireland's national *Sectoral Planning Guidelines for Climate Change Adaptation* (used by Government Departments) by adopting the six-stage methodology which is outlined in the guidelines. ⁽¹³⁾ This ensures that TII's approach to climate adaptation corresponds with that which the Department of Transport uses in its *Transport Climate Change Sectoral Adaptation Plan*.
- In order to understand its climate risks, TII has adopted the two-phase approach outlined in the European Commission's *Technical guidance on the climate proofing of infrastructure in the period 2021-2027*. ⁽⁴⁾ Any significant climate risks identified in the climate screening stage will be subject to a more detailed climate risk assessment. This methodology is set out in more detail in Section 5.

By integrating these national and international policies and guidance documents on climate adaptation within its approach, TII is aligning with best practice and supporting the delivery of the national adaptation effort across Ireland, in line with the *Project Ireland 2040 National Planning Framework*, ⁽³⁸⁾ the *Programme for Government: Our Shared Future*, ⁽³⁹⁾ the United Nations (UN) Sustainable Development Goals, ⁽⁴⁶⁾ and the European Green Deal. ⁽¹⁰⁾



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TII Climate Adaptation Strategy

Section 3.

Strategic objectives



3. Strategic objectives for adapting to climate change

This section outlines TII's aim and strategic objectives regarding climate adaptation. This will inform future decisions to ensure that climate adaptation is considered across TII's networks and organisation, including people, processes, and standards.

The development of TII's Climate Adaptation Strategy has included consultation across the organisation. This engagement has resulted in, and enabled the development of, TII's climate adaptation aim, strategic objectives, and enabling factors, as shown in Figure 10.

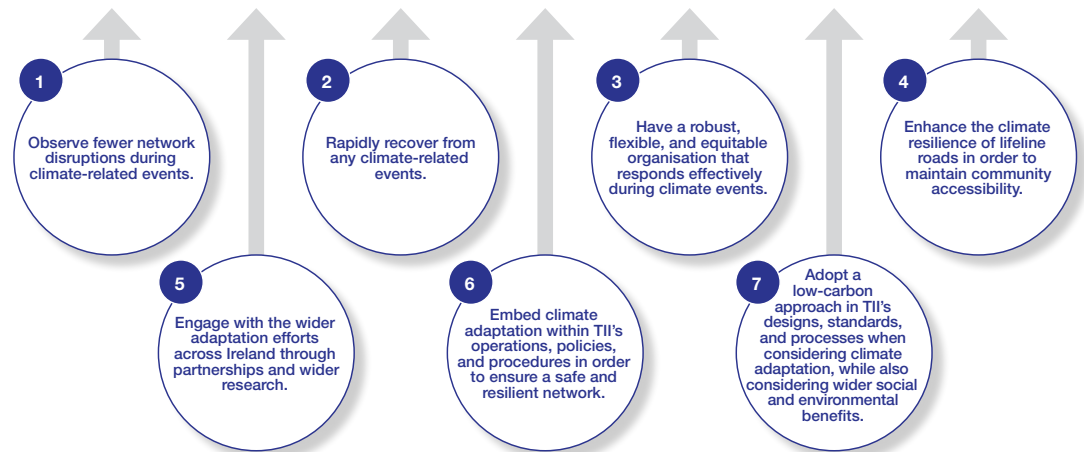
TII's purpose

To provide sustainable transport infrastructure and services, delivering a better quality of life, supporting economic growth, and respecting the environment.

TII's climate adaptation aim

To be an organisation that is adaptive to the impacts of climate change and maintain its commitment to sustainability.

TII's climate adaptation strategic objectives



TII's enabling factors

Clear governance, roles, and responsibilities to implement and lead on climate adaptation activities across TII.

Improved understanding of climate hazards, risks, and system impacts.

Climate adaptation embedded within policies and standards.

Figure 10. TII's climate adaptation aim and strategic objectives

3.1 How the climate adaptation strategic objectives align with the SIP

As outlined in figure 10, this Climate Adaptation Strategy is underpinned by seven strategic objectives for climate adaptation. These strategic objectives have been developed to reflect the six principles for sustainability (Figure 11) as presented in TII's SIP, which forms the basis of all climate-proofing activities within the organisation. ⁽¹²⁾ The seven strategic objectives have been mapped across to the six principles for sustainability, as shown in Table 3. This mapping exercise has been important in ensuring this Climate Adaptation Strategy delivers on TII's wider sustainability aims. The first two principles of sustainability have the greatest number of links with the climate adaptation strategic objectives, as those principles focus on securing safe, efficient, and resilient networks for which climate adaptation is a key requirement.

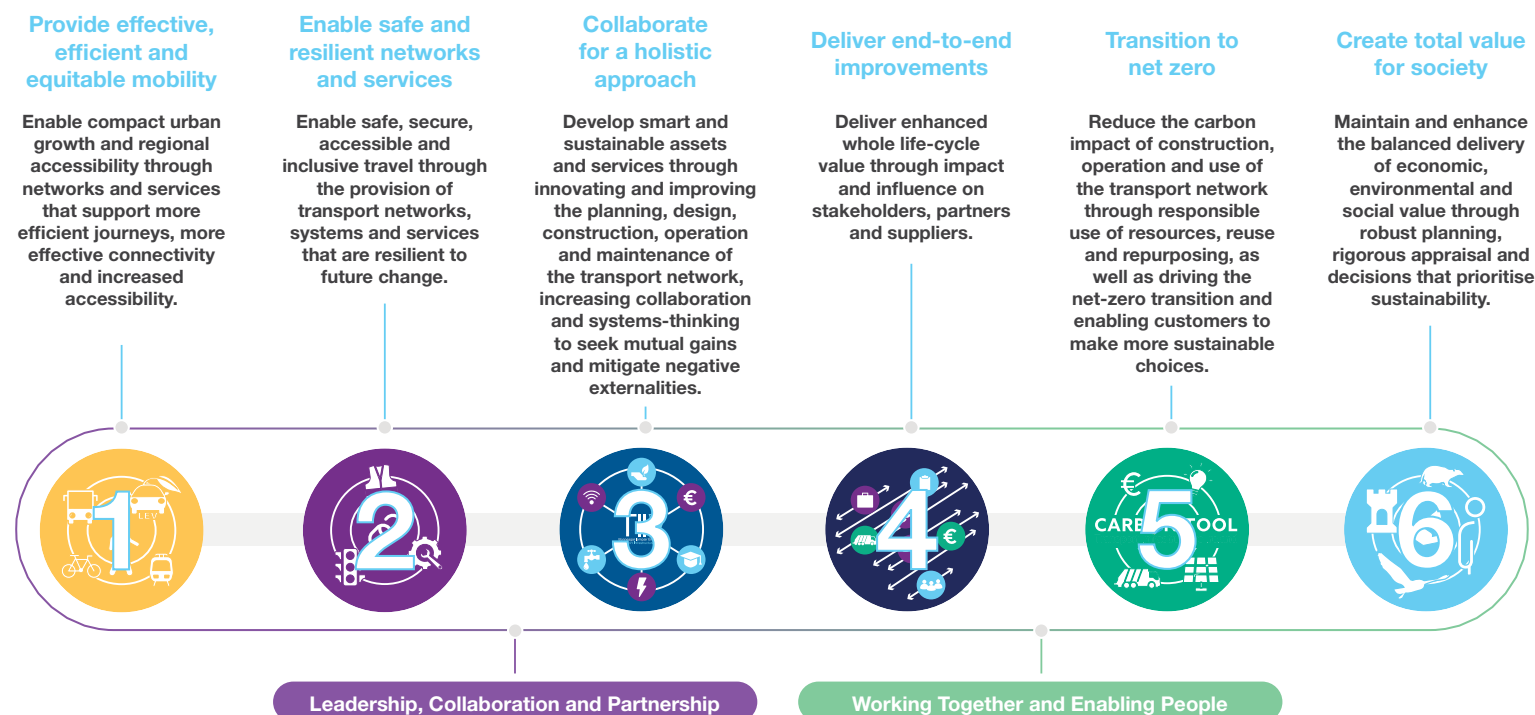


Figure 11. The six principles underpinning the SIP ⁽¹²⁾

Table 3 TII's climate adaptation strategic objectives and how they deliver on the SIP's six sustainability principles


Strategic objectives (SOs)		SIP principles that SOs align with					
		1	2	3	4	5	6
1	Observe fewer network disruptions during climate-related events	✓	✓				
2	Rapidly recover from any climate-related events	✓	✓				
3	Have a robust, flexible, and equitable organisation that responds effectively during climate events	✓	✓	✓			
4	Enhance the climate resilience of lifeline roads in order to maintain community accessibility	✓	✓				✓
5	Engage with the wider adaptation efforts across Ireland through partnerships and wider research	✓	✓	✓	✓		
6	Embed climate adaptation within TII's operations, policies, and procedures in order to ensure a safe and resilient network	✓	✓	✓	✓		
7	Adopt a low-carbon approach in TII's designs, standards, and processes when considering climate adaptation, while also considering wider social and environmental benefits	✓	✓	✓		✓	✓



TII Climate Adaptation Strategy

Section 4.

TII's understanding



4. TII's understanding of climate risks

4.1 The ongoing impacts of climate change

Ireland is already experiencing a changing climate, and the impacts are apparent. Some key evidence of Ireland's changing climate is presented in Figure 12.

Climate hazards are events or long-term changes to which TII assets can be vulnerable. Examples of climate hazards include flooding from heavy rainfall events and insufficient drainage, coastal erosion from extreme storm events that can destroy networks, or extreme high temperatures that can melt road surfaces.

Climate risks arise when hazards occur, affecting vulnerable assets and leading to a detrimental impact. For example, roads can be vulnerable to heavy rainfall events (the climate hazard) when the capacity of drainage systems is not designed to manage the rainfall intensities being experienced and would therefore be at risk from the downstream impacts of flooding, such as road closures. However, if the drainage systems' capacities were designed to accommodate the rainfall volumes, the system would not be as vulnerable to heavy rainfall events and so the risk would be lower.

