Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Climate Impact Screening Report

TII Climate Adaptation

Date: December 2023

Contents Table

1. Introduction

In 2019, Ireland declared a national climate and biodiversity emergency. Changes in Ireland's climate is causing extreme weather events to become more frequent which is already impacting Transport Infrastructure Ireland's (TII) networks. Ageing infrastructure, asset deterioration and increased demand will likely mean that TIIs assets are increasingly vulnerable to a range of climate hazards (e.g. flooding, extreme heat and extreme wind). As a result, there is a need to better understand the risks to, and adapt, TII's networks to climate change in order to minimise any climate-related impacts on customers.

In December 2022, TII published its updated Climate Adaptation Strategy[1]. This was a direct response to Action 297 of Ireland's Climate Action Plan 2021[2] – "Improve climate resilience and adapt to climate change on the Light Rail and National Road Network". The strategy sets out several follow-up actions that TII will be undertaking over the next five years, to continue its progress in achieving its climate adaptation aim *"to be an organisation that is adaptive to the impacts of climate change and maintain its commitment to sustainability"*. The actions set out, and their timeframes are provided in Table 1 below. Immediate actions, Actions 1 and 2 are presented in yellow in Table 1, with this report representing the response to Action 1.2 and 1.3. The prioritisation of the climate screening will set the basis for the assets and climate hazards that are considered in Action 2.

Table 1 TII's climate adaptation actions, taken from the Climate Adaptation Strategy. The actions which are addressed or referred to within this report are shown in yellow.

Action No.	Action	Indicative Dates
0	Publish TII's *Climate Adaptation Strategy.*	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 (*Union Internationale des Transports Publics*; UITP).	Ongoing

[1] Transport Infrastructure Ireland. Climate Adaptation Strategy. Transport Infrastructure Ireland. [online] 2022. [cited 29 June 2023.] https://www.tii.ie/technical-services/environment/changing-climate/Climate-Adaptation-Strategy-2022_v2.pdf

[2] Department of the Environment, Climate and Communications. Climate Action Plan 2021: Securing Our Future. Government of Ireland. [Online] 2021. [Cited: 29 June 2023.] https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/

The Strategy sets out TII's six-stage approach to climate adaptation (Figure 1) in line with the national Sectoral Planning Guidelines for Climate Change Adaptation[3]. The development and publication of TII's Climate Adaptation Strategy achieved stage one of the six-stage approach. Following the Strategy's publication, TII then commenced the three subsequent stages of the climate adaptation approach, stages 2, 3 and 4, which together aim to improve understanding of how climate change poses a risk to the assets across the organisation. These three stages also align with the climate risk assessment component of TII's recently published 'Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways) - Overarching Technical Document'[4].

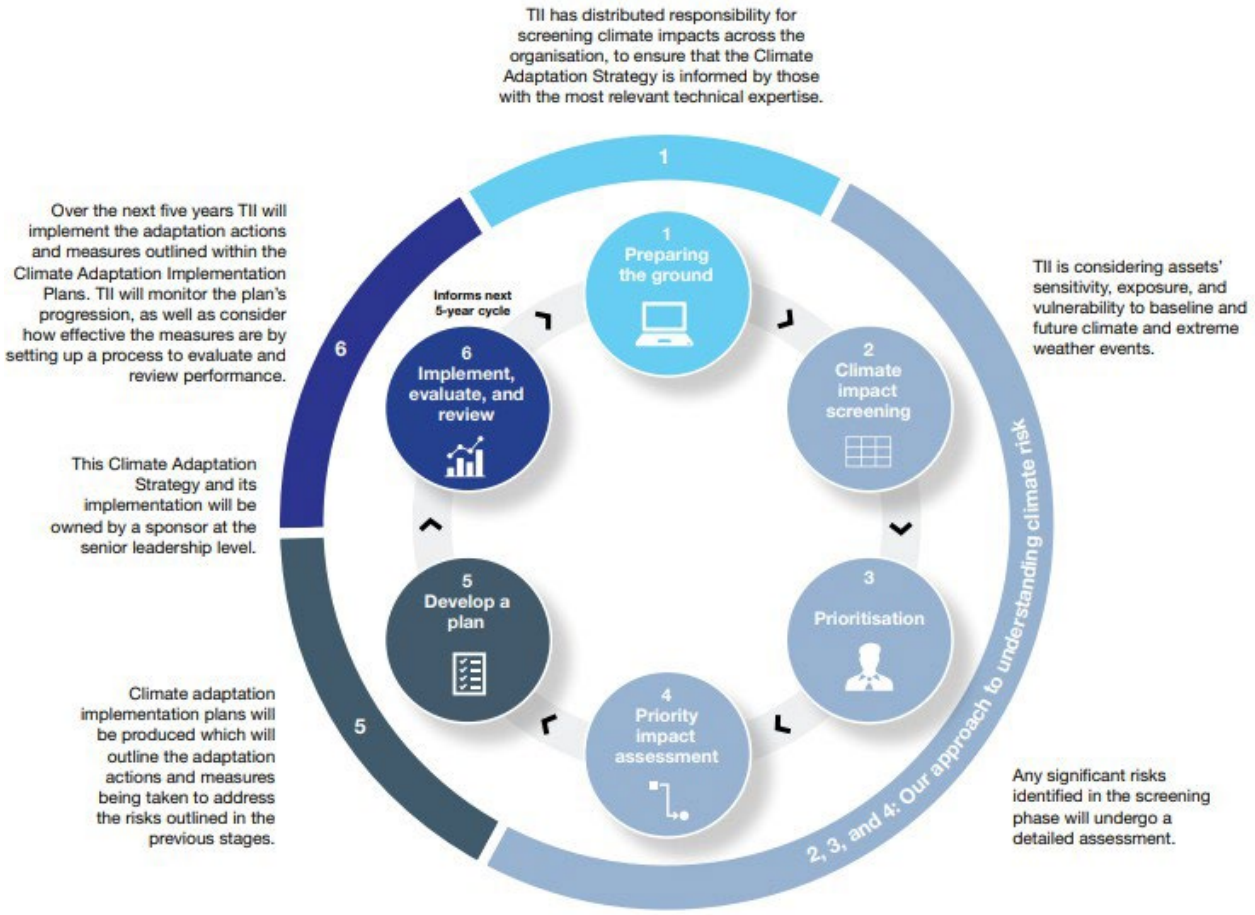

Figure 1 TII's climate adaptation approach, adapted from the Sectoral Planning Guidelines for Climate Change Adaptation.

[3] Department of Communications, Climate Action and Environment. Sectoral Planning Guidelines for Climate Change Adaptation. Government of Ireland. [Online] 2018. [Cited: 16 September 2022.] https://www.gov.ie/pdf/?file=https://assets.gov.ie/129614/9bcbb18e-7203-4079-9a59-833842e932f2.pdf .

[4] Transport Infrastructure Ireland, "PE-ENV-01104 Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways)," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01104-01.pdf.

- **Stage 2: Climate Impact Screening** – this stage is comprised of a high-level assessment of how a range of climate hazards can or may affect the full range of TII's assets. TII assets are grouped into six categories, as presented in the Strategy (Figure 2): national roads; light rail; rural cycleways and national and regional greenways; buildings; land; and people. Each of the six asset groups have their own assessment. The outputs of this stage are six competed assessments whereby all climate hazard and asset pairings are assigned an overall vulnerability rating.
- **Stage 3: Prioritisation** – this stage involves identifying which climate hazard and asset pairings from the Climate Impact Screening assessments (Stage 2) are significantly vulnerable such that they require further investigation. This is based on the vulnerability ratings, with all high vulnerability and some medium vulnerability pairs taken forward.
- **Stage 4: Detailed Climate Risk Assessment** – this stage aims to deep-dive into the priority hazard-asset pairs to better understand the risk, including how the risk may vary spatially based on variable climatic conditions, or based on asset age. The methodology for undertaking this detailed assessment is currently being scoped in a separate work package.

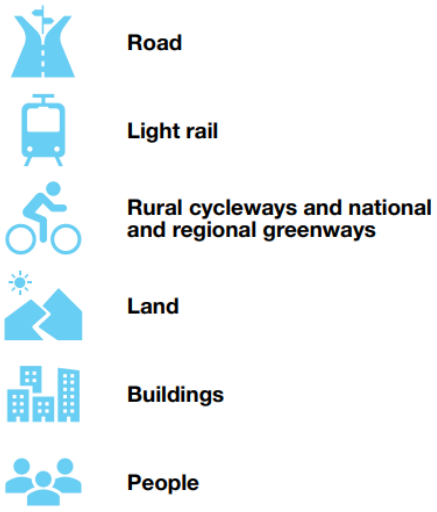

Figure 2 Categorisation of TII's assets.

On behalf of TII, this report summarises the process and results from Arup's delivery of Stages 2 and 3, which includes the Climate Impact Screening assessments and prioritisation in line with the timelines presented in Table 1 (Q1 and Q2 of 2023). This report's layout is summarised below:

- **Section 2** of this report outlines how the process of assessing climate risks within TII has been governed, ensuring an understanding of how assets currently respond to severe weather has been appropriately captured within the assessments.
- **Section 3** sets out the methodology for Stages 2 and 3 of TII's climate adaptation approach, including the development of the Climate Impact Screening Excel tool, how the assessments were undertaken and how the results from that assessment were used to prioritise which climate hazard/asset pairings would be taken forward for more detailed risk assessment.
- **Sections 4 to 9** provides further detail on the approach to and results from each of the six asset groups' Climate Impact Screening assessments.
- **Section 10** provides a disclaimer related to the use of climate data within the Climate Impact Screening assessments.
- **Section 11 and 12** presents the final conclusions and provides next steps to support TII in delivering the Detailed Climate Risk Assessment (Stage 4), in line with the actions outlined in the Strategy.

2. Governance and engagement

A Steering Group meeting was held in March 2023 to provide an overview of TII's progress, to outline the next steps for TII's climate adaptation process, and to agree who the six asset group representatives would be. The six asset group Project Managers (PMs) were nominated to represent each asset group and were assigned a role as asset group PMs, which involved:

- Being available to support workshops and meetings to inform the Climate Impact Screening assessments;
- Identifying, supporting and coordinating the provision of required data and information to Arup where possible;
- Coordinating inputs from other TII asset specialists where required; and
- Providing sign off for the Climate Impact Screening assessment for the asset group.

Figure 3 Governance of climate adaptation implementation.