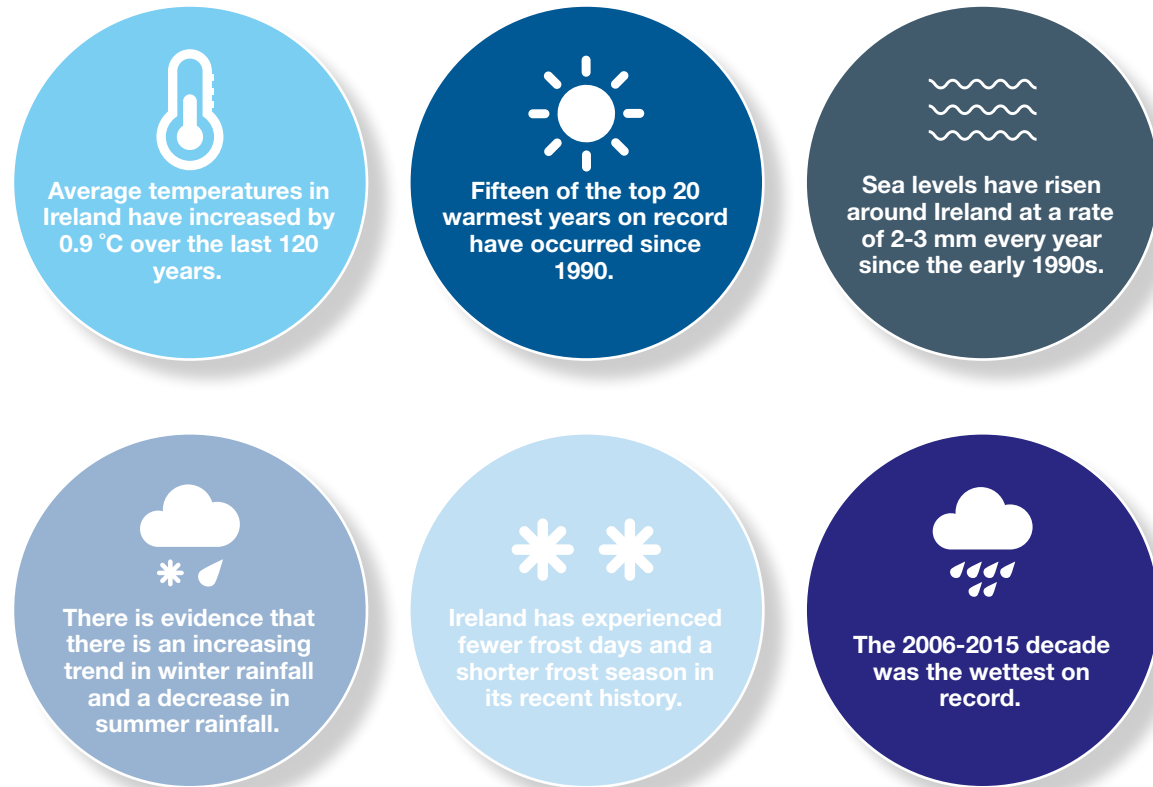


Figure 12 Current evidence of Ireland's changing climate⁽⁵⁸⁾

TII has recently experienced extreme weather events that have affected its networks and services. Some examples and the lessons learned from these events are illustrated in the case studies in Appendix A.2. These events demonstrate the vulnerability of TII's networks and services to weather events. With extreme weather events set to become more frequent and severe due to climate change, the associated disruptions have the potential to result in very real economic, social, and safety impacts. According to *The Global Risks Report 2022, 17th Edition*, climate action failure is ranked as the main long-term threat globally and identified as one of Ireland's main risks.⁽⁵⁹⁾ These extreme weather events not only result in service disruption on the National Road and light rail networks themselves, but can also lead to cascading impacts and failures across other essential systems (see Section 6.9.1 for further information on interdependencies).

Examples of these knock-on impacts include:

- Limited access to places of work and healthcare facilities
- Limited movements of essential supply chains, and
- Reduced access to other critical infrastructure sites, including power stations, telecommunications sites, and water treatment works.

4.2 Future climate projections

What are climate projections?

Even if emissions stopped immediately, past emissions are 'locked in' and will cause warming for decades to come, leading to continued climatic changes. While it is certain that the climate will continue to change, there is uncertainty regarding the magnitude and frequency of these climatic changes. This is partly driven by the range in possible future carbon emissions. To plan for future climate change despite this uncertainty, future climate projection data has been produced by meteorological organisations on behalf of the Intergovernmental Panel on Climate Change (IPCC) for a range of future emissions pathways. Examples of these pathways are the **Representative Concentration Pathways (RCPs)** and the more recent **Shared Socioeconomic Pathways (SSPs)**.^{(60) (6)}

By combining climate projections with a current understanding of how extreme weather affects TII's infrastructure and networks, it is evident that climate change will worsen some climate impacts if appropriate adaptation measures are not taken. For example, changes to the intensity and frequency of extreme weather events can exacerbate hazard profiles, including floods, strong winds, wildfires, droughts, rain-induced landslides, and storm surges.⁽⁶¹⁾

A summary of some future climate trends and resulting impacts is presented in Figure 13.⁽⁶²⁾



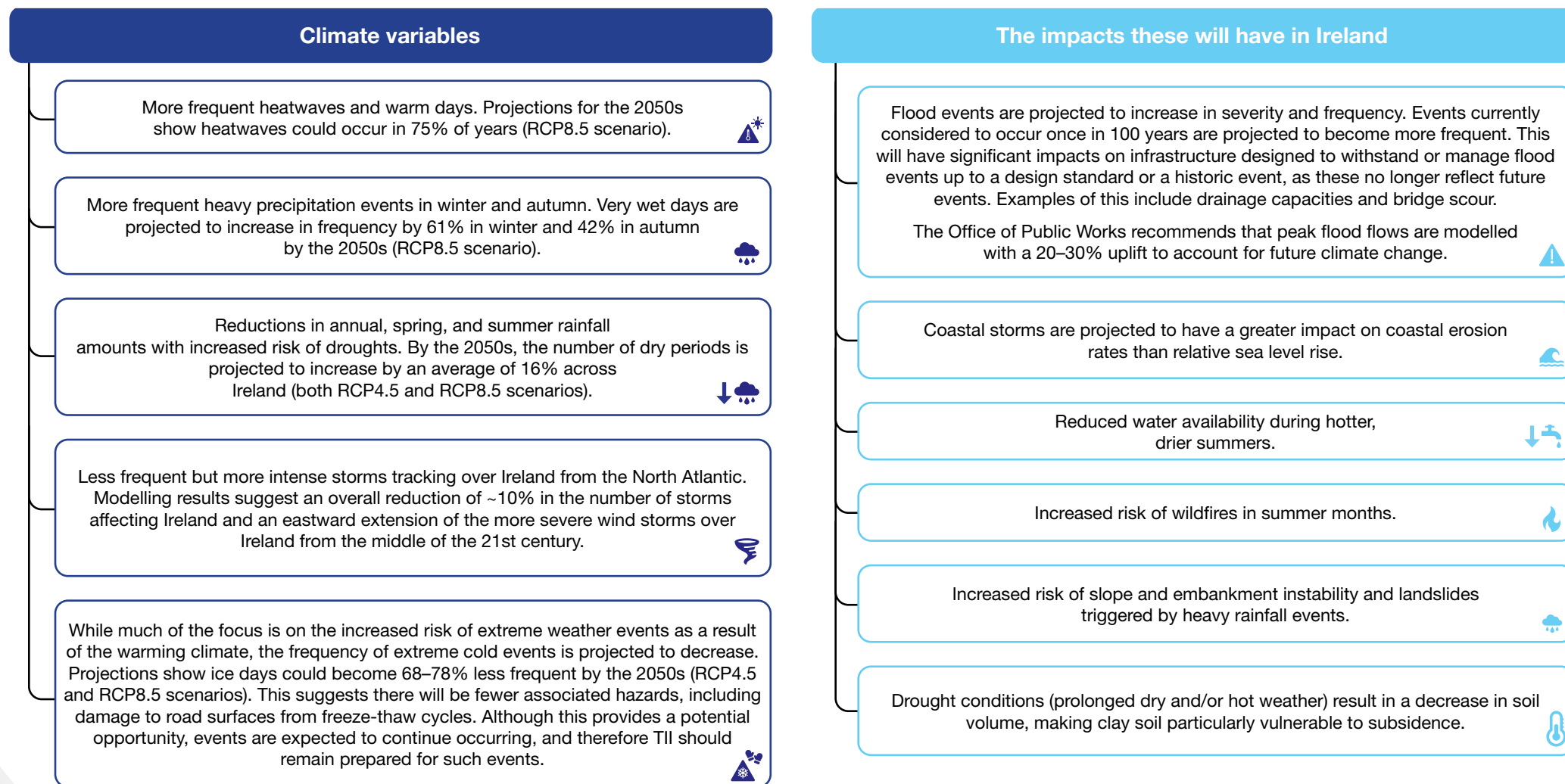


Figure 13. How climate variables are projected to change, and the associated impacts (57) (58) (62) (63)

4.3 TII's key climate hazards and risks

The climate hazards shown in Figure 14 are informed by those presented in the national *Transport Climate Change Sectoral Adaptation Plan* ⁽⁴³⁾ and the European Union's (EU's) taxonomy of climate-related hazards. ⁽⁶⁴⁾ The key climate hazards outlined in TII's previous Climate Adaptation Strategy from 2017 were those that increase the risk of flooding. This new Climate Adaptation Strategy broadens the consideration of climate hazards beyond flooding. TII will reconsider its key climate-related hazards based on the findings from the climate screenings and detailed risk assessments that will be undertaken as detailed in Section 5.

Figure 15 summarises how the key climate hazards translate to potential challenges for TII's networks and assets, with the potential for economic, social, and safety impacts.

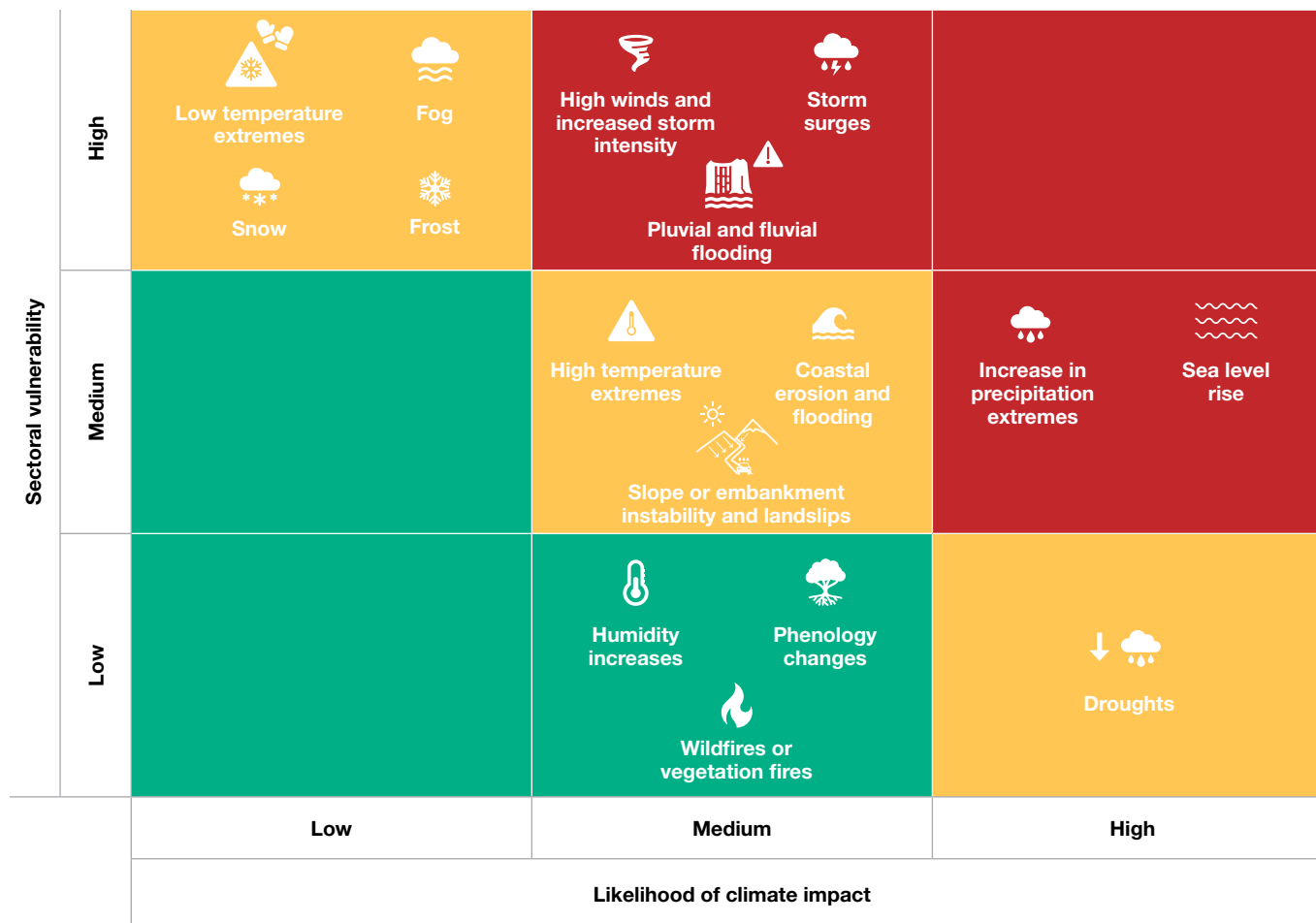


Figure 14 Climate hazard screening for the transport sector, adapted from Transport Climate Change Sectoral Adaptation Plan ⁽⁴³⁾