The PMs for each of the six asset groups were consulted throughout the development of the Climate Impact Screening assessments in order to maintain clarity and consistency. A summary table of the engagement carried out is detailed further in Appendix A.1. Broadly, the approach to engagement included:

- **Initial meeting** held with each TII asset group PM to provide Arup with information and agree on the key attendees for the proposed workshops.
- Arup populated **draft Climate Impact Screening assessments** based on the information provided during the initial meetings and engagement with subject matter experts.
- A **workshop** was held for each asset group with TII PMs and other relevant TII asset specialists to validate the vulnerability ratings assigned to each asset group, update the draft Climate Impact Screening assessments and to provide further inputs, justification and potential knowledge gaps. The workshops provided an opportunity for the Arup team to understand if any additional hazards should be considered for the assessments.

- Arup issued a draft Climate Impact Screening Assessment to each asset group PM, who had an opportunity to **review the draft assessments and provide feedback** to the Arup team following the workshops. These reviews allowed each asset group PM to **agree on prioritisation** of asset categories.
- The **final draft** Climate Impact Screening assessments were issued to TII PMs for **sign off**.

3. Approach to climate impact screening

The approach to Climate Impact Screening is aligned with TII's 'Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways) - Overarching Technical Document'[5]. It is understood that this guidance has predominantly been developed for application on new projects. However, the approach to risk assessment is consistent with the EU 'Technical guidance on the climate proofing of infrastructure in the period 2021-2027' which is routinely applied on existing infrastructure. The risk assessment framework in PE-ENV-01104 provides a useful methodology to undertake the climate impact screening and detailed risk assessment and will be aligned with future climate assessments on new schemes.

To complete the Climate Impact Screening assessment, Arup developed an Excel-based tool. This tool has six key steps, as presented in Figure 4, with more detail on each step provided in Sections 3.1 to 3.6. The Climate Impact Screening Assessment excel tool template can be found in Appendix A.2.

The purpose of this screening assessment is to provide a high-level assessment across all climate hazards that may impact to TII's assets. Several limitations and assumptions of the approach to the Climate Impact Screening are set out in Section 3.7.

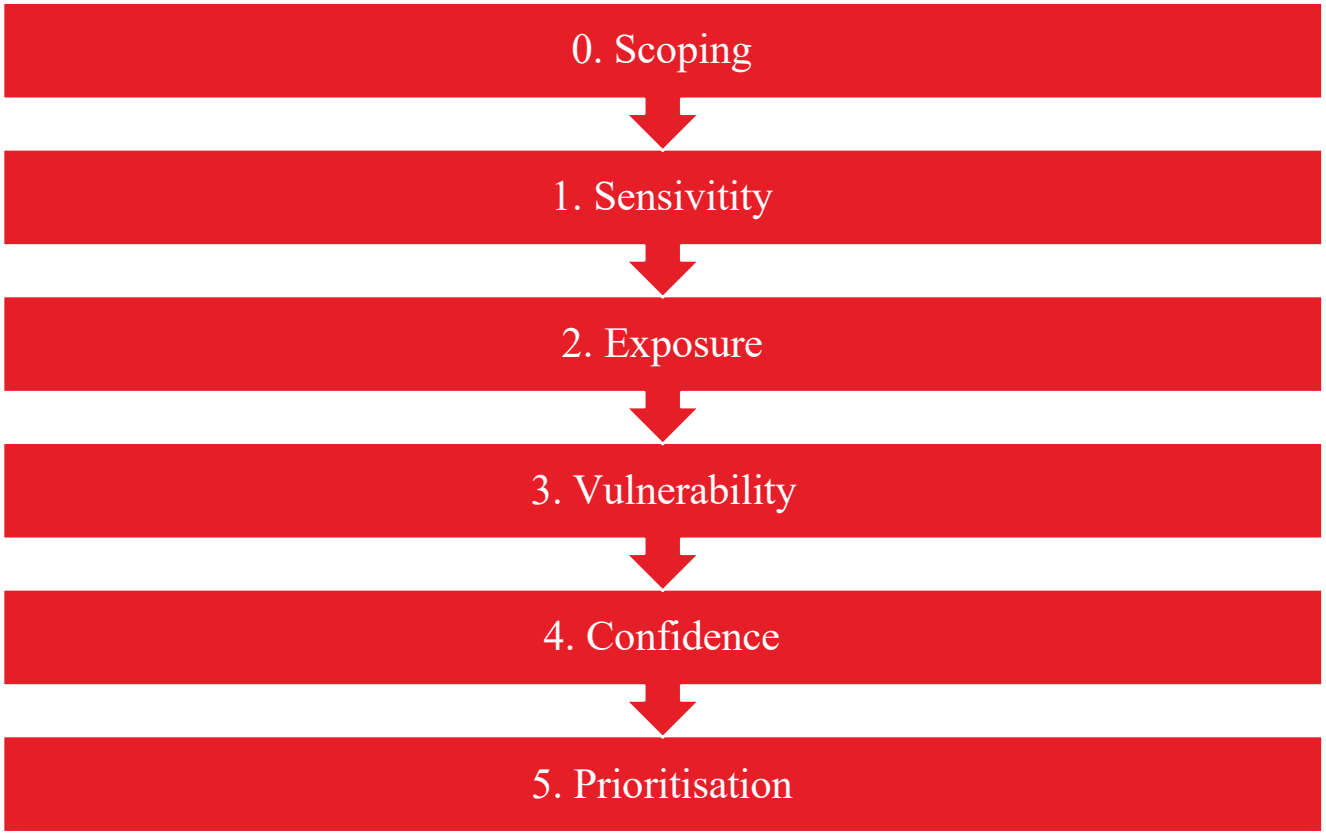

Figure 4 Climate Impact Screening workflow diagram.

[5] Transport Infrastructure Ireland, "PE-ENV-01104 Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways)," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01104-01.pdf

3.1 Step 0: Scoping

For each asset group, climate hazards and asset categories were defined in collaboration with the TII PMs and Arup asset specialists, to develop asset-hazard pairings (e.g. wildfire risk to road pavements).

3.1.1 Hazards

A core range of climate hazards has been drawn from those listed in the TII Climate Guidance (PE-ENV-01104)[6]. During consultation with each of the six asset group Project Managers, this list was reviewed with additional hazards added where relevant to the asset group. A full summary of the range of climate hazards assessed in the Climate Impact Screenings is presented in Table 2.

Table 2 Range of climate hazards considered within the climate impact screening assessments.

Climate hazards	Asset group					
	National Roads	Light Rail	Greenways and Cycleways	Buildings	Land	People
Flooding (coastal) – including sea level rise and storm surge	✓	✓	✓	✓	✓	✓
Flooding (fluvial)	✓	✓	✓	✓	✓	✓
Flooding (pluvial)	✓	✓	✓	✓	✓	✓
Flooding - groundwater	✓	✓	✓	✓	✓	✓
Extreme heat	✓	✓	✓	✓	✓	✓
Extreme cold (including freeze-thaw)	✓	✓	✓	✓	✓	✓
Wildfire	✓	✓	✓	✓	✓	✓
Drought	✓	✓	✓	✓	✓	✓
Extreme wind	✓	✓	✓	✓	✓	✓
Lightning	✓	✓	✓	✓	✓	✓
Hail	✓	✓	✓	✓	✓	✓
Natural landslides	✓	✓	✓		✓	✓
Engineered slope failure	✓	✓	✓	✓	✓	✓
Fog	✓	✓	✓	✓	✓	✓
Coastal erosion	✓		✓			✓
Increase in average temperatures					✓	

[6] Transport Infrastructure Ireland, "PE-ENV-01104 Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways)," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01104-01.pdf.

3.1.2 Assets

The list of asset types under each asset group were developed collaboratively with the TII asset group Project Manager as well as other asset specialists, both within TII and their Arup counterparts.

For the 'national roads' and 'greenways and cycleways' asset groups, the asset lists align with existing asset management categorisations or series. Each asset group's list of asset types is presented in the respective 'Asset categories' sections within this report.

3.2 Step 1: Sensitivity

Sensitivity is defined as the degree to which an asset is adversely affected by a climate hazard. The effect may be direct (such as high temperatures leading to the melting or rutting of pavements) or indirect (such as damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Each climate hazard-asset pairing is assigned a sensitivity rating and score, based on the definitions presented in Table 3. These definitions are reproduced from the TII Climate Standard[7] and are extended to refer to the extent of asset damage. Assigning sensitivity ratings is based on asset specialist knowledge provided during engagement with TII and Arup asset specialists, as well as examples of past events identified from existing literature. Alongside the rating, a narrative is also provided to justify the score provided.

Table 3 Sensitivity rating, definitions, and scores.

Rating (and score)	Rating Definition
Low (1)	It is possible the climate hazard will have a low or negligible impact on the asset category. (i.e. periphery or little damage to the asset)
Medium (2)	It is possible or likely the climate hazard will have a moderate impact on the asset category. (i.e. moderate damage to most of the asset)
High (3)	The climate hazard will or is likely to have a major impact on the asset category (i.e. asset destroyed or subjected to large scale damage reuqiring major engineering works)

3.3 Step 2: Exposure

Exposure is defined as the presence of assets in a location that could be adversely affected by climate hazards. It is recognised that some networks (national roads, greenways and land) are geographically diverse. Therefore, an assumption has been made on the average level of exposure to which a network might be subject. However, a site-specific assessment is recommended to better understand the spatial variation in risks to particular assets.

Each climate hazard-asset pairing is assigned two exposure ratings and scores, based on the definitions presented in Table 4 one for present-day, and one for future considering the impacts of climate change.

[7] Transport Infrastructure Ireland, "PE-ENV-01105 Climate Assessment of Proposed National Roads - Standard," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01105-01.pdf

These definitions are reproduced directly from the TII Climate Standard[8]. The process of assigning the exposure ratings considers evidence of past events in Ireland. Climate projection information is used to define the future exposure score.

This future climate data uses range of sources, in particular leaning on high-resolution climate projection data produced for the Environmental Protection Agency in 2020, the accompanying report[9] and Climate Ireland Data Explorer[10]. It is understood that these future climate projection data will be updated through the outputs emerging from Met Éireann's TRANSLATE project[11]. Alongside the rating score, narrative justifications are provided.

Table 4 Exposure rating, definitions, and scores.

Rating (and score)	Rating Definition
Low (1)	It is unlikely or rare this climate hazard will occur (i.e. might arise a number of times in a generation or in a lifetime).
Medium (2)	It is possible this climate hazard will occur (i.e. might arise a number of times in a decade).
High (3)	It is almost certain or likely this climate hazard will occur (i.e. might arise once to several times per year).

3.4 Step 3: Vulnerability

Vulnerability is defined as the function of sensitivity and exposure, to capture the extent to which an asset is vulnerable to a climate hazard.

The vulnerability scores are automatically populated in the Arup Climate Impact Screening Excel tool, using the defined sensitivity and exposure scores, based on the logic presented in the vulnerability matrix (Figure 5). All vulnerability ratings are also subject to a review workshop with TII and Arup asset specialists in attendance, to ensure an accurate overall picture or low/medium/high vulnerability aligning with best knowledge of both asset performance and climate impacts. Where changes are needed, these are reflected in the sensitivity or exposure scores and further justification is provided.

[8] Transport Infrastructure Ireland, "PE-ENV-01105 Climate Assessment of Proposed National Roads - Standard," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01105-01.pdf

[9] Nolan, P. and Flanagan, J. (2020) High-resolution Climate Projections for Ireland – A Multi-model Ensemble Approach. Environmental Protection Agency Report No. 339.Accessed online on 15th September 2022 here: https:// www.epa.ie/publications/research/climate-change/Research_Report_339_Part1.pdf.

[10] Climate Ireland, "Climate Data Explorer," Climate Ireland, [Online]. Accessed online on 9th June 2023 here: https://climateireland.ie/#!/tools/climateDataExplorer.

[11] Met Éireann (2023) TRANSLATE. Accessed here on 4th July 2023: https://www.met.ie/science/translate.

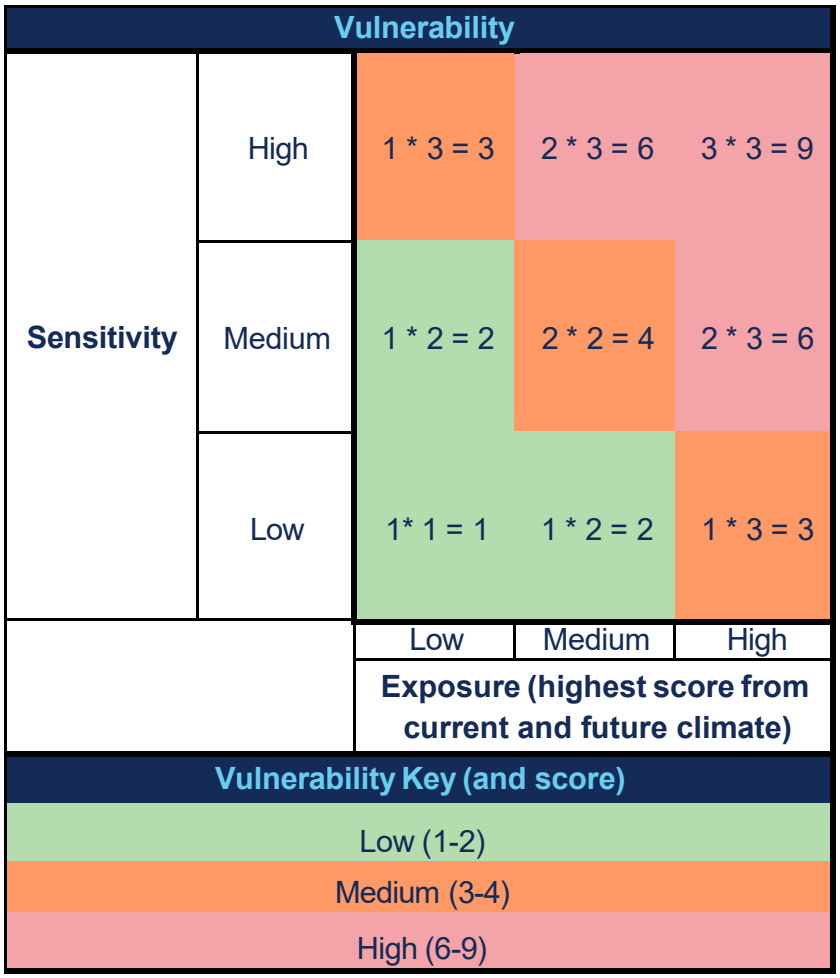

Figure 5 Vulnerability matrix used in climate impact screening.

3.5 Step 4: Confidence

Confidence scores are also provided for each of the climate hazard-asset pairs, to reflect the potential uncertainty in the data and evidence that informed the chosen sensitivity and exposure scores. The definitions of the three confidence scores are provided in Table 5.

Table 5 Confidence rating, definitions, and scores.

Rating (and score)	Rating Definition
Low (1)	The assessment of vulnerability cannot be supported by available data, and there are no available examples of how the climate hazard may affect the asset being considered.
Medium (2)	The assessment of vulnerability can be supported by information, data and expert kowledge, but is lacking clear association meaning that it is open to challenge.
High (3)	The assessment of vulnerability can be supported by information, data and expert kowledge that is beyond reasonable doubt.

3.6 Step 5: Prioritisation

The final step of the Climate Impact Screening assessment forms Stage 3 of TII's climate adaptation approach.

The aim of this prioritisation step is to refine the full suite of climate hazard-asset pairs assessed in the Climate Impact Screening to a shorter list of pairs that require further investigation, having been identified of being vulnerable to climate impacts within the screening assessment. The further investigation stage aligns with Stage 4 of TII's climate adaptation approach. Ultimately, the results from the detailed assessment in Stage 4 will be used to inform TII's Climate Adaptation Plan(s). These plans will identify appropriate adaptation actions and measures that aim to reduce climate risks to acceptable levels (Stage 5 of TII's climate adaptation approach).

The process of prioritisation adopted here aligns with the EU Technical Guidance[12] that has informed the TII Climate Standard[13]. Asset-hazard pairings are categorised as 'prioritised' or 'under watching brief' based on the vulnerability. If 'prioritised', the pairings will undergo a more detailed assessment in the next stage. If 'under watching brief', the pairings will not undergo a more detailed assessment in the next stage, but should be reviewed in line with the 5-year cycle.

- **High vulnerability:** The climate hazard-asset pairings shown in red in the screening assessments (included in Sections 4, 5, 6, 7, 8, and 9) have a high vulnerability and are therefore automatically prioritised to be taken through for a more detailed impact assessment.
- **Medium vulnerability:** The climate hazard-asset pairings shown in orange in the screening assessments have a medium vulnerability and have either been taken through for a more detailed impact assessment or kept under watching brief – decided by the core project team. The core project team consists of TII asset specialists and technical climate change lead, as well as Arup climate risk and infrastructure specialists.
- **Low vulnerability:** The climate hazard-asset pairings shown in green have a low vulnerability score and are therefore kept under watching brief.

3.7 Method limitations and assumptions

Several limitations and assumptions have been identified during this Climate Impact Screening assessment, which include:

- The approach is aligned with TII's Climate Guidance[14] and Standard[15]. However, this guidance was principally developed for application on new schemes, as opposed to being used on assessing climate risk to a portfolio of existing assets, as is being assessed here.

[12] European Commission (2021) Technical guidance on the climate proofing of infrastructure in the period 2021- 2027. European Commission. [Online] Accessed online on 9 August 2022 here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.C_.2021.373.01.0001.01.ENG.

[13] Transport Infrastructure Ireland, "PE-ENV-01105 Climate Assessment of Proposed National Roads - Standard," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01105-01.pdf.

[14] Transport Infrastructure Ireland, "PE-ENV-01104 Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways)," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01104-01.pdf.

[15] Transport Infrastructure Ireland, "PE-ENV-01105 Climate Assessment of Proposed National Roads - Standard," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01105-01.pdf

Therefore, the assessment has, as much as possible, adopted the approach set out in the climate guidance and standard, but the different application should be recognised.

- The developed screening tool is not a spatial risk assessment. Geographic factors that may exacerbate or decrease exposure; for example elevation, or proximity to the coast, are not considered. For the purposes of this assessment, impact screening has been undertaken at a national scale (except for the Light Rail network which principally is in the Dublin vicinity).
- The screening tool has not considered the characteristics of individual assets and their spatial locations, as well as factors that may contribute to an assets sensitivity to a climate hazard (e.g. health of an asset, its materials, age, construction or specific design features. The asset sensitivity assessment considers whether there has been any historical evidence of asset failure at a portfolio level and uses engineering judgement for how assets may respond in future.

4. National Roads

4.1 Key findings

- Key climate hazards that were found to present a higher level of vulnerability for national roads asset group include; engineered slope failure, coastal erosion, fluvial flooding and pluvial flooding.
- The asset categories within the national roads network that are highly vulnerable across all climate hazards are drainage and structures.

4.2 Asset categories

A Climate Impact Screening assessment of the National Primary and Secondary Road Network (see Figure 6 below) was undertaken. The following asset categories were included in the scope of the screening assessment for the national roads asset group, as agreed with the TII asset group PM:

- Pavements[16];
  - Subnetwork 0 - Motorway and Dual Carriageway Network;
  - Subnetwork 1 - Engineered Single Carriageway;
  - Subnetwork 2 - Urban Areas;
  - Subnetwork 3 - Legacy Network High Traffic;
  - Subnetwork 4 - Legacy Network Low Traffic;
- Kerbs, Footways, and Paved Areas;
- Drainage[17];
- Structures;
- Tunnels;
- Earthworks;
- Utilities;
- ITS, Traffic Control and Communication;
- Landscaping;
- Buildings;
- Road markings;

[16] Following conversations with TII pavement specialists, it was felt that pavements was too broad a category to reflect the different pavement engineering and characteristics across the national road network, therefore 5 subnetwork pavement types have been proposed.

[17] It is understood that drainage is not present at all locations on the national roads network. Where this is the case, this will be reflected in the detailed risk assessment in terms of how it may impact other asset classes. In this assessment, the potential of how drainage may be physically impacted by certain types of climate hazards is being considered (e.g. how a lack of drainage may impact stability of earthworks).

- Road Restraint Systems;
- Signs, light posts, fences and noise barriers;
- Ancillary Infrastructure;
- Weather stations; and
- Service areas.