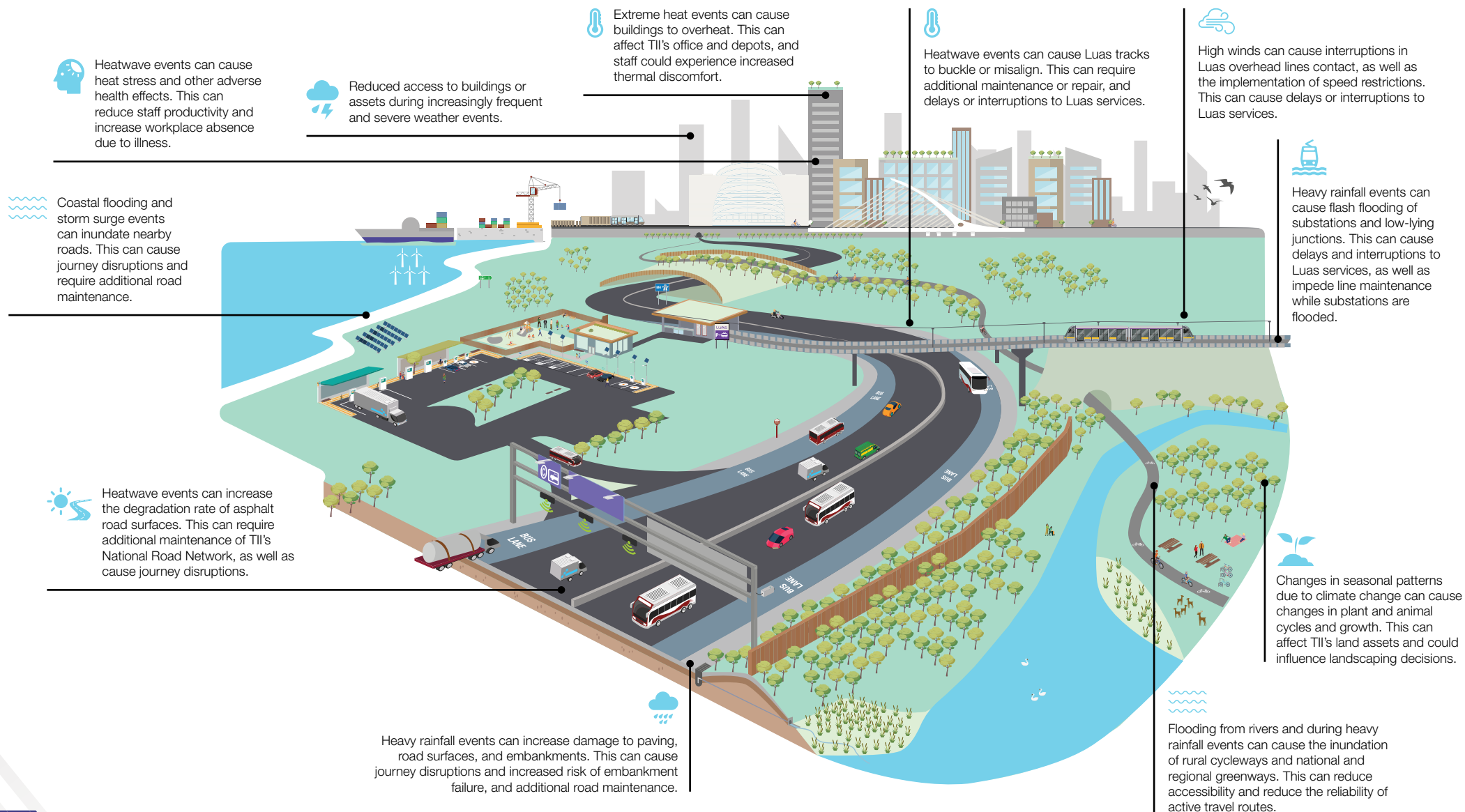


Figure 15 Infographic outlining how high- and medium-risk climate hazards affect TII's assets

4.4 How climate risks vary across Ireland

The previous sections outlined how the climate can affect the National Road, light rail, and cycleway and greenway networks across Ireland, both at present and over the coming decades. Considering climate risks at a national scale is useful for identifying which assets require the most attention. However, it is also important to understand the spatial nature of climate hazards to identify locations that are more vulnerable, ultimately ensuring that investment and adaptation measures are targeted in the correct locations.

A summary of how climate hazards and risks vary across TII's networks is shown in Figure 16. TII can combine spatial asset data with climate projection data to identify priority assets/sections of the network that would benefit from climate adaptation measures. An example of where this has been considered is the Critical Infrastructure Vulnerability to Climate Change (CIVIC) study, a research project funded by the Environmental Protection Agency (EPA).^{(56) (65)} Maps from this study that combine climate and asset data relevant to TII are presented in Appendix A.3.

Consideration must also be given to differences in vulnerability associated with the age, design life, materials, and recent investments in TII's assets. TII's understanding of past impacts of weather events can support with identifying which parts of the network are most vulnerable.

Beyond TII's infrastructure assets, it is important to consider how the risk posed by climate change can vary across TII's workforce. For example, in periods of extreme weather, staff members with underlying conditions or existing vulnerabilities, or those with caring responsibilities, may be unable to work or may have to work fully from home.