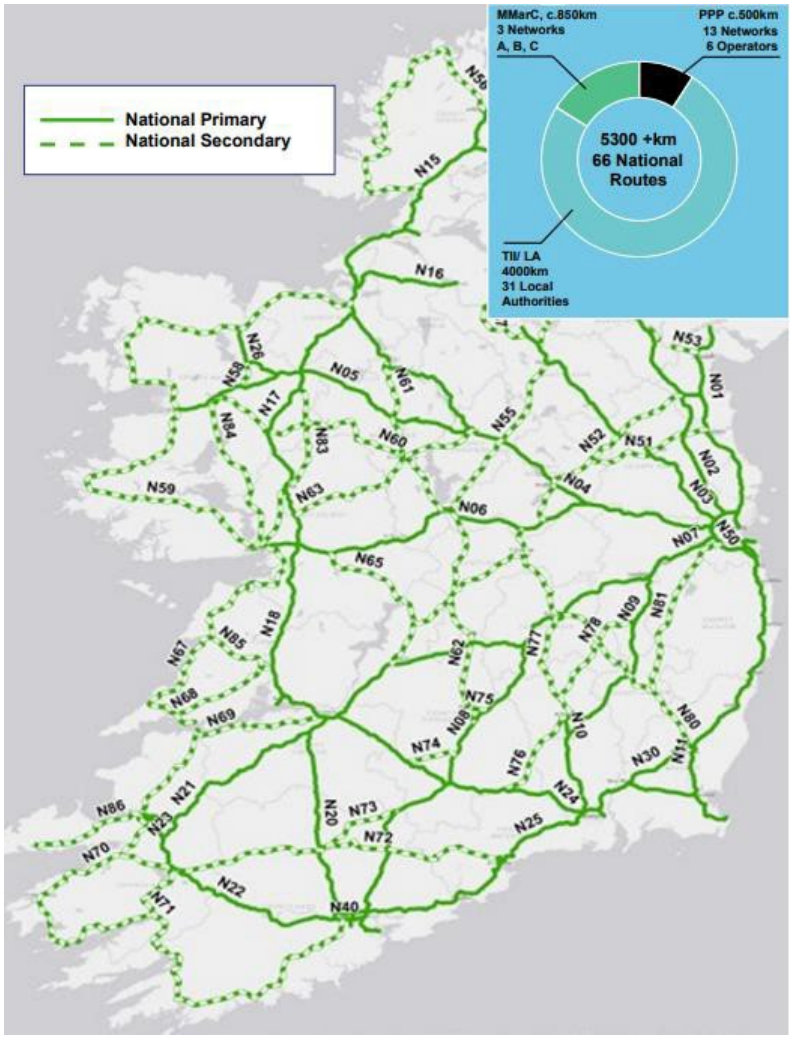

Figure 6 Map of National primary and secondary road networks[18].

4.3 Climate hazards

The key climate hazards identified for the national roads Climate Impact Screening assessment include:

- Flooding (coastal) – including sea level rise and storm surge;
- Flooding (fluvial/ river);

[18] Transport Infrastructure Ireland. Climate Adaptation Strategy 2022. Transport Infrastructure Ireland. [online] 2022. [cited: 29 June 2023.] https://www.tii.ie/technical-services/environment/changing-climate/Climate-Adaptation-Strategy-2022_v2.pdf

- Flooding (pluvial/ surface water);
- Flooding – groundwater (driven by low intensity, prolonged rainfall);
- Extreme heat;
- Extreme cold (including freeze-thaw cycles);
- Wildfire;
- Drought;
- Extreme wind;
- Lightning;
- Hail;
- Natural landslides and slope failures beyond road boundaries;
- Engineered slope failure (instability of slopes that are engineered, and typically owned by TII, to maintain gradient and alignment of network);
- Fog; and
- Coastal erosion.

4.4 Prioritisation

The completion of the Climate Impact Screening assessment for national roads has identified the asset categories that, based on expert judgment, are most vulnerable to the impacts of certain climate hazards. Table 6 below presents a summary of the asset-hazard pairings that are being taken forward for prioritisation (red – high vulnerability) and that are likely to be taken forward for prioritisation (orange – medium vulnerability). As described in Section 3, the assets being taken forward for prioritisation are based on the verified vulnerability ratings. The asset-hazard pairings being taken forward for national roads (summarised in Table 7 below) will be subject to a more detailed priority impact assessment in the next stage. The prioritised asset-hazard pairings are detailed further in the Excel files attached with this summary document of the Climate Impact Screening assessment for national roads.

Table 6 Summary table of climate impact screening assessment for national roads[19]

Division	Asset categories	Climate Variable														
		Flooding (coastal) – including sea level rise and storm surge	Flooding (fluvial / river)	Flooding (pluvial / surface water)	Flooding – groundwater (driven by low intensity, prolonged rainfall)	Extreme heat	Extreme cold (including freeze–thaw cycles)	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides and slope failures beyond road boundaries	Engineered slope failure	Fog	Coastal erosion
		Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability
National Roads	Subnetwork 0 – Motorway and Dual Carriageway Network	4	3	3	4	6	6	2	2	2	2	2	3	6	2	6
National Roads	Subnetwork 1 – Engineered Single Carriageway	4	3	3	4	6	6	2	2	2	2	2	3	6	2	6
National Roads	Subnetwork 2 – Urban Areas	4	6	6	4	9	6	2	2	2	2	2	3	6	2	6
National Roads	Subnetwork 3 – Legacy Network High Traffic	4	6	6	4	9	6	2	2	2	2	2	3	6	2	6
National Roads	Subnetwork 4 – Legacy Network Low Traffic	4	6	6	4	9	6	2	2	2	2	2	3	6	2	6
National Roads	Kerbs, Footways, and Paved Areas	4	6	6	4	9	6	2	4	2	2	2	3	6	2	6
National Roads	Drainage	6	9	9	6	6	6	2	6	2	2	2	3	6	2	6
National Roads	Structures	6	9	9	6	4	4	3	2	6	6	2	3	6	2	6
National Roads	Tunnels	9	9	9	2	4	6	2	4	4	2	2	3	6	2	3
National Roads	Earthworks	6	9	9	6	6	2	2	4	2	2	2	3	6	2	6
National Roads	Utilities	4	9	9	4	4	4	3	2	4	4	2	3	6	2	6
National Roads	ITS, Traffic Control and Communication	4	6	6	2	2	2	3	2	4	4	2	3	6	2	6
National Roads	Landscaping	4	3	3	2	4	2	3	6	4	2	2	3	6	2	6
National Roads	Buildings	4	6	6	4	4	2	3	2	4	2	2	3	6	2	6
National Roads	Road markings	4	6	6	2	4	4	3	2	2	2	2	3	6	2	6
National Roads	Road Restraint Systems	4	6	6	2	2	2	1	2	2	2	2	3	6	2	6
National Roads	Signs, light posts, fences and noise barriers	4	9	9	2	2	2	2	2	6	2	2	3	6	2	6
National Roads	Ancillary Infrastructure	4	9	9	4	2	2	3	2	4	2	2	3	6	2	6
National Roads	Weather stations	6	6	6	4	2	2	3	2	2	4	4	3	6	2	6
National Roads	Service areas	4	6	6	4	9	6	2	4	2	2	2	3	6	2	6

[19] It is understood that there are very few locations on the national roads network where coastal flooding and coastal erosion are currently not an issue. However, it is important to bring through these climate hazards to the next stage to gain a better understand of the asset locations in relation to these hazards.

Table 7 Asset-hazard pairings for prioritisation – national roads

Asset-hazard pairings being taken forward for prioritisation															
Asset categories		**Climate hazard**													
		Flooding (coastal)	Flooding (fluvial)	Flooding (pluvial/ surface water)	Flooding (groundwater)	Extreme heat	Extreme cold	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides and slope failures beyond road boundaries	Engineered slope failure	Fog	Coastal erosion
Pavements	Subnetwork 0 - Motorway and Dual Carriageway Network	✓	✓	✓	✓	✓	✓						✓	✓		✓
	Subnetwork 1 - Engineered Single Carriageway															
	Subnetwork 2 - Urban Areas															
	Subnetwork 3 - Legacy Network High Traffic															
	Subnetwork 4 - Legacy Network Low Traffic															
Kerbs, Footways, and Paved Areas		✓	✓	✓	✓	✓	✓		✓				✓	✓		✓
Drainage		✓	✓	✓	✓	✓	✓		✓				✓	✓		✓
Structures		✓	✓	✓	✓	✓	✓			✓	✓		✓	✓		✓
Tunnels		✓	✓	✓	✓		✓						✓	✓		✓
Earthworks		✓	✓	✓	✓	✓	✓		✓				✓	✓		✓
Utilities		✓	✓	✓	✓	✓					✓		✓	✓		✓
ITS, Traffic Control and Communication		✓	✓	✓	✓	✓				✓	✓		✓	✓		✓
Landscaping		✓	✓	✓	✓	✓			✓				✓	✓		✓
Buildings		✓	✓	✓	✓	✓				✓			✓	✓		✓
Road markings		✓	✓	✓	✓								✓	✓		✓
Road Restraint Systems		✓	✓	✓	✓	✓	✓						✓	✓		✓
Signs, light posts, fences and noise barriers		✓	✓	✓	✓	✓	✓			✓			✓	✓		✓
Ancillary Infrastructure		✓	✓	✓		✓							✓	✓		✓
Weather stations		✓	✓	✓		✓							✓	✓		✓
Service areas		✓	✓	✓	✓	✓	✓						✓	✓		✓

5. Light Rail

5.1 Key findings

- The key climate hazards that were found to have the highest level of vulnerability for the light rail asset group include; fluvial flooding, pluvial flooding, extreme heat and groundwater flooding.
- The asset categories within the light rail network that are highly vulnerable across all climate hazards are ballasted track, underground and overground electrical sub-stations (ESS's)/ kiosks and tech rooms.

5.2 Asset categories

A Climate Impact Screening assessment of the light rail network (Luas) (see Figure 7 below) was undertaken. The following asset categories were included in the scope of the screening assessment for the light rail asset group, as agreed with the TII asset group PM:

- Drainage;
- Earthworks;
- Embedded track;
- Ballasted track;
- Direct fixed track (fixed to concrete);
- Rolling stock;
- Luas stops;
- Automatic fare collection;
- Overhead line equipment;
- Utilities;
- Control and communication systems;
- Structures;
- Landscaping;
- Buildings;
- Overground ESS's/ tech rooms/ kiosks;
- Underground ESS's and tech rooms;
- Lifts/ escalators;
- Depot equipment; and
- Park and ride car parks.

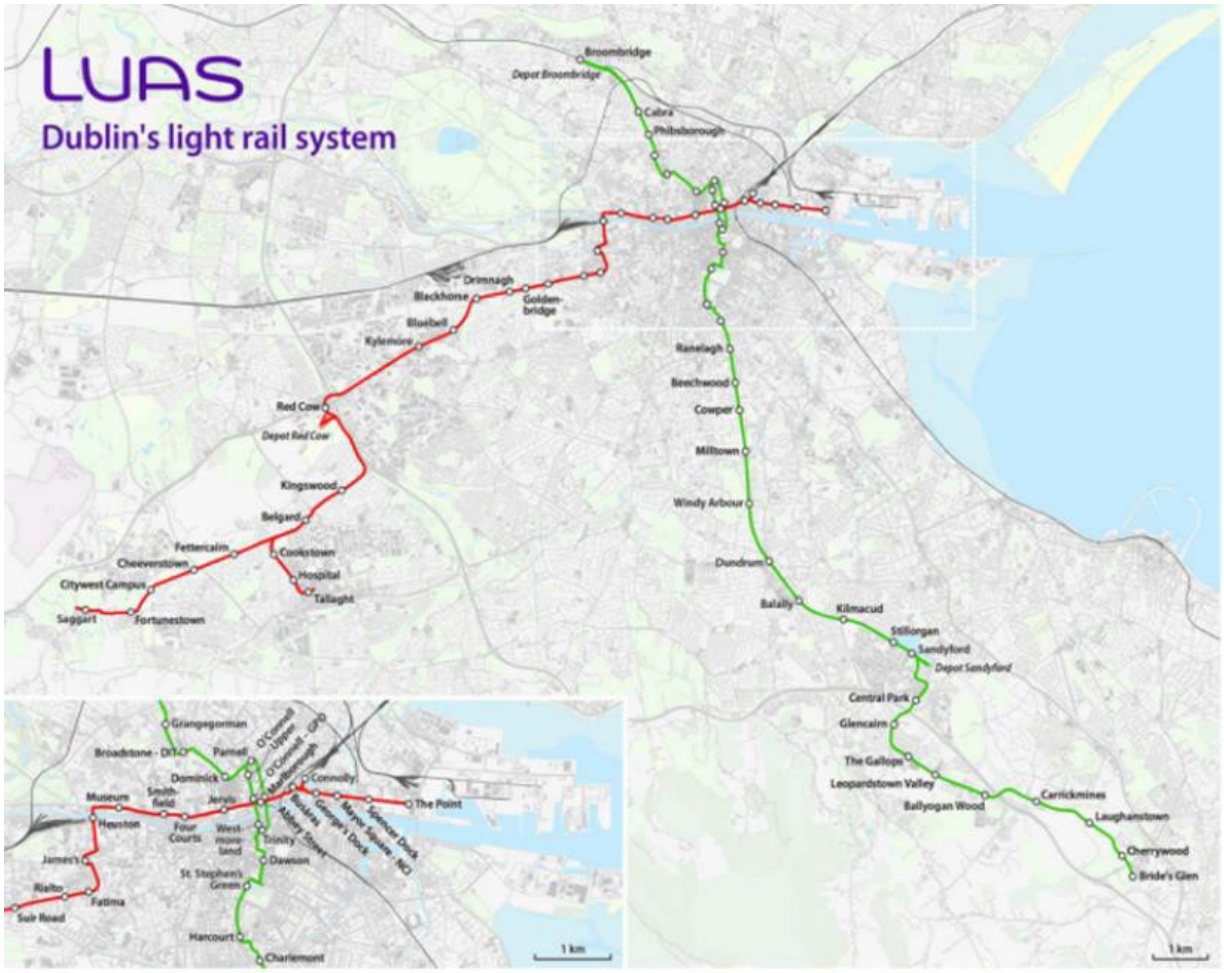

Figure 7 Map of TII's light rail network (Luas green line and red line).[20]

5.3 Climate hazards

The key climate hazards used for the light rail Climate Impact Screening assessment were:

- Flooding (coastal) – including sea level rise and storm surge;
- Flooding (fluvial/ river);
- Flooding (pluvial/ surface water);
- Flooding – groundwater (driven by low intensity, prolonged rainfall);
- Extreme heat;
- Extreme cold;
- Wildfire;
- Drought;

[20] Transport Infrastructure Ireland. Climate Adaptation Strategy 2022. Transport Infrastructure Ireland. [online] 2022. [cited: 29 June 2023.] https://www.tii.ie/technical-services/environment/changing-climate/Climate-Adaptation-Strategy-2022_v2.pdf

- Extreme wind;
- Lightning;
- Hail;
- Natural landslides;
- Engineered slope failure; and
- Fog.

5.4 Prioritisation

The Climate Impact Screening assessment for light rail has identified the asset categories that are most vulnerable to the impacts of the climate hazards. Table 8 below presents a summary of the asset-hazard pairings that are being taken forward for prioritisation (red – high vulnerability) and that are likely to be taken forward for prioritisation (orange – medium vulnerability). As described in Section 3, the assets being taken forward for prioritisation are based on the verified vulnerability ratings. The asset-hazard pairings being taken forward for light rail (summarised in Table 9 below) will be subject to a more detailed priority impact assessment in the next stage. The prioritised asset-hazard pairings are detailed further in the Excel files attached with this summary document of the Climate Impact Screening assessment for light rail.

Table 8 Summary table of climate impact screening assessment for light rail.

Division	Asset categories	Climate Variable													
		Flooding (coastal) - including sea level rise and storm surge	Flooding (fluvial / river)	Flooding (pluvial / surface water)	Flooding - groundwater (driven by low intensity, prolonger rainfall)	Extreme heat	Extreme cold	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides	Engineered slope failure	Fog
		Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability
Light rail	Drainage	3	9	9	6	3	2	2	2	2	2	2	2	4	2
Light rail	Earthworks	3	9	9	6	3	2	2	4	2	2	2	2	4	2
Light rail	Embedded track	1	3	3	2	6	6	3	2	2	2	2	2	4	2
Light rail	Ballasted track	3	9	9	6	9	6	3	2	2	2	2	2	4	2
Light rail	Direct fixed track (fixed to concrete)	1	3	3	2	6	6	3	2	2	2	2	2	4	2
Light rail	Rolling stock	1	3	3	2	3	2	3	2	2	2	2	2	4	2
Light rail	Luas stops	1	3	3	2	3	4	3	2	2	2	2	2	4	2
Light rail	Automatic fare collection	2	6	6	4	3	4	3	2	2	2	2	2	4	2
Light rail	Overhead line equipment	1	3	3	2	9	6	3	2	6	6	2	2	4	2
Light rail	Utilities	1	3	3	2	3	2	3	2	4	4	2	2	4	2
Light rail	Control and communication systems	3	9	9	6	3	4	3	2	4	2	2	2	4	2
Light rail	Structures	3	9	9	6	3	4	3	2	4	2	2	2	4	2
Light rail	Landscaping	1	3	3	2	9	4	3	6	4	4	2	2	4	2
Light rail	Buildings	2	6	6	4	3	2	3	2	4	4	2	2	4	2
Light rail	Overground ESS's/ tech rooms/ kiosks	3	9	9	6	6	4	3	2	4	4	2	2	4	2
Light rail	Underground ESS's and tech room	3	9	9	6	6	4	2	2	2	2	2	2	4	2
Light rail	Lifts/ escalators	3	9	9	6	3	2	3	2	2	2	2	2	4	2
Light rail	Depot equipment	1	3	3	2	3	4	3	2	2	2	2	2	4	2
Light rail	Park and ride car parks	3	9	9	6	3	4	2	2	2	2	2	2	4	2

Table 9 Asset-hazard pairings for prioritisation – light rail

Asset-hazard pairings being taken forward for prioritisation														
Asset	**Climate hazard**													
	Flooding (coastal)	Flooding (fluvial)	Flooding (pluvial/ surface water)	Flooding (groundwater)	Extreme heat	Extreme cold	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides	Engineered slope failure	Fog
Drainage	✓	✓	✓	✓	✓								✓	
Earthworks	✓	✓	✓	✓	✓			✓					✓	
Embedded track		✓	✓		✓	✓							✓	
Ballasted track	✓	✓	✓	✓	✓	✓							✓	
Direct fixed track (fixed to concrete)		✓	✓		✓	✓							✓	
Rolling stock		✓	✓		✓								✓	
Luas stops		✓	✓		✓	✓							✓	
Automatic fare collection		✓	✓	✓	✓	✓							✓	
Overhead line equipment		✓	✓		✓	✓			✓	✓			✓	
Utilities		✓	✓		✓				✓	✓			✓	
Control and communication systems	✓	✓	✓	✓	✓	✓			✓				✓	
Structures	✓	✓	✓	✓	✓	✓			✓				✓	
Landscaping		✓	✓		✓				✓				✓	
Buildings		✓	✓	✓	✓				✓	✓			✓	
Overground ESS's/ tech rooms/ kiosks	✓	✓	✓	✓	✓	✓		✓		✓			✓	
Underground ESS's and tech room	✓	✓	✓	✓	✓	✓							✓	
Lifts/ escalators	✓	✓	✓	✓	✓								✓	
Depot equipment		✓	✓		✓	✓							✓	
Park and ride car parks	✓	✓	✓	✓	✓	✓								

6. Rural Cycleways and National and Regional Greenways

6.1 Key findings

- The key climate hazards that were found to have the highest level of vulnerability for the rural cycleways and national and regional greenways asset group include; flooding (coastal, fluvial and pluvial), engineered slope failure, and coastal erosion.
- The asset categories within the rural cycleways and national and regional greenways network that are highly vulnerable across all climate hazards are the different types of pavement and structures.
- The asset workshop highlighted that older structures assets have been found to be sensitive to certain climate hazards, due to their significant age and having been adopted from the historic rail network. This will be an important consideration when looking at the more detailed assessment, which will aim to distinguish between older structures and more recent, purpose-built structures.
- The asset categories of medium priority for wildfire have been taken forward for prioritisation as a result of the rural cycleways and national and regional greenways network being vulnerable to wildfire. Although there is limited data on wildfire probability on a national scale, it is understood that a study is being planned over the next two years on wildfire risk in Ireland.
- The assessments have been undertaken with very limited asset data. Certain geographic factors or characteristics of individual assets have not been considered which may exacerbate or decrease asset sensitivity and exposure.

6.2 Asset categories

A Climate Impact Screening assessment for the rural cycleways, national and regional greenways network was undertaken. The following asset categories were included in the scope of the screening assessment for the rural cycleways, national and regional greenways asset group, as agreed with the TII asset group PM:

- Signs, light posts and fences;
- Drainage;
- Earthworks;
- Pavements[21]:
  - Pavement Type A - Bituminous material base/binder and surface course;
  - Pavement Type B - Unbound granular base with surface dressing;
  - Pavement Type C - Unbound granular base, un-sealed;
- Kerbs, footways, and paved areas;

[21] Following conversations with TII pavement specialists, it was felt that pavements was too broad a category to reflect the different types of pavement engineering and characteristics across the rural cycleways and greenways network, therefore 3 sub-pavement types have been proposed.

- Road markings;
- Utilities;
- Traffic control and communication;
- Structures;
- Tunnels;
- Landscaping;
- Buildings; and
- Ancillary infrastructure.

It is noted that TII is looking for further clarity on the assets associated with Rural Cycleways and National and Regional Greenways. Therefore, we recommend reassessing these asset classes in the next phase of work to understand whether the asset categories can be rationalised. There may also be a requirement to consider National Cycleway network moving forward also.