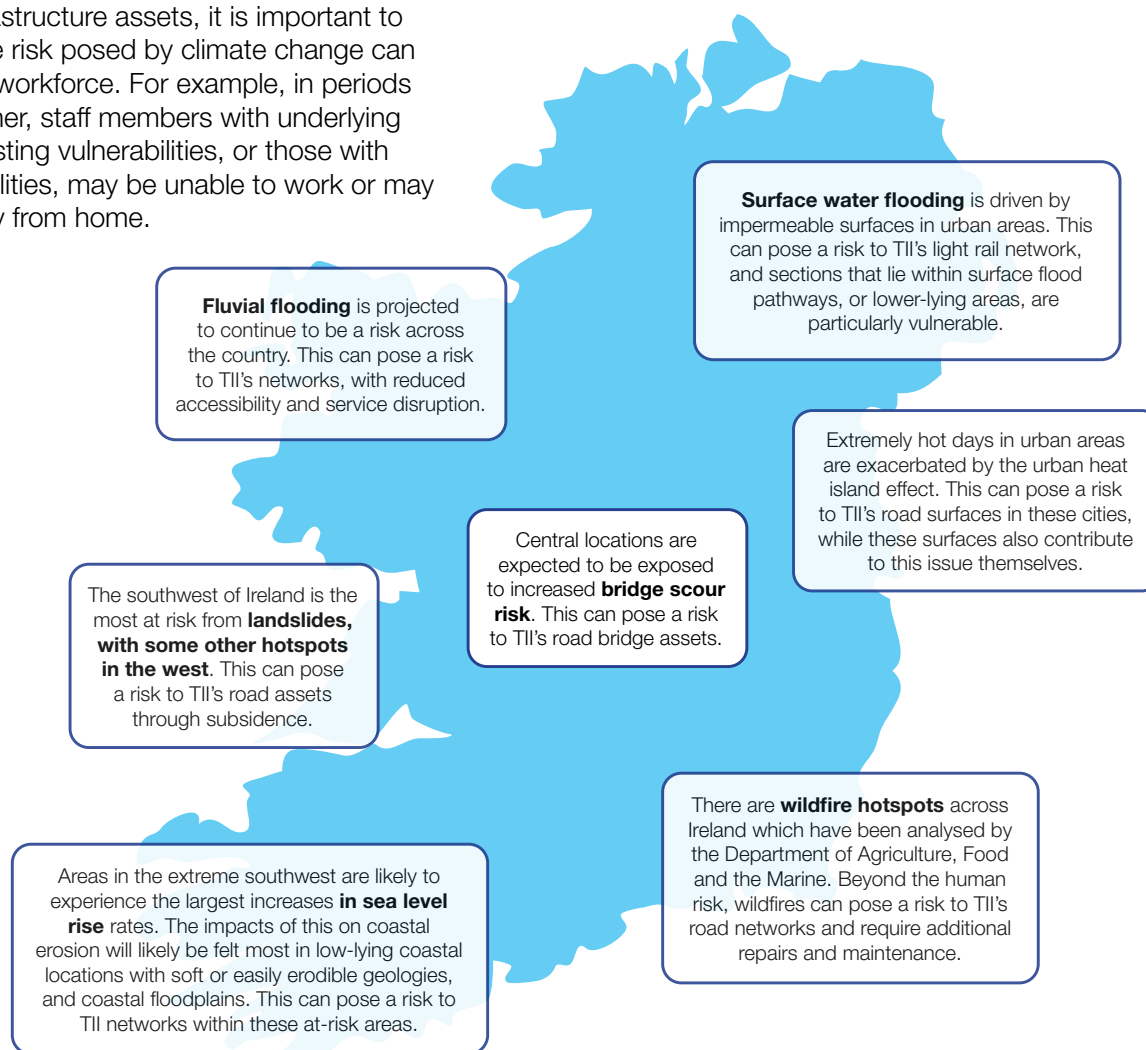


Figure 16 How climate risks and hazards vary across Ireland

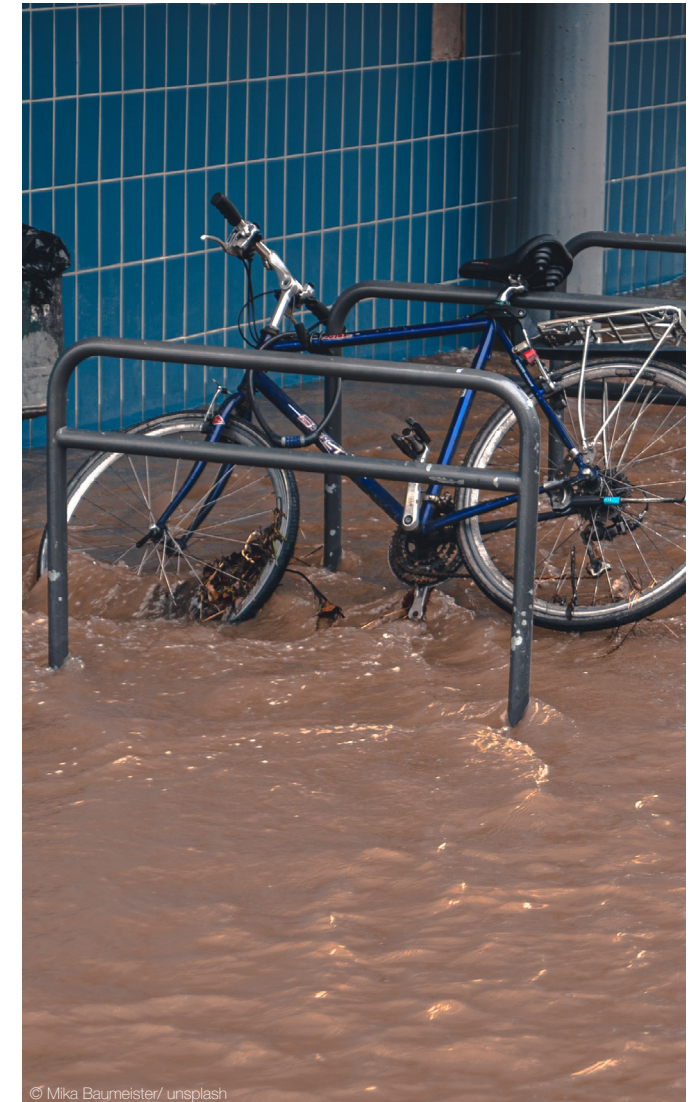
4.5 Continually improving TII's understanding of climate risks

Robust future climate projections are a key requirement in the climate adaptation planning process. However, it has typically been challenging to access climate projections in a useful format for the transport sector in Ireland. To address this, Met Éireann is currently leading Ireland's National Framework for Climate Services (NFCS), a global initiative led by the World Meteorological Organization that provides a coordinating mechanism to facilitate the development and delivery of climate services at a national scale. TII has a working partnership with the NFCS and is a key stakeholder in its TRANSLATE project, which is being delivered by Met Éireann and climate researchers from the University of Galway and University College Cork (UCC).⁽⁴⁹⁾

The TRANSLATE project has four deliverables:

1. To standardise climate projections for Ireland, using the newer SSP projections from the latest climate models
2. To document and prioritise sector-specific climate service requirements
3. To develop sector-specific climate services, and
4. To develop communication material.

The outputs from this project will inform more detailed risk assessments that will be undertaken by TII (outlined in Section 5.4) and will enable TII to make better-informed choices related to the future climate.



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TII Climate Adaptation Strategy

Section 5.

TII's approach



5. TII's approach to climate adaptation

TII's approach to climate adaptation is founded on the six-stage process outlined in the national *Sectoral Planning Guidelines for Climate Change Adaptation* ⁽¹³⁾ and summarised in Figure 17. This approach aligns with the approach adopted by the *Transport Climate Change Sectoral Adaptation Plan*. ⁽⁴³⁾ Further detail on each of these six stages is provided in Sections 5.1–5.6. It is intended that this approach and strategy will be reviewed on a cyclical basis every 5 years, aligning with the cycle being adopted by government sectors.

Adopting this six-stage process progresses the climate adaptation approach by considering a wide range of climate-related hazards and all six of TII's asset types (see Table 3). This enables climate adaptation to be considered across the organisation, beyond the National Road and light rail networks that were the focus of TII's 2017 Climate Adaptation Strategy. ⁽⁹⁾

This six-stage process provides the framework within which TII can deliver on its seven strategic objectives for climate adaptation, presented in Section 3. Incorporating carbon mitigation and climate adaptation into this process will enable TII to develop a net zero and resilient future that is aligned with Ireland's national ambitions.

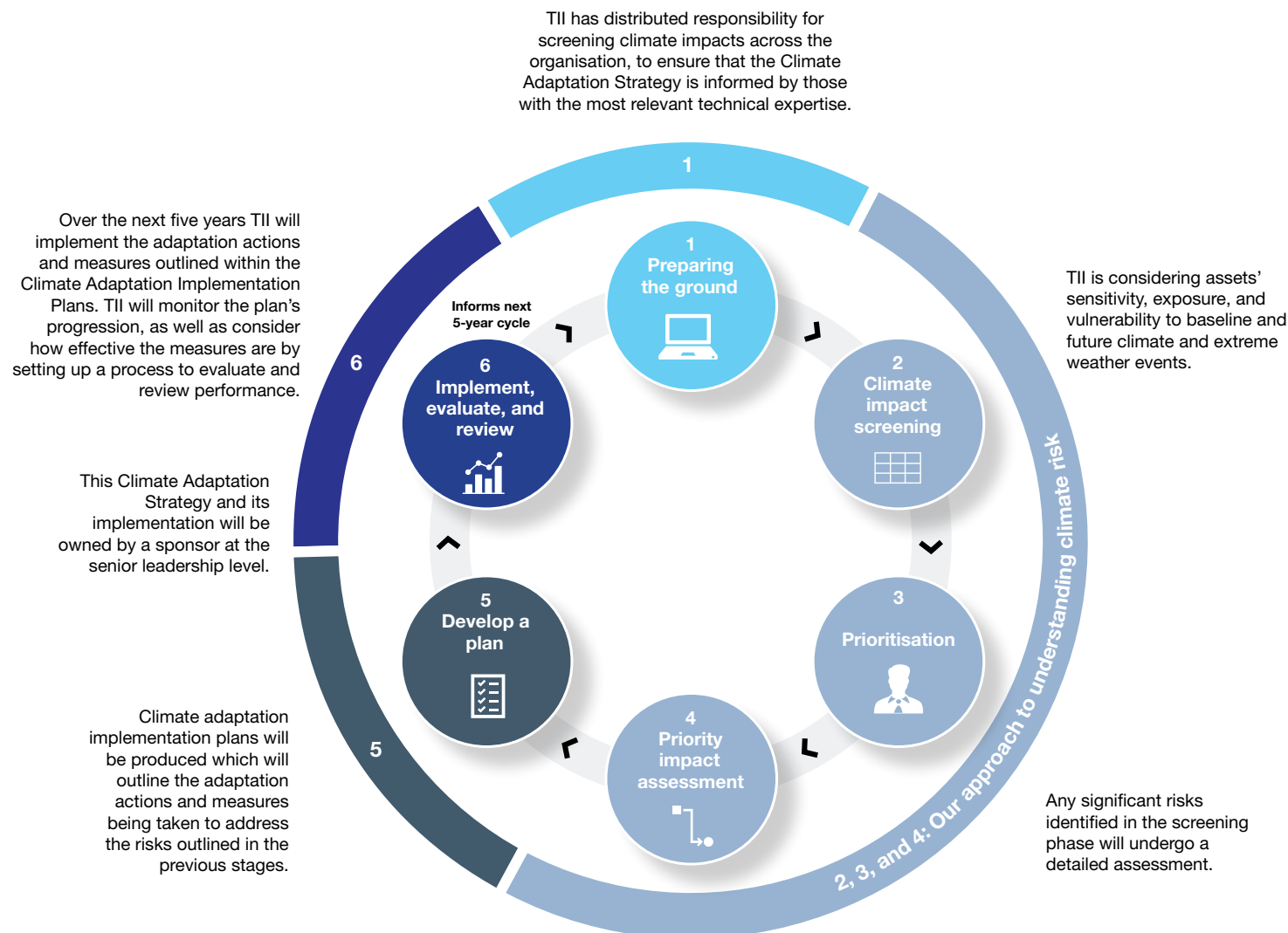


Figure 17 TII's climate adaptation approach, adapted from the Sectoral Planning Guidelines for Climate Change Adaptation ⁽¹³⁾

5.1 Stage 1: Preparing the ground

This Climate Adaptation Strategy forms the main output of Stage 1 of the six-stage adaptation process and lays the foundations for Stages 2–6. It also ensures effective governance of climate adaptation, as outlined in Section 7. This Climate Adaptation Strategy acts as a springboard for other adaptation activities in which TII embeds climate adaptation and climate-proofing into ‘business as usual’ activities across the organisation.

This Climate Adaptation Strategy has been informed by extensive engagement across the organisation. Engagement has included workshops and has resulted in knowledge sharing across TII that has provided several immediate benefits, which include:

- Improving the understanding of the importance of climate adaptation and how it relates to broader sustainability themes
- Enabling a wider understanding of TII’s key climate risks, as identified in the *Transport Climate Change Sectoral Adaptation Plan*
- Highlighting and bringing together the significant volume of work which is already ongoing in climate adaptation across TII, supported by lessons learned from past extreme weather events and the efficacy of interventions to adapt to climate change and extreme weather events, and

- Identifying gaps in adaptation action, particularly when considering non-infrastructure-based adaptation and the importance of organisational resilience to climate change; this has led TII to emphasise the importance of assessing climate impacts across its six asset groups (see Table 3).

5.2 Stage 2: Climate impact screening

Climate impact screening assessments will be undertaken across the organisation to consider how climate change impacts TII’s assets. This stage aligns with Phase 1 (screening) from the two-phase approach set out in *Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline and Greenways) – Overarching Technical Document*.⁽²⁴⁾ This guidance has been informed by and is aligned with the European Commission’s *Technical guidance on the climate proofing of infrastructure in the period 2021-2027*.⁽⁴⁾



The climate impact screening assessment comprises three stages:

1. Sensitivity: The extent to which the climate hazard may affect the asset, irrespective of location. For example, road surfaces may be more sensitive to the impacts of heavy rainfall and flooding than they are to high winds, whereas the Luas would be more impacted by high winds. If impacts to the asset affect overall service delivery and cause disruption, this will be a priority taken forward to the next stage. The sensitivity rating should also consider how the climate hazard in question can affect other systems (such as the electricity grid) that could have knock-on or interdependency effects for TII's assets. For example, extreme weather events can result in electricity outages, which limits the availability of traction power for the Luas network.

2. Exposure: The extent (frequency and severity) to which Ireland experiences the climate hazard in question. In this climate impact screening stage, exposure will be considered at the national scale. Climate data will be used to inform the scores here, for both present day and future climate scenarios. For the future scenarios, TII will assess climate risks under medium and high emissions scenarios (RCP4.5 and RCP8.5, respectively). These scenarios have been selected as they align with the *Transport Climate Change Sectoral Adaptation Plan*⁽⁴³⁾ and the latest transport sector climate indicators being developed by Climate Ireland.⁽⁵⁸⁾ The most severe score will be taken forward for the vulnerability rating.

3. Vulnerability: For each asset type, an overall vulnerability score will be produced by combining the sensitivity and exposure scores. These scores will be used to categorise whether the asset type has low, medium, or high climate vulnerability.



5.3 Stage 3: Prioritisation

The outputs from Stage 2 (climate impact screening) will be used to identify the key assets that need to be prioritised for further investigation. Assets identified with a vulnerability score of high or higher will be prioritised and taken forward to the next assessment phase (Stage 4), requiring a more detailed climate risk assessment. Assets with a climate vulnerability score of medium can also be taken forward, at the discretion of TII. The output of this stage will be a list of assets and their medium/high hazards.