6.3 Climate hazards

The key climate hazards used for the greenways Climate Impact Screening assessment were:

- Flooding (coastal) – including sea level rise and storm surge;
- Flooding (fluvial/ river);
- Flooding (pluvial/ surface water);
- Flooding – groundwater (driven by low intensity, prolonged rainfall);
- Extreme heat;
- Extreme cold;
- Wildfire;
- Drought;
- Extreme wind;
- Lightning;
- Hail;
- Natural landslides;
- Engineered slope failure;
- Fog; and
- Coastal erosion.

6.4 Prioritisation

The completion of the Climate Impact Screening assessment for rural cycleways, national and regional greenways identified the asset categories that will be most vulnerable to the impacts of certain climate hazards.

The asset categories for rural cycleways and national and regional greenways have been assessed but it is recognised that these assets are currently not under the maintenance of TII. It is assumed that the assessment for this asset group will support TII in the development of rural cycleways and national and regional greenways. Table 10 below presents a summary of the asset-hazard pairings that are being taken forward for prioritisation (red – high vulnerability) and that are likely to be taken forward for prioritisation (orange – medium vulnerability). As described in Section 3, the assets being taken forward for prioritisation are based on the verified vulnerability ratings. The asset-hazard pairings being taken forward for rural cycleways and national and regional greenways (summarised in Table 11 below) will be subject to a more detailed priority impact assessment in the next stage. The prioritised asset-hazard pairings are detailed further in the Excel files attached with this summary document of the Climate Impact Screening assessment for rural cycleways and national and regional greenways.

Table 10 Summary table of climate impact screening assessment for cycleways and greenways.

Division	Asset categories	Climate Variable														
		Flooding (coastal) – including sea level rise and storm surge	Flooding (fluvial / river)	Flooding (pluvial / surface water)	Flooding – groundwater (driven by low intensity, prolonged	Extreme heat	Extreme cold (including freeze–thaw)	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides	Engineered slope failure	Fog	Coastal erosion
		Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability	Whole Country Vulnerability
Greenways and cycleways	Signs, light posts and fences	9	9	6	2	3	2	3	2	4	2	2	3	6	2	6
Greenways and cycleways	Drainage	9	9	9	6	3	4	1	4	4	2	4	3	6	2	6
Greenways and cycleways	Earthworks	9	9	9	6	6	2	1	4	4	2	2	3	6	2	6
Greenways and cycleways	Pavement Type A – Bituminous material base/binder and surface course	6	6	6	4	9	6	2	6	4	2	2	3	6	2	6
Greenways and cycleways	Pavement Type B – Unbound granular base with surface dressing	9	6	6	4	9	6	2	6	4	2	2	3	6	2	6
Greenways and cycleways	Pavement Type C – Unbound granular base, un–sealed	9	6	6	4	9	6	2	6	4	2	2	3	6	2	6
Greenways and cycleways	Kerbs, footways, and paved areas	6	6	6	2	6	4	2	6	4	2	2	3	6	2	6
Greenways and cycleways	Road markings	6	6	6	2	6	2	3	2	2	2	2	3	6	2	6
Greenways and cycleways	Utilities	9	9	6	4	3	2	2	2	4	4	2	3	6	2	6
Greenways and cycleways	Traffic control and communication	6	6	6	2	3	4	3	2	4	4	2	3	6	2	6
Greenways and cycleways	Structures	9	9	9	6	6	6	3	4	2	2	4	3	6	2	6
Greenways and cycleways	Tunnels	9	9	9	4	6	6	3	2	2	2	2	3	6	2	6
Greenways and cycleways	Landscaping	6	6	6	2	6	4	3	6	4	2	2	3	6	2	6
Greenways and cycleways	Buildings	9	9	9	4	6	4	3	4	4	2	4	3	6	2	6
Greenways and cycleways	Ancillary infrastructure	9	9	6	2	3	2	3	2	4	2	4	3	6	2	6

Table 11 Asset-hazard pairings for prioritisation – rural cycleways and national and regional greenways

Asset-hazard pairings being taken forward for prioritisation																
Asset		**Climate hazard**														
		Flooding (coastal)	Flooding (fluvial)	Flooding (pluvial/ surface water)	Flooding (groundwater)	Extreme heat	Extreme cold	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides	Engineered slope failure	Fog	Coastal erosion
Signs, light posts and fences		✓	✓	✓				✓		✓			✓	✓		✓
Drainage		✓	✓	✓	✓	✓			✓				✓	✓		✓
Earthworks		✓	✓	✓	✓	✓			✓				✓	✓		✓
Pavements	Pavement Type A - Bituminous material base/binder and surface course	✓	✓	✓	✓	✓	✓		✓				✓	✓		✓
	Pavement Type B - Unbound granular base with surface dressing	✓	✓	✓	✓	✓	✓		✓	✓			✓	✓		✓
	Pavement Type C - Unbound granular base, un-sealed	✓	✓	✓	✓	✓	✓		✓	✓			✓	✓		✓
Kerbs, footways, and paved areas		✓	✓	✓		✓	✓		✓				✓	✓		✓
Road markings		✓	✓	✓		✓		✓					✓	✓		✓
Utilities		✓	✓	✓	✓								✓	✓		✓
Traffic control and communication		✓	✓	✓		✓	✓	✓					✓	✓		✓
Structures		✓	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓
Tunnels		✓	✓	✓	✓	✓	✓	✓					✓	✓		✓
Landscaping		✓	✓	✓		✓		✓	✓				✓	✓		✓
Buildings		✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓
Ancillary infrastructure		✓	✓	✓				✓					✓	✓		✓

7. Buildings

7.1 Key findings

- The key climate hazards that were found to have the highest level of vulnerability for the buildings asset group include; flooding (coastal, fluvial, pluvial and groundwater), and extreme heat.
- The asset categories within the buildings asset group that are highly vulnerable across all climate hazards are drainage, utilities, server rooms and ICT equipment.

7.2 Asset categories

A Climate Impact Screening assessment for TII's headquarter offices at Parkgate street and other buildings within the TII network was undertaken. Other buildings such as depots have been included in other respective asset groups. The following asset categories were included in the scope of the screening assessment for the buildings asset group, as agreed with the TII asset group PM:

- Drainage;
- Heating, Ventilation & Air Conditioning (Hvac);
- UPS (uninterruptable power supply);
- Structures and façade;
- Utilities;
- Server rooms;
- Office car park; and
- ICT equipment.

7.3 Climate hazards

The key climate hazards used for the buildings Climate Impact Screening assessment were:

- Flooding (coastal) – including sea level rise and storm surge;
- Flooding (fluvial/ river);
- Flooding (pluvial/ surface water);
- Flooding – groundwater (driven by low intensity, prolonged rainfall);
- Extreme heat;
- Extreme cold;
- Wildfire;
- Drought;
- Extreme wind;

- Lightning;
- Hail;
- Engineered slope failure; and
- Fog.

7.4 Prioritisation

The completion of the Climate Impact Screening assessment for buildings identified the asset categories that will be most vulnerable to the impacts of certain climate hazards. Table 12 below presents a summary of the asset-hazard pairings that are being taken forward for prioritisation (red – high vulnerability) and that are likely to be taken forward for prioritisation (orange – medium vulnerability). As described in Section 3, the assets being taken forward for prioritisation are based on the verified vulnerability ratings. The asset-hazard pairings being taken forward for buildings (summarised in Table 13 below) will be subject to a more detailed priority impact assessment in the next stage. The prioritised asset-hazard pairings are detailed further in the Excel files attached with this summary document of the Climate Impact Screening assessment for buildings.

Table 12 Summary table of climate impact screening assessment for buildings.

Division	Asset categories	Climate Variable												
		Flooding (coastal) - including sea level rise and	Flooding (fluvial / river)	Flooding (pluvial)	Flooding - groundwater (driven by low	Extreme heat	Extreme cold (including freeze-thaw)	Wildfire	Drought	Extreme wind	Lightning	Hail	Engineered slope failure	Fog
		Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country
		Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability
Buildings	Drainage	6	6	6	6	6	4	2	4	2	2	4	3	2
Buildings	Heating, Ventilation & Air Conditioning (Hvac)	4	4	4	4	9	4	3	2	2	2	2	1	2
Buildings	UPS (uninterruptable power supply)	6	6	6	6	3	2	3	2	2	2	2	1	2
Buildings	Structures and façade	2	2	2	2	9	2	3	4	4	4	4	3	2
Buildings	Utilities	6	6	6	6	6	4	3	4	2	2	2	3	2
Buildings	Server rooms	6	6	6	6	9	2	3	4	2	2	2	1	2
Buildings	Office car park	4	4	4	4	6	4	2	2	4	2	4	3	2
Buildings	ICT equipment	6	6	6	6	6	2	3	2	2	4	2	1	2

Table 13 Asset-hazard pairings for prioritisation - buildings

Asset-hazard pairings being taken forward for prioritisation													
Asset	**Climate hazard**												
	Flooding (coastal)	Flooding (fluvial)	Flooding (pluvial/ surface water)	Flooding (groundwater)	Extreme heat	Extreme cold	Wildfire	Drought	Extreme wind	Lightning	Hail	Engineered slope failure	Fog
Drainage	✓	✓	✓	✓	✓								
Heating, Ventilation & Air Conditioning (Hvac)	✓	✓	✓	✓	✓	✓							
UPS (uninterruptable power supply)	✓	✓	✓	✓									
Structures and façade					✓				✓				
Utilities	✓	✓	✓	✓	✓	✓							
Server rooms	✓	✓	✓		✓								
Office car park	✓	✓	✓	✓	✓				✓				
ICT equipment	✓	✓	✓	✓	✓								

8. Land

8.1 Key findings

- The key climate hazards that were found to have the highest level of vulnerability for the land asset group include; natural landslides and engineered slope failure.
- Most of the asset categories within the land asset group are vulnerable to all listed climate hazards.

8.2 Asset categories

A Climate Impact Screening assessment for the land associated with TII's networks was undertaken. The following asset categories were included in the scope of the screening assessment for the land asset group, as agreed with the TII asset group PM:

- Woodland;
- Woodland Strips;
- Treelines;
- Individual trees or groups;
- Hedges;
- Grass verge;
- Soil;
- Wetland / Pond / Waterbody;
- Feature / Ornamental Areas; and
- Grass track.

8.3 Climate hazards

The key climate hazards used for the land Climate Impact Screening assessment were:

- Flooding (coastal) – including sea level rise and storm surge;
- Flooding (fluvial/ river);
- Flooding (pluvial/ surface water);
- Flooding – groundwater (driven by low intensity, prolonged rainfall);
- Extreme heat;
- Extreme cold;
- Wildfire;
- Drought;

- Extreme wind;
- Lightning;
- Hail;
- Natural landslides;
- Engineered slope failure;
- Fog; and
- Increased annual average temperature.