5.4 Stage 4: Priority impact assessment

Stage 4 involves undertaking a more detailed climate risk assessment (a priority impact assessment) for each of the priority assets and hazards identified in Stage 3. This aligns with the second phase of the European Commission's *Technical guidance on the climate proofing of infrastructure in the period 2021-2027*.⁽⁴⁾

Each asset and hazard combination will be assigned likelihood and consequence scores; these will be combined to give an overall risk score, as detailed below:

- **Likelihood:** How likely the hazard is to occur, based on future scenario data.
- **Consequence:** The severity or magnitude of the impact associated with the climate hazard, should it occur.
- **Risk:** A function of likelihood and consequence.

The assessment methodology for this stage is subject to change. It will likely be influenced by the sector-specific climate projection data being produced by the Met Éireann-led TRANSLATE project,⁽⁴⁹⁾ which will inform the likelihood score, and the consequence score will be informed by the transport climate adaptation indicators being developed by the EPA-funded Climate Ireland and builds on the work of the EPA funded research project 379.⁽⁵⁷⁾ One potential assessment method is to use a geographic information system (GIS) to record or identify particularly vulnerable assets or sections of the networks, which can be used to define spatially variable consequence or impact scores. This GIS approach is dependent on the outputs of the TII Asset Management Strategy.⁽¹⁷⁾ Information on the criticality of an asset or network section (e.g. traffic volumes, or proximity to strategic locations) will be used to inform the potential consequence of asset failure and support the prioritisation of adaptation actions.

The likelihood and consequence ratings will be combined to assign a risk rating (see Table 4). The initial risk rating will consider the existing or planned controls.

The assessment will be repeated when adaptation measures have been identified in order to derive a residual risk rating and ensure that residual risks are at an acceptable level.



Likelihood	Almost certain					
	Likely					
	Moderate					
	Unlikely					
	Rare					
		Insignificant	Minor	Moderate	Major	Catastrophic
		Consequence				

KEY

Low risk

Medium risk

High risk

Severe risk

Table 4 Priority impact assessment risk matrix, as per the European Commission's *Technical guidance on the climate proofing of infrastructure in the period 2021-2027* ⁽⁴⁾

5.5 Stage 5: Develop a plan

TII will produce climate adaptation implementation plans in order to address the most significant risks identified in Stage 4. The future climate adaptation actions in these implementation plans will include a mixture of 'soft', 'green', and 'grey' adaptation measures, as summarised in Table 5.

It is important that adaptation measures are embedded across the asset life cycle, through (1) planning, (2) design, and (3) operation. Climate adaptation measures will vary significantly across asset and network types, and, due to differing responsibilities for the operation and maintenance of assets, the approach for each asset type will diverge at this stage.

It is important to consider that the development of long-term climate resilience for TII's transport systems should not limit economic growth, social progress, or Ireland's wider efforts to decarbonise the transport sector. ⁽⁴²⁾ There are trade-offs to be considered when developing and prioritising adaptation measures; for example, grey adaptation options are typically more carbon-intensive, which would impact on the ability to deliver on the fifth SIP principle, "Transition to net zero". Where possible, TII will adopt a low-carbon approach in its designs, standards, and processes when considering climate adaptation, while also considering wider social and environmental benefits, as per its seventh strategic objective (see Section 3). This aligns with the carbon reduction approach set out in PAS 2080¹ for carbon management. ⁽⁶⁶⁾

¹ Note that PAS 2080 is due to be updated by the end of 2022.

The social implications of the climate adaptation implementation plans will also be considered. For example, the impact that any intervention might have on more vulnerable communities – such as people with disabilities, the young, and the elderly – will be considered. This will align with TII’s responsibilities under the Irish Human Rights and Equality Commission Act 2014. ⁽⁶⁷⁾

The draft implementation plans can be analysed by assessing the residual climate risks to TII’s assets based on the chosen adaptation measures in each plan in order to ensure that any residual risks are acceptable to TII and its customers.

Table 5 Soft, green, and grey adaptation measures

Adaptation measure type	Definition	TII’s current examples	TII’s future examples
Soft	Policy, managerial, or legislation based approaches designed to alter human behaviour and styles of governance towards climate change impacts, such as changes to policies or processes.	<ul style="list-style-type: none"> The Luas Severe Weather Management Plan provides guidance on how to respond to future extreme weather events and minimise the impact of the changing climate on TII assets. ⁽³⁴⁾ 	<ul style="list-style-type: none"> Conduct or support wider research into areas where TII does not fully know or understand the potential impacts of climate change. Support the redevelopment of technical standards or policies to ensure they appropriately consider climate change.
Green	Measures that make use of the natural environment and seek to use nature-based properties to enhance the resilience of human and natural systems to climate change impacts.	<ul style="list-style-type: none"> Supporting peat rehabilitation through hydrological controls and drain blocking, in partnership with the National Parks and Wildlife Service. Replanting or afforestation of land. Installing Sustainable Drainage Systems (SuDS). Taking measures to enhance biodiversity and create or maintain pollinator corridors. 	<ul style="list-style-type: none"> TII plans to provide shade and tree planting to ensure that greenways can be used in extreme heat.
Grey	Measures that involve technical or engineering solutions to climate change impacts.	<ul style="list-style-type: none"> Amending road or greenway elevation or implementing flood defences to accommodate flood levels. Managed realignment in coastal areas. Replacing existing drainage systems to increase capacity in line with expected increases in heavy rainfall. 	

5.6 Stage 6: Implementation, monitoring, and review

5.6.1 Implementation

Following the development of climate adaptation implementation plans, TII will implement the identified adaptation actions and measures. By doing so, TII will deliver on its seven climate adaptation strategic objectives set out in Section 3.

TII will use available tools, such as TII's *Climate Guidance for Roads, Light Rail, and Rural Cycleways (Offline and Greenways) – Overarching Technical Document* ⁽²⁴⁾ and the *TII Carbon Tool for Road and Light Rail Projects: User Guidance Document*, ⁽²⁶⁾ in order to ensure that the delivery of the measures considers their total environmental impact. TII will also review and update its standards, where required, to embed climate adaptation across its processes and decision-making.

5.6.2 Monitoring and review

To understand progress in climate adaptation, TII will regularly evaluate its progress towards the proposed actions outlined in Section 8, and towards those identified in the climate adaptation implementation plans. It is anticipated that this evaluation process will adopt indicators developed through the case study undertaken with Climate Ireland which builds upon the EPA-funded Research Project 379. ⁽⁵⁷⁾

This review process will involve regular engagement with those divisions across the organisation that are overseeing the implementation of climate adaptation measures and actions.

This process will enable TII to update its climate adaptation measures based on future improvements in climate risk understanding, or learnings from extreme weather events. Monitoring against TII's climate adaptation plans will also provide insight into whether potential maladaptation or other unanticipated side effects are occurring that may have previously been unknown, and ensure that any such maladaptation is not locked in. This will support the development of TII's next Climate Adaptation Strategy and form a key part of the 5-year climate adaptation cycle being adopted by Government sectors.



TII Climate Adaptation Strategy

Section 6.

TII's progress



6. TII's progress on climate adaptation

Since the publication of TII's first Climate Adaptation Strategy in 2017, there have been significant advancements that have driven the need for this second Climate Adaptation Strategy, as shown in Figure 18. This section details TII's progress on embedding climate change adaptation into major and minor schemes over the past five years using technical adaptation measures. This section also outlines the key partnerships which ensure that the organisation can collectively adapt to climate change. For example, TII is partnering with Climate Ireland to establish climate resilience indicators to measure the outcomes of TII's adaptation actions. Using these indicators will support TII to quantify the benefits and assess the effectiveness of its climate adaptation measures.

While TII is adapting to climate change, it recognises the importance of not contributing further to emissions which could exacerbate climate change. Climate mitigation activities, also referred to as carbon reduction measures, are needed to reduce future climate change, and are being considered in TII's Climate Action Roadmap. ⁽¹¹⁾

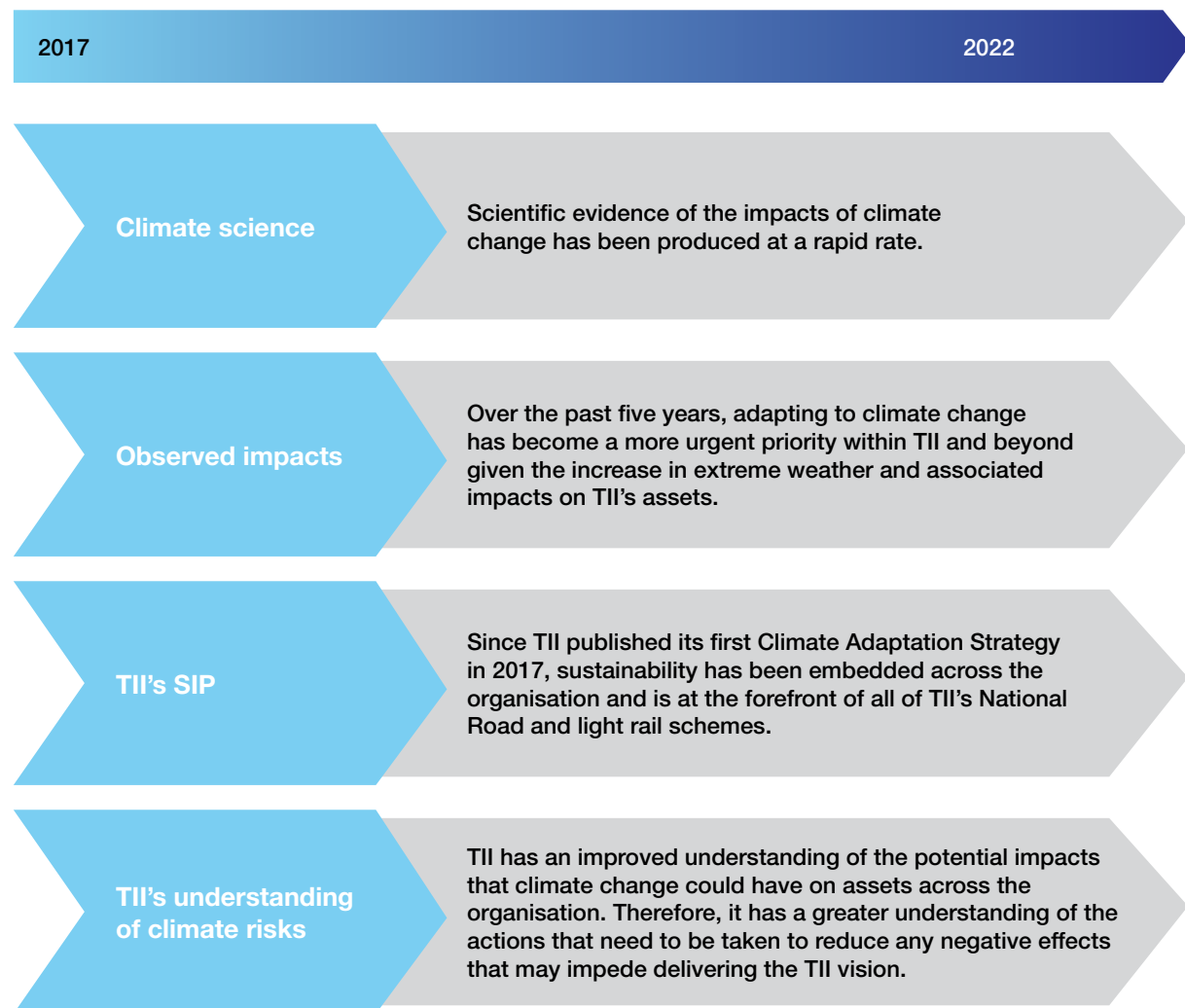


Figure 18 Climate adaptation developments since publishing the 2017 Climate Adaptation Strategy

6.1 National Roads

To date, TII's National Road network has typically performed well during extreme weather events. For example, there has been minimal structural damage to pavements from extreme weather over the past ten years. However, the TII National Road network has experienced some impacts from such events. One example of this occurred in September 2016, when the N11 at Silverbridge in Bray, County Wicklow was subject to erosion and scour from the river Dargle. More detail about this event is outlined in Case Study 3 (Appendix A.2).

Table 6 outlines how TII is supporting the adaptation of the National Road network to ongoing and future climate change. The table shows how adaptation measures are important to consider across the design and operation/maintenance phases of the assets' life cycles.

Table 6 National Road network's progress on climate adaptation

Design	
Irish Analytical Pavement Design Method	Road pavements are now designed using the Irish Analytical Pavement Design Method (IAPDM), which incorporates current climate projections into the design methodology. Traditionally, pavements were designed without consideration of climate change factors. ⁽⁶⁸⁾
National road upgrades	A large portion of the motorway network has been completed or upgraded since 2010, and the single carriageway network has had structural overlays where necessary to strengthen the road pavement and improve resilience to extreme weather events.
Climate assessment of proposed National Road projects	TII is producing the <i>Climate Assessment of Proposed National Road Projects – Standard</i> , ⁽³¹⁾ which includes a methodology for incorporating climate adaptation into new road schemes. This is being developed alongside the <i>Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline and Greenways) – Overarching Technical Document</i> . ⁽²⁴⁾
Mass Haul	The Sustainable Earthworks Mass Haul analysis tool (Mass Haul) has been developed to assist TII in highlighting opportunities for more sustainable design through earthworks and haulage optimisation. It will improve the evaluation and analysis of earthworks requirements to support climate-focused designs.
TII Carbon Tool	TII has developed and is implementing a carbon tool for road and light rail projects to assess the carbon impact of each project. The carbon tool supports TII in understanding the carbon emissions of proposed climate adaptation options, and therefore ensures that trade-offs between resilience and mitigation measures are understood. The <i>TII Carbon Tool for Road and Light Rail Projects: User Guidance Document</i> provides guidance on the carbon tool. ⁽²⁶⁾

Table 6 National Road network's progress on climate adaptation

Operation and maintenance	
TII Winter Service Manual	The <i>Winter Service Manual</i> was published by TII in 2022 and sets out mandatory requirements and guidance for the management and provision of winter service on sections of the National Road network managed by local authorities. ⁽³³⁾ TII has facilitated significant improvements in relation to winter service by developing a sophisticated national weather prediction system, funding capital improvements, and providing specialised training for designated local authority staff. The aim of this is to make the roads safer and more resilient during extreme winter weather, based on lessons learned from previous winters (as outlined in Case Study 4 in Appendix A.2).
Artificial intelligence for weather warnings	TII is using artificial intelligence to detect types of climatic conditions and linking this information to advanced Variable Message Signs (VMS) on the National Road network. For example, the VMS direct drivers to drive cautiously during hail events, with the aim of improving road safety. More detail on this is presented in Case Study 5 in Appendix A.2.
TII Asset Management Strategy	TII is currently developing an Asset Management Strategy, of which climate adaptation and mitigation will be an integral part. This Asset Management Strategy will assist TII with its approach to climate adaptation as it will provide TII with asset-specific management plans.
dTIMS for pavement asset management	TII uses an asset management system (dTIMS) which stores critical information on the characteristics and condition of the pavement network. TII is exploring the possibility of integrating its existing climate risk analysis (for example, on flooding) into this asset management system. This will give TII a holistic picture of its road network and the risks to which it is exposed, so that an integrated approach can be taken for the network.
Pavement condition surveys	TII conducts annual surveys as part of its road pavement management procedures to assess the condition of the National Road pavements, which is recorded in dTIMS. This data allows TII to project the rate of deterioration – for example, as a result of weather and climate change events – to inform necessary maintenance interventions based on best practice asset management principles.
Reduction in road salting	TII will be making a major investment over the next four years in transport depots to improve the efficiency of salt spreading, with the objective of reducing the amount of salt being used on the road network by 10–20%. TII plans to transition from dry salt spreading to pre-wet spreading operations. This will require investment in depot facilities such as salt saturators and brine storage tanks, along with the upgrade of spreading equipment to have pre-wet capabilities. This will increase TII's ability to respond to extreme weather and minimise disruptions to the National Road network, while also reducing carbon emissions. This is detailed further in Case Study 4 in Appendix A.2.

6.2 Land

TII is addressing the climate and biodiversity emergency that was declared in 2019 in terms of management of its land. TII strives to increase the quality and quantity of green infrastructure across its network. Along with supporting local biodiversity, green infrastructure can also provide climate adaptation and wider benefits, both to the assets and to the service users. For example, tree cover reduces the ground temperature, which can support in protecting assets during high temperatures, alongside providing water attenuation, carbon sequestration, social amenity, and air quality benefits.

Natural interventions and solutions are multifunctional, and their value is linked to wider environmental and social benefits as well as offering climate resilience. Once the soft landscaping has been established, TII's management approach in many areas is a limited intervention and self-sustaining approach.

TII also recognises the value of nature-based solutions and the many community benefits that a well-designed and maintained landscape can bring to those who live along and use its varied transport corridors.

A summary of how the climate and biodiversity emergency is being addressed is shown in Table 7.

Table 7 Progress on climate adaptation and biodiversity

Development of design standards and strategies	
TII Soft Landscape Standard	TII is developing a Soft Landscape Standard which will consider how native species are impacted by climate change, and will detail which species should be planted along TII's transport networks.
TII Biodiversity Strategy	TII is developing a Biodiversity Strategy that will promote climate adaptation on the transport network. TII's Biodiversity Strategy will align with the <i>EU Biodiversity Strategy for 2030</i> to set out actions for reversing the degradation of ecosystems and protecting the natural environment. ⁽⁴⁷⁾
Pollinator-friendly management of: Transport Corridors	TII co-authored <i>Pollinator-friendly management of: Transport Corridors</i> as part of the All-Ireland Pollinator Plan. Having genetic and species diversity across TII's network will assist TII in its adaptation efforts through providing benefits such as preventing landslides and soil erosion, and limiting the impact of extreme flooding, heat, and air pollution. This also assists in supporting the national adaptation effort of which biodiversity is a core tenet. ⁽²¹⁾
Project life cycle	
Biodiversity reviews	Reviews are conducted, as appropriate, on transport projects within TII in order to ensure that biodiversity features such as trees and plants are being considered.
Embedding biodiversity expertise within TII and local authorities	TII aims to embed biodiversity expertise in transport infrastructure design teams and establish a centre of knowledge within the organisation to review infrastructure designs. As part of this process, TII is also providing informal support to local authorities which are delivering TII-funded schemes. In this way, TII can play a pivotal role in ensuring that local authorities can support efforts to increase biodiversity and create connected wildlife corridors throughout the country.
Project life cycle	
Land restoration surveys	TII is developing surveys to assess the suitability of land for restoration. One restoration approach, tree planting, can effectively support the prevention of soil erosion, reduce surface water flooding, lower the air temperature, and increase biodiversity, all of which support climate adaptation and the development of resilient systems.

6.3 Light rail

Recently, TII's light rail network has experienced disruptions to Luas services and operations as a result of extreme climatic conditions, such as flooding (as exemplified in Case Study 1 in Appendix A.2) and during some significant snowfall events. Lessons learned from such events have led to the development of the Severe Weather Management Plan, summarised in Table 8.

6.4 Rural cycleways and greenways

TII is responsible for delivering some of Ireland's greenway routes. This is a new remit in which TII is developing its understanding of climate change impacts through the creation of its asset risk screening. TII is set to incorporate these learnings into future designs of greenways. Table 9 summarises some key relevant progress that is supporting TII with its climate adaptation agenda.

Table 8 Light rail network's progress on climate adaptation

Operation and maintenance	
TII Severe Weather Management Plan	The Severe Weather Management Plan provides guidance on how to minimise the impacts to Luas services in the event of extreme weather conditions through detailed procedures, including the cessation of Luas operations. A decision to pause Luas operations is influenced by infrastructure capabilities and availability of equipment used to reduce the impact of extreme climate conditions. This guidance provides staff with an improved understanding of how to respond during events and will lead to improved outcomes for Luas users. ⁽³⁴⁾
Collaboration	Collaboration between the Commercial Operations and Network Management divisions has allowed for the sharing of experiences and lessons learned about winter service provision. This has led to an improved understanding of overall winter service capability within the organisation and yielded enhancements in that capability.

Table 9 Progress on climate adaptation for rural cycleways and greenways

Design	
Rural cycleway design standard	TII has recently published updated technical standards for greenway development: <i>Rural Cycleway Design (Offline & Greenway)</i> . ⁽⁶⁹⁾ This standard identifies the types of pavements used to build such infrastructure and any risks associated with these pavement types, such as erosion.
Partnership working	
National and regional greenway programme	The development of the national and regional greenways programme, the National Cycle Network, and major rural active travel projects is coordinated to maximise synergies and overall network development. The development of these programmes is coordinated with partner and stakeholder organisations – such as local authorities and the National Transport Authority – which are advancing local, county, and urban cycle and pedestrian networks. The collaborative approach enables TII to pass on its improved understanding of climate risk to other organisations in order to influence decision-making and improve climate resilience across the wider cycle network. ⁽²⁰⁾

6.5 Buildings

TII has been carrying out works on its building assets relating to climate mitigation, as summarised in Table 10. These mitigation efforts are an important part of TII's climate-proofing approach.

Climate adaptation is an emerging area, and an improved understanding of the risks posed by climate change to TII's buildings will be developed through the climate risk screening process (see Section 5.2). TII endeavours to monitor the performance of its core building assets and look for opportunities to improve its efficiency.

Table 10 TII's progress on climate mitigation for buildings

Operation and maintenance	
Decarbonisation of buildings	TII is investigating decarbonisation opportunities across its assets and operations. TII has identified that the three Luas depot roofs are extensive, making them ideal locations for the generation of renewable electricity. TII has commenced phase one of a renewable energy project which involves the installation of a rooftop solar photovoltaic array. This will assist with national climate adaptation efforts through on-site generation of electricity, reducing TII's reliance on the national grid. TII is reviewing wider opportunities for rooftop or ground-mounted photovoltaic arrays at its motorway maintenance depots distributed across the National Road network, and, where feasible, will develop on-site generation projects.
Energy efficiency	
Public sector energy efficiency targets	TII is working to meet the public sector energy efficiency targets for 2030. For example, TII's headquarters now operates with greater efficiency due to the replacement of core heating and cooling equipment on all three Parkgate Street buildings. Similar core equipment upgrades have also been completed at the Luas Sandyford depot building following the extension of the building. Additionally, all lighting uses energy-efficient light-emitting diode (LED) technology.
Building management system	Space and water heating is controlled from a central building management system (BMS) and an intelligent lighting system operates based on people's presence and activity within the offices. This enables improved energy efficiency and is particularly important given the newly established hybrid and blended working approaches.