'Increased annual average temperature' was added as an additional climate hazard to those taken from TII's Climate Guidance for National Roads, Light Rail and Rural Cycleways (offline and greenways) standard[22] for the purpose of the land asset group Climate Impact Screening assessment.

8.4 Prioritisation

The completion of the Climate Impact Screening assessment for land identified the asset categories that will be most vulnerable to the impacts of certain climate hazards. Table 14 below presents a summary of the asset-hazard pairings that are being taken forward for prioritisation (red – high vulnerability) and that are likely to be taken forward for prioritisation (orange – medium vulnerability). As described in Section 3, the assets being taken forward for prioritisation are based on the verified vulnerability ratings. The asset-hazard pairings being taken forward for land (summarised in Table 15 below) will be subject to a more detailed priority impact assessment in the next stage. The prioritised asset-hazard pairings are detailed further in the Excel files attached with this summary document of the Climate Impact Screening assessment for land.

[22] Transport Infrastructure Ireland, "PE-ENV-01104 Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways)," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01104-01.pdf.

Table 14 Summary table of climate impact screening assessment for land.

Division	Asset categories	Climate Variable														
		Flooding (coastal) - including sea	Flooding (fluvial / river)	Flooding (pluvial / surface water)	Flooding (groundwater)	Extreme heat	Extreme cold	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides	Engineered slope failure	Fog	Increased annual average temperature
		Coastal	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country	Whole Country
		Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability
Land	Woodland	4	3	4	2	6	4	6	4	4	2	2	6	6	2	6
Land	Woodland Strips	6	6	4	2	6	4	6	6	6	4	2	6	6	2	6
Land	Treelines	6	6	4	2	6	4	6	6	6	4	4	6	6	2	6
Land	Individual trees or groups	6	6	6	2	6	4	6	6	6	4	4	6	6	2	6
Land	Hedges	6	6	4	2	6	4	6	6	6	2	4	6	6	2	6
Land	Grass verge	6	9	9	2	6	4	6	4	2	2	2	6	6	2	6
Land	Soil	6	9	9	2	6	4	6	6	4	2	2	6	6	2	4
Land	Wetland / Pond / Waterbody	6	9	6	2	6	2	6	6	2	2	4	6	6	2	4
Land	Feature / Ornamental Areas	6	9	9	2	4	2	4	4	6	2	4	6	6	2	4
Land	Grass track	6	9	9	4	6	6	6	4	2	2	2	6	6	2	2

Table 15 Asset-hazard pairings for prioritisation - land

Asset-hazard pairings being taken forward for prioritisation															
Asset	**Climate hazard**														
	Flooding (coastal)	Flooding (fluvial)	Flooding (pluvial/ surface water)	Flooding (groundwater)	Extreme heat	Extreme cold	Wildfire	Drought	Extreme wind	Lightning	Hail	Natural landslides	Engineered slope failure	Fog	Increased annual average temperature
Woodland	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓		✓
Woodland Strips	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓		✓
Treelines	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓		✓
Individual trees or groups	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓		✓
Hedges	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓		✓
Grass verge	✓	✓	✓		✓	✓	✓	✓				✓	✓		✓
Soil	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓		✓
Wetland / Pond / Waterbody	✓	✓	✓		✓		✓	✓				✓	✓		✓
Feature / Ornamental Areas	✓	✓	✓					✓	✓			✓	✓		✓
Grass track	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓

9. People

9.1 Key findings

- The TII divisions at risk from the impacts of climate events are Network Management, Corporate Services, Business Services and the Board.
- There are a significant number of external organisations that are critical to TII's day-to-day operations and who are vulnerable to the impacts of climate events. These include local authorities, consultants and contractors, other modes of transport and public transport operators.

TII's people are a core component of its organisation. It is important to recognise that this asset group is very different to the physical asset groupings discussed in previous sections. As such, it was found that the standardised methodology for undertaking the Climate Impact Screening assessment used for the other five asset groups was not appropriate for 'People'. In addition, while it is becoming increasingly common for organisations to consider the climate risks to its physical assets, the potential climate impacts to staff are under-considered; Arup is unaware of other similar organisations that have undertaken such an assessment. Consequently, Arup has developed a bespoke assessment methodology for this asset group.

This bespoke methodology is formed of four key steps, shown in Figure 8 with more detail on the four steps provided in Sections 9.2 to 9.5. Within these steps, stages 2-4 of TII's climate adaptation approach are covered: impact screening, prioritisation, and detailed climate risk assessment (Figure 1). The assessment considers **likelihood** and **consequence** of impacts to people from the range of climate hazards used in other five assessments– a step in advance of the other asset assessments. This is because sufficient levels of detail on which roles require priority adaptation actions is provided in this bespoke assessment. As a result, the final priority ratings have been changed from medium and high priority to medium and high risk, and the medium and high risk internal and external stakeholders will be taken forward for adaptation planning. Therefore, the next step for the people asset group is to develop a climate adaptation action plan.

An initial workshop was held with TII PMs following the first draft of the Climate Impact Screening assessment to discuss any issues and to establish clarification on people assets.

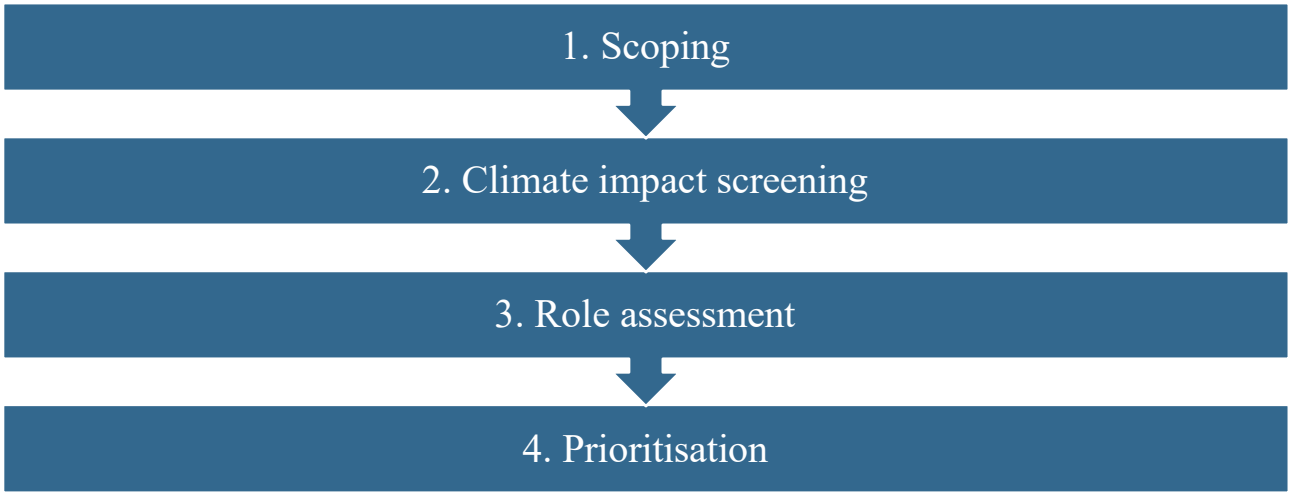

Figure 8 People climate risk assessment workflow diagram.

9.2 Step 1: Scoping

This first step involved developing the scope of the people Climate Impact Screening assessment by understanding job roles and teams associated with TII, key climate hazards and working environments. A working environment is defined as the places where work associated with TII's key roles and responsibilities is undertaken. A list of roles (internal and external), key climate hazards, and working environments was compiled and agreed with TII, as part of step one. Examples of each are presented in Figure 9.

The project team engaged with the TII HR and Occupational Heath teams, as well as an Arup engineer who is familiar with the wide range of teams across TII. This engagement enabled the scoping of the assessment to be finalised.

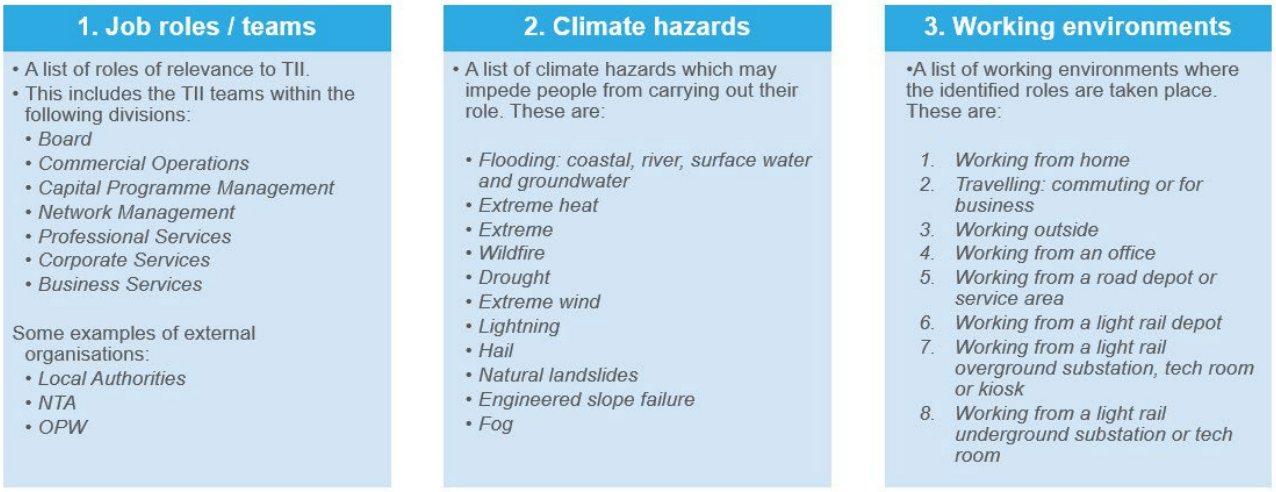

Figure 9 Examples of the roles, climate hazards and working environments adopted for the people climate risk assessment.

9.2.1 Job roles / teams

Table 16 and Table 17 respectively list all TII teams (referred to as internal stakeholders) and external stakeholders that are included in the scope of the screening assessment for the people asset group.

Table 16 Full list of TII divisions and teams included in people assessment.