6.6 People

It is crucial for TII to consider its people within its approach to climate adaptation and ensure that measures are in place to accommodate safe working environments during extreme weather events. Table 11 summarises staff policies that enable the workforce to continue working in a safe way during such events.

Table 11 TII's progress on considering climate impacts on its people

Policy	
Flexible and remote working	Over the past two years, human resources have implemented flexible working and a remote working policy. In the event of extreme weather, the workforce now has improved capability to continue working remotely.
TII Severe Weather Policy	TII has a Severe Weather Policy which informs decision-making during extreme weather events – for example, deciding to close or delay opening of offices and indicating when to instruct members of staff to stay home and work remotely. TII continues to assess the risks climate change poses to its staff and what measures it can introduce to mitigate these risks.

6.7 Procurement

TII is developing strategies which incorporate climate mitigation and adaptation into the procurement of its contracts. TII is committed to compliance with EU and national legislation and related regulations, as well as departmental and Office of Government Procurement guidelines, circulars, and codes of practice that are relevant to the procurement of works, supplies, and services. ⁽⁷⁰⁾ Table 12 summarises the work undertaken related to embedding sustainability into TII's procurement process.

Table 12 TII's sustainable procurement progress on climate adaptation and mitigation

Guidance	
TII Sustainable Procurement Guidance	TII's Sustainable Procurement Guidance (2021) is an internal document which is based on the EPA's publication, <i>Green Public Procurement: Guidance for the Public Sector</i> . ⁽⁷¹⁾ TII is developing a library of sustainable selection and award criteria questions across all sectors which contract managers can draw on during the development of tender documents. ⁽⁷²⁾

Governance

Sustainability Procurement Assurance Committee

TII is submitting a proposal to form a Sustainability Procurement Assurance Committee that TII staff will be able to consult on sustainable initiatives to include when drafting tenders. The Committee will focus on key critical areas where sustainability measures can be embedded into a procurement process during its review of tenders. These key areas include market engagement, exclusion and selection criteria, technical specifications, award criteria, and contract performance clauses.

6.8 TII's support of Ireland's wider climate and biodiversity agenda

TII recognises that climate hazards affect not only its assets but also the wider community. Ireland's approach to climate adaptation is an ongoing effort, and, as an organisation, TII will work collaboratively to support this wider agenda. Table 13 overleaf, provides some examples of the ways in which TII's adaptation efforts also provide wider environmental benefits to society.

Table 13 Wider benefits created by TII's climate adaptation activities

Flood risk	
SuDS	TII promotes the installation of SuDS across its networks, which protect the infrastructure while reducing the risk of flooding to nearby homes and properties.
Biodiversity	
Tree planting	Trees sequester carbon, prevent soil erosion, increase biodiversity, support water retention and quality, and create pollinator pathways. TII seeks opportunities to incorporate tree planting into schemes where possible.
Improving habitat connectivity	TII is supporting habitat connectivity improvements across the wider landscape and reducing fragmentation effects. TII owns and manages 14000 ha of land assets on the National Road network, which can be used to boost biodiversity. ⁽¹⁷⁾
Environment	
Reducing air pollution	<p>Increasing temperatures will worsen air quality and pollution. TII is taking steps to reduce its contribution to air pollution, including the following:</p> <ul style="list-style-type: none"> • Incentivising low-emission vehicles through the Low Emissions Vehicle Toll Incentive. • Providing active travel measures (including cycleways and greenways) alongside the Luas network, which will reduce air pollution by reducing the number of vehicles on the road • The development of a Road Emissions Model (REM) to quantify and visualise GHG emissions of vehicles on the National Road network; this tool can be used to inform policy and test policy proposals to support GHG emission reductions on TII's National Road network ⁽²⁵⁾ • The development of a Carbon Tool, which calculates embodied carbon associated with construction and maintenance of the National Road and light rail networks, ⁽²⁶⁾ and • Considering how deposition from exhaust fumes can be managed to reduce the risk of them entering the watercourse.
Environmental Product Declarations	Through the adoption of Environmental Product Declarations, TII can ensure that the materials used on its network do not have unintended negative impacts on the local environment.
Bog rehabilitation	TII is involved in a Bog Rehabilitation Project. This research project will examine the methodologies required for the rehabilitation of wetlands as part of the management of road infrastructure projects, and lessons learned will be applied to TII projects.
ROADSOIL	ROADSOIL is an international research project funded by the Conference of European Directors of Roads (CEDR) which examines the sustainable use and management of soils in road projects, focusing on impacts, soil functions, and reuse. ⁽⁷³⁾ This CEDR research project has funding and coordination support from TII, which is acting as research manager for this project. Lessons learned will be applied to other TII projects.
N6 Native Woodland Pilot Project	The N6 Native Woodland Pilot Project is a research project funded by TII which examines the methodologies used for offsetting carbon associated with infrastructure by native woodland planting in land available from National Road network projects.

6.9 Partnerships

TII's partnerships are key to ensuring that the organisation can collectively adapt to climate change. TII has existing formalised partnerships with the Department of Transport (DoT), local authorities, contractors, and network operators, as well as transport authorities and bodies both in Ireland and internationally. TII also has working partnerships with Met Éireann, Climate Ireland, and Ireland's university sector. Some examples of the partnerships that TII supports in relation to climate adaptation are presented in Table 14.

Table 14 TII's climate adaptation partnerships

Transport authorities and bodies	
DoT	TII will continue to work collaboratively with the DoT. The DoT engages with TII on climate adaptation – for example, through the <i>Transport Climate Change Sectoral Adaptation Plan</i> , which names TII as a stakeholder on some of the DoT's actions. The DoT also has the opportunity to respond to this Climate Adaptation Strategy.
Climate Action Regional Offices (CAROs) and local authorities	As TII completes its climate impact screening and priority impact assessments, it will engage with the CAROs and local authorities to communicate key priority assets and hazards that may require climate adaptation.
Climate science research	
TRANSLATE	Met Éireann is leading the TRANSLATE project, implemented by the Irish Centre for High-End Computing (ICHEC) and UCC, which aims to standardise future climate projections for Ireland and develop climate services that meet the climate information needs of decision-makers. ⁽¹⁴⁾ TII is one of the transport sector stakeholders for the project and will greatly benefit from the climate data generated, which it can apply within current asset design and maintenance processes. Examples of such data include rainfall intensities in drainage design and heat thresholds for pavement design.
Climate Ireland	TII has been collaborating with EPA-funded Climate Ireland (the national resource for climate adaptation implemented by UCC), which is developing climate resilience indicators. It is anticipated that these indicators will be incorporated into TII's climate risk assessment process. ⁽⁵⁷⁾
CIViC study	TII is a stakeholder for the CIViC study, a research project led by the EPA that considers critical infrastructure's vulnerability to climate change. ⁽⁵⁶⁾ This project includes a GIS-based climate change risk assessment for the transport sector, which has informed TII's understanding of climate risk as presented in Section 4.4.

Table 14 TII's climate adaptation partnerships

Industrial research and collaborations

TII maintains close contact and corporate membership with several organisations, including, but not limited to, CEDR, the Forum of European National Highway Research Laboratories (FEHRL), the European Road Transport Research Advisory Council (ERTRAC), the World Road Association (PIARC), and the International Association of Public Transport (*Union Internationale des Transports Publics*; UITP). This engagement supports TII in maintaining an awareness of international developments in transport and of opportunities to participate in collaboration research projects. For example, TII is currently supporting a CEDR research programme investigating climate change resilience on road networks across Europe. ⁽⁷⁴⁾

Supply chain partnerships

TII works in partnership with its supply chain to understand the potential operational risks in the event of a shock from a climate-related event. TII recognises how interconnected with, and dependent on, its global supply chain the organisation is. To ensure that this is considered, TII will work closely with its contractors and the wider supply chain to consider climate adaptation. This collaborative approach will enable TII to identify risks and vulnerabilities across the supply chain, alongside taking steps to address them.

6.9.1 Interdependencies

Interdependencies refer to systems or organisations which are connected to, or rely on, another system or organisation to fully operate.

The continued operation of TII's infrastructure networks is vital to ensuring that communities have access to jobs, education, and leisure activities, while guaranteeing that freight and people can travel and ensuring the provision of essential goods and services (such as food and healthcare) within the wider infrastructure system. TII also depends on many services and infrastructure systems to enable it to operate. For example, TII requires provision of water for construction and operations, an energy supply to operate Luas and street lights, and telecommunications to support traffic management. TII recognises the importance of these interdependencies with other key networks and systems. Figure 19 demonstrates the breadth and depth of TII's interdependencies and highlights the importance of ensuring that its assets are adapted to climate change to enable Ireland to thrive.

Climate vulnerabilities associated with TII's infrastructure assets and networks can not only result in service disruption on the National Road or light rail networks themselves but can also lead to cascading impacts and failures across other essential systems, such as the public being unable to access healthcare and road closures leading to the restriction of essential supply chains. Establishing an understanding and efficient management of such interdependent climate risks is essential for improving TII's resilience, and

furthermore, that of the whole transport network. Similarly, if the interdependent services (e.g. energy, water and telecommunications) that TII's operations relies on are not resilient in a changing climate, then this could impact on the ability of TII to be an organisation that is adaptive to the impacts of climate change.

Managing the risks from climate change will need the engagement of, support from, and collaboration with, a considerable range of organisations that operate in and influence numerous infrastructure and government sectors within Ireland, such as those organisations set out in Section 6.9. Without this collaboration, TII will not be able to implement many aspects of its climate strategy and subsequent adaptation plans in the most efficient, appropriate or effective way.

Interdependencies will also become more complex and critical as TII sees vehicle fleets change composition from vehicles that rely on fossil fuels to electric vehicles. Furthermore, changing land use may also impact on TII's networks; for example, rewetting and the re-establishment of bogs may have an impact on the drainage of the National Road network.

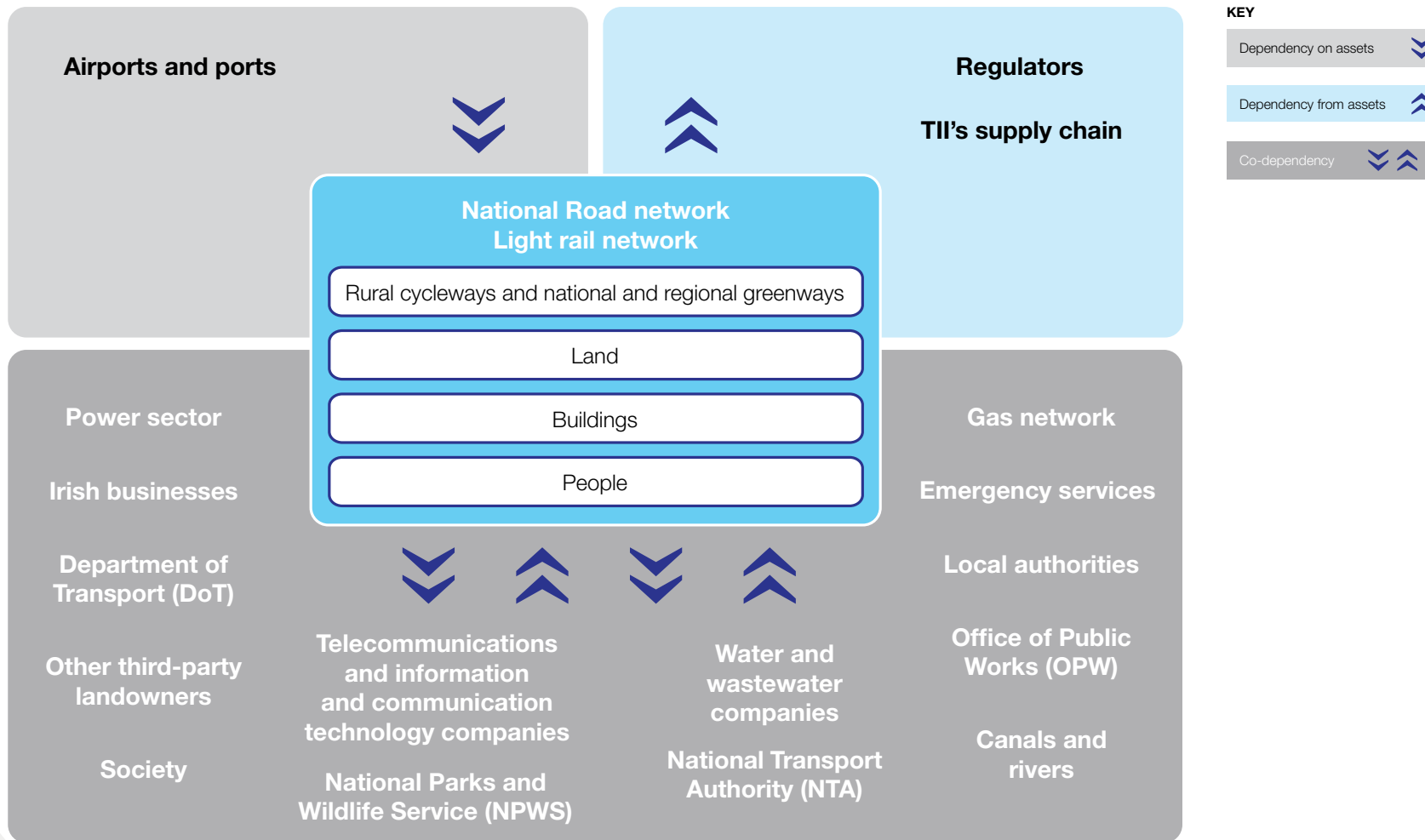


Figure 19 Interdependencies between TII and other infrastructure systems and organisations

TII Climate Adaptation Strategy

Section 7.

TII's governance

7. TII's governance of climate adaptation

This section outlines TII's approach to the governance of climate adaptation within the organisation. This Climate Adaptation Strategy has been co-produced with all sections of TII, so that climate adaptation can be embedded across the whole organisation. TII recognises that the approach to delivering an effective climate adaptation response will be best achieved when the various divisions within TII are provided with the tools, knowledge, and guidance to implement adaptation for its assets.

The overall responsibility for the Climate Adaptation Strategy will sit with the office of the Chief Executive within TII. At a strategic level, this office will be responsible for the organisation's adaptation activities, with devolved responsibility to all TII directorates to propose a plan to protect its assets from the impacts of climate change.

Externally, TII will continue to work collaboratively with the DoT. The DoT engages with TII on climate adaptation; for example, through the *Transport Climate Change Sectoral Adaptation Plan*, which names TII as a stakeholder. The DoT also has the opportunity to respond to this Climate Adaptation Strategy. TII will also engage with the wider transport sector, valued partners and stakeholders, and the wider community to deliver this Climate Adaptation Strategy. As TII completes its climate impact screening and priority impact assessments, it will engage with CAROs and local authorities to communicate key priority assets and hazards that may require climate adaptation.

Figure 20 sets out TII's internal governance structure and its relationship with the DoT. More details about the governance responsibilities for climate adaptation will be addressed when climate adaptation implementation plans are developed.



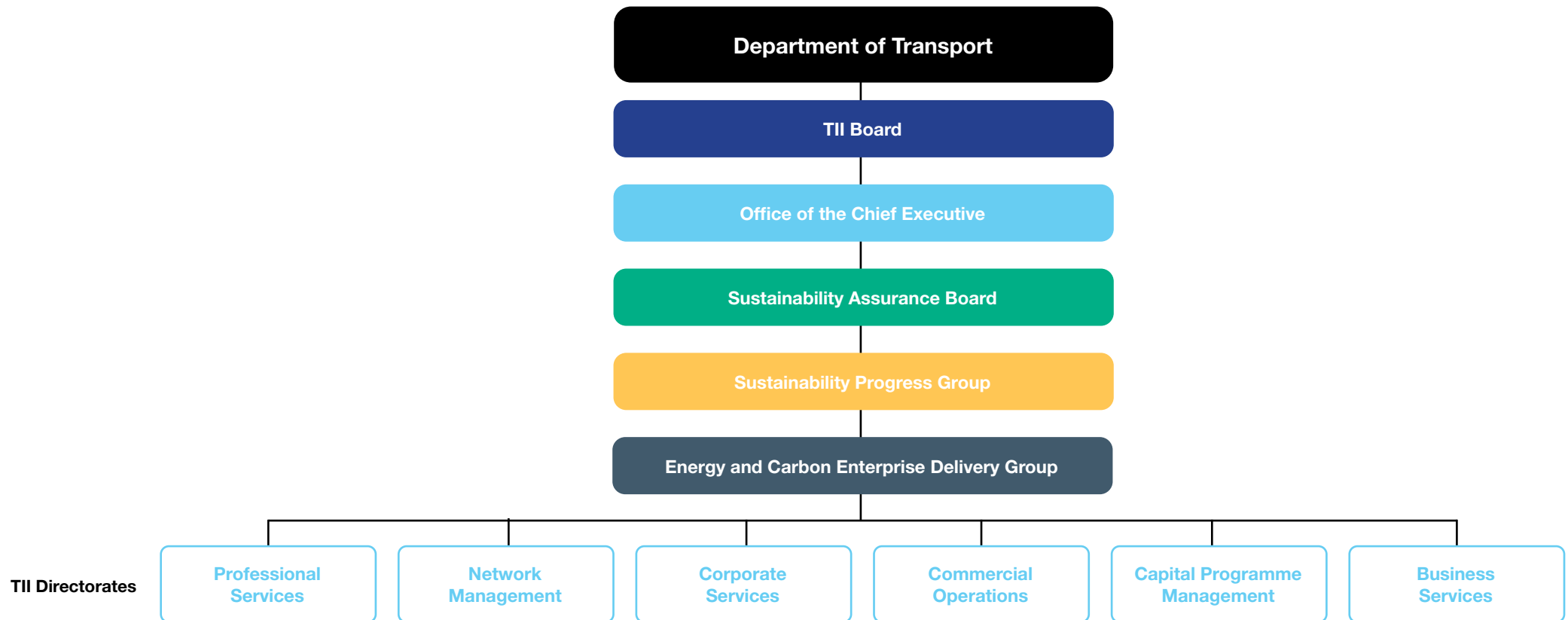


Figure 20 TII's climate adaptation governance structure

TII Climate Adaptation Strategy

Section 8. Next steps



8. Next steps

TII is not complacent about the scale of the challenge that climate change risks pose to its networks. There is much to do, and continued action is required in terms of understanding climate risks, building capacity to adapt to climate change, and investing in current and future levels of resilience to climate impacts. This Climate Adaptation Strategy provides the foundations for TII's continued climate adaptation activities. The publication of recent standards, for example Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline and Greenways) – Overarching Technical Document. (24) highlights TII's commitment to ensure that the design of new infrastructure is resilient to future climate change.

Several actions have therefore emerged to support the implementation of this Climate Adaptation Strategy within TII and are summarised in Table 16. Facilitating these actions and ensuring that TII's networks are adapted to future climate change will require significant resources and investment. Going forward, work will be undertaken to obtain a better understanding of climate risks to TII and costs of the climate adaptation actions that will form a fundamental part of climate adaptation implementation planning (Stage 5 of TII's climate adaptation approach). This understanding will assist TII to create climate adaptation budgets that will be subject to appropriate due diligence, subject to the receipt of funding, and assign sufficient funds to implement planned actions.

Delivering on these planned actions will enable TII to achieve its aim of being an organisation that is adaptive to the impacts of climate change while maintaining its commitment to sustainability.

TII has developed several tangible actions to build on, which are outlined in Table 15. It is expected that these actions will form the basis of TII's climate adaptation activities over the next five years, in line with the sectoral adaptation planning cycle. Together, these actions will ensure that TII embeds climate adaptation into its 'business as usual' activities and continues the transition to climate-proofing its organisation.

Detailed time frames and programmes will be developed when Actions 1 and 2 are complete. The time frames will align with the 5-year review cycle being adopted by Government sectors.



Table 15 Upcoming climate adaptation actions

Action No.	Action	Indicative Dates
0	Publish TII's <i>Climate Adaptation Strategy</i> .	December 2022
1	1.1 Develop governance and resourcing requirements.	Commence in Q1 2023
	1.2 Complete climate screening (see Stage 2 of TII's climate adaptation approach in Section 5.2) for National Roads, light rail, greenways and cycleways, land, buildings, and people.	In progress Complete by Q1 2023
	1.3 Identify priority climate hazards through climate screening (see Stage 3 of TII's climate adaptation approach in Section 5.3) for National Roads, light rail, greenways and cycleways, land, buildings, and people.	In progress Complete by Q2 2023
2	Undertake a more detailed climate risk assessment for all climate hazards identified as priorities (see Stage 4 of TII's climate adaptation approach in Section 5.4).	Dependent on completion of Action 1 Complete flood risk assessment for National Roads Complete by Q4 2024
3	Develop and implement climate adaptation implementation plans (see Stage 5 of TII's climate adaptation approach in Section 5.5). These plans will include estimates of resourcing, time frames, measurement, and monitoring of proposed adaptation measures.	Dependent on completion of Action 2 Commence in Q1 2025
Partnerships & Research		
4	Provide support to the Department of Transport with its upcoming Transport Climate Change Sectoral Adaptation Plan.	Ongoing
5	Continue TII's working relationship with Climate Ireland and University College Cork (UCC) to support the definition of a final list of climate resilience indicators. This will support Action 3.	To commence in 2023
6	Continue engagement with Met Éireann's TRANSLATE project. ⁽¹⁴⁾	Commenced in Q3 2022 and due to be complete by Q2 2023
7	Continue TII's working relationship with climate-focused groups, including, but not limited to, the Conference of European Directors of Roads (CEDR), the Urban Transport-Related Air Pollution (UTRAP) Working Group, the European Union Committee on Transport and Tourism (TRAN), and the International Association of Public Transport (<i>Union Internationale des Transports Publics</i> ; UITP).	Ongoing

TII Climate Adaptation Strategy

Section 9. References



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