TII Division	TII Team
Board	Board and Executive Committee
	Corporate Comms
Commercial Operations	Light Rail
	Light Rail: Operations
	Light Rail: Marketing
	Tolling Business
	PPP Procurement & Finance

TII Division	TII Team
	Financial Operations
Capital Programme Management	Roads Capital Programme
	Public Transport Capital Programme
	Public Transport Capital Programme: Public Transport Construction
	Public Transport Capital Programme: Public Transport Construction - Traffic
	Public Transport Capital Programme: Public Transport Construction - Projects Communications/Liaison
	Public Transport New Scheme Planning: Drawing Control
	Public Transport New Scheme Planning: Surveying
	Public Transport Capital Programme: Engineering Design
	Public Transport Capital Programme: Roads & Drainage
	Public Transport Capital Programme: Structural Design
	Public Transport Capital Programme: Track
	Public Transport Capital Programme: Utilities
	Public Transport Capital Programme: Architecture
	Public Transport Capital Programme: Power & Systems Engineering
	Public Transport Capital Programme: Rolling Stock Engineering
	Public Transport Capital Programme: Network Enhancements
	Project Services: Quality & Document Control
	Project Services: Programme Management
	Project Services: Risk
	Project Services: Commercial
	Land & Property Acquisition
Network Management	Network Operations: Traffic Management
	Network Operations: Motorways Operations & Maintenance
	Network Operations: Tunnels Operations & Maintenance

TII Division	TII Team
	Network Operations: PPP Operations
	Network Operations: Maintenance & Winter Operations
	Network Operations
	Pavement Engineering & Asset Management
	Structures Engineering & Asset Management
	Network Data
Professional Services	Strategic & Transport Planning
	Archaeology & Heritage
	Research & Standards
	Environmental Policy & Compliance
	Safety Roads & Tunnels
	Rail & Occupational Safety
Corporate Services	Facilities & Support Services
	Regulatory & Administration
	Procurement
	IT
Business Services	Finance/Accounting
	HR
	Board Secretarial
	Legal & Governance
	Internal Audit
	Land Use Planning

Table 17 Full list of external stakeholders included in people assessment.

External stakeholder group	Division or organisation
Local Authorities	Greenways management
	Roads (inc. winter maintenance)
	Fire services
	Environment Section
	County and City Management Association (CCMA)
	Regional Assemblies
	Planning
Government Departments	Department of Transport
	Department of Housing, Local Government and Heritage
	Department of Justice
	Department of Education
	Department of Environment, Climate and Communications
State Agencies	National Transport Authority (NTA)
	NTA Exec Team
	Inland Fisheries
	NPWS (National Parks & Wildlife Service)
	Irish Water
	Forestry Services
	NSAI (National Standards Authority Of Ireland)
	Irish Rail
	Dublin Bus
	3rd Level Institutions (universities etc.)
	SEAI (Sustainable Energy Authority of Ireland)
	Waterways Ireland

External stakeholder group	Division or organisation
	OPW (Office for Public Works)
	EPA (Environmental Protection Agency)
	GSI (Geological Survey Ireland)
	National Biodiversity Ireland
	Heritage Council
	Teagasc (The Agriculture and Food Development Authority)
	Pesticide Registration and Control Division
	Gas Networks Ireland
	Eirgrid
	Coillte (Forestry)
	Bord na Mona (The Peat Board)
	National Asset Management Agency (NAMA)
	An Bord Pleanala (The Planning Board)
	Enterprise Ireland
	National Monuments Service
	National Museum of Ireland
	Commission for Railway Regulation (CRR)
	Health and Safety Authority (HSA)
	Railway Accident Investigation Unit (RAIU)
	An Garda Siochana (Police)
	NISO (National Irish Safety Organisation)
	IDA
	RSA (Driving test)
	Health Service Executive
	ESB Networks Ireland

External stakeholder group	Division or organisation
Environmental NGOs	Environmental NGOs
Special Interest Group	IRHA (Irish Road Haulage Association)
	Engineers Ireland
	CIF (Construction Industry Federation)
	Irish Asphalt Pavement Producers Association (IAPA)
	CILT Chartered Institute of Logistics & Transport Ireland)
	Royal Irish Academy
	Cycling
	AA
	Ports
	Airports
	Developers
	IBEC (Business Membership and lobbying group)
	IFA (Irish Farmers' Association)
	Irish Barrier Association (IBA)
Public & Public Representative	General Public
	Land Owners
	Elected Officials
Businesses	Kiosk or service area businesses
Contractors	Main Contractors
	PPP Cos
	PPP Conc
	MMARC
	Arch Contractors
	Luas Operator

External stakeholder group	Division or organisation
Consultants	Consultants

9.2.2 Climate hazards

The key climate hazards used for the people Climate Impact Screening assessment (Step 2) are:

- Flooding (coastal) – including sea level rise and storm surge;
- Flooding (fluvial/ river);
- Flooding (pluvial/ surface water);
- Flooding – groundwater (driven by low intensity, prolonged rainfall);
- Extreme heat;
- Extreme cold;
- Wildfire;
- Drought;
- Extreme wind;
- Lightning;
- Hail;
- Natural landslides;
- Engineered slope failure;
- Fog; and
- Coastal erosion.

Many of the hazards identified in this list were taken from the TII Climate Guidance[23], with some additional hazards added following stakeholder engagement.

9.2.3 Working environments

When developing the methodology for the people asset group, it was recognised that the key factor that influences a person's vulnerability to a climate hazard event is where they are undertaking that role. For example, those in roles that require having to travel to and physically maintain a section of network are more likely to be exposed to a climate hazard than someone able to work from home. As such, a list of working environments where the roles identified in Section 9.2.1 are undertaken was developed. These are:

- Working from home
- Travelling: commuting or for business
- Working outside
- Working from an office

[23] Transport Infrastructure Ireland, "PE-ENV-01104 Climate Guidance for National Roads, Light Rail, and Rural Cycleways (Offline & Greenways)," TII Publications, Dublin, 2022. Accessed here on 29th June 2023: https://www.tiipublications.ie/library/PE-ENV-01104-01.pdf.

- Working from a road depot
- Working from a light rail depot
- Working from a light rail overground substation, tech room or kiosk
- Working from a light rail underground

9.3 Step 2: Climate Impact Screening

The second step assessed the list of working environments (e.g. working from home, working from an office or working outside) against the key climate hazards (e.g. extreme heat, flooding and lightning). This stage assessed how the types of hazards to which stakeholders may be exposed vary depending on where they undertake their role. The Climate Impact Screening assessment tool was applied to this step to assess the sensitivity and exposure of the listed working environments.

The working environments that identified as a 'high' vulnerability were taken through to prioritisation along with any working environments that were of 'medium' vulnerability that were taken through on a case-by-case basis. The output of step two is a list of priority climate hazards for each working environment. This demonstrated that any roles which could not be solely undertaken from home if needed, face a higher likelihood of being at-risk from a wider range of climate hazards, due to the increased exposure from travelling from home to work elsewhere, including working outside where the exposure to climate hazards is particularly severe.

A workflow detailing this second step is presented in Figure 10.

Ste1p 2: Climate lhaza1rd sc1iree11ing

For the Peopie asset gmup, the main motor influencing a role's vulnerability to climate hazards is the wodciing environments where the role is undertaken.

This climate hazard screening captures the climate hazards to which earn working environment is vulnerable.

Input:
List of dimate hazards
List of working environments

Worki11g environments
This influences the types and magnitudes of hazards to which stakeholders will be exposed

Tlorking *from an office*
Tforking outside
Travelli,1g commwing or for business
Tforking *from home*

Workingft'om a light l'ail wu:lerground substation. or tech room
liforkingjrom a light l'ail overground sub.station, tech room or kiosk
liforkingjrom a light l'ail depot
liforkingjrom a road depot or sel'vice W'€a

Climate hazards

flooding: coasfaf, rive. surface water and groundwater
Extreme heat
Extreme cofcf
Hi/di.fire
Drought
Extreme wjnd
Lightning
Hail
Nafu,raf landslides
Engineered slope failure
Fog

Climate hazards associated with the working environment

Apply Climate Impact Screening tool to assess sensitivity and exposure of each working environment to each climate hazard.

Calculate overall vulnerability score for each hazard using matrix.

Screen climate hazards in if identified as high vulnerability from the impact screening tool, and review on case-by-case basis those hazards that come out as medium vulnerability.

Travelling (either commuting1 **or** for business)	**Working** •Olutside	'!/\lorking from home	**Work!ing** in an office	Working from a mad] depot or servioe area	Working from a light rail depot	'!/\forking from an overground light raii substation, tech morn **orkiosk**	Worl<ing from an **underground light rail** suosratiOln or tern room
Flooding: coastal, flllivial **pluvial and** groundv,ater	Flooding: coastal, flllivial pllivial and groundwater	Flooding: coastal, fluvial **pluvial and** groundwater	Flooding: coastal, fluvial pluvial and groundi.vater	Flooc:ling: coastal, fluvial pluvial and groundwater	Flooding: ooastal, fluvial pluvial and groundwater	Flooding: ooastal, fluvial pluvial and groundwater	Flooding: ooastal, fluvial pluvial and groundi.vater
Extreme heat	Extreme heat	Extreme **heat**	Extreme heat	Extreme heat	Extreme heat	Extreme heat	Extreme heat
Extreme cold	Extreme cold	Wilclfire	Wildfire	Wildfire	Wildfire	Wildfire	Wildfire
Wilclfire	Wildfire	Coastal erosion	Coastal erosion	Coastal erosion	Coastal erosion	Coastal erosion	Coastal erosion
Extreme wind	**Extreme wind**						
Lightning	Lightning						
Hail	**Hail**						
Fog	Fog						
Goastal erosion	Goastal erosion						

Output:
List of priority climate hazards for each working environment

Figure 10 Climate impact screening workflow for the people climate risk assessment.

9.4 Step: 3 Role assessment

The third step aims to define the **likelihood** and **consequence** of a climate hazard affecting each identified internal and external role.

Here, likelihood is based on roles' working environments, and whether the role can be done effectively while working from home, based on the rationale detailed in Step 2 above. Roles that involved working from home have a relatively low likelihood of experiencing climate hazards and roles that do not involve working from home have a relatively high likelihood of experiencing climate hazards. It is important to note there are some limitations and key assumptions associated with this approach; for example, people in hybrid roles (part-office, part-WFH), may be already working from the office when a climate event occurs, making it more likely they will be affected by the event, either while at work or while travelling home. An adjustment rating column is also provided to enable the likelihood score to be adjusted based on a more nuanced understanding of day-to-day role.

The consequence of a climate hazard affecting roles is based on whether a role is critical for the day-to-day operations of TII. Roles that were found to be critical to day-to-day operations were identified as having high consequences in the short and long-term. Roles that were not found to be critical to day-to-day operations were identified as having high consequences in the long term and low consequences in the short term.

A workflow detailing this third step is presented in Figure 11.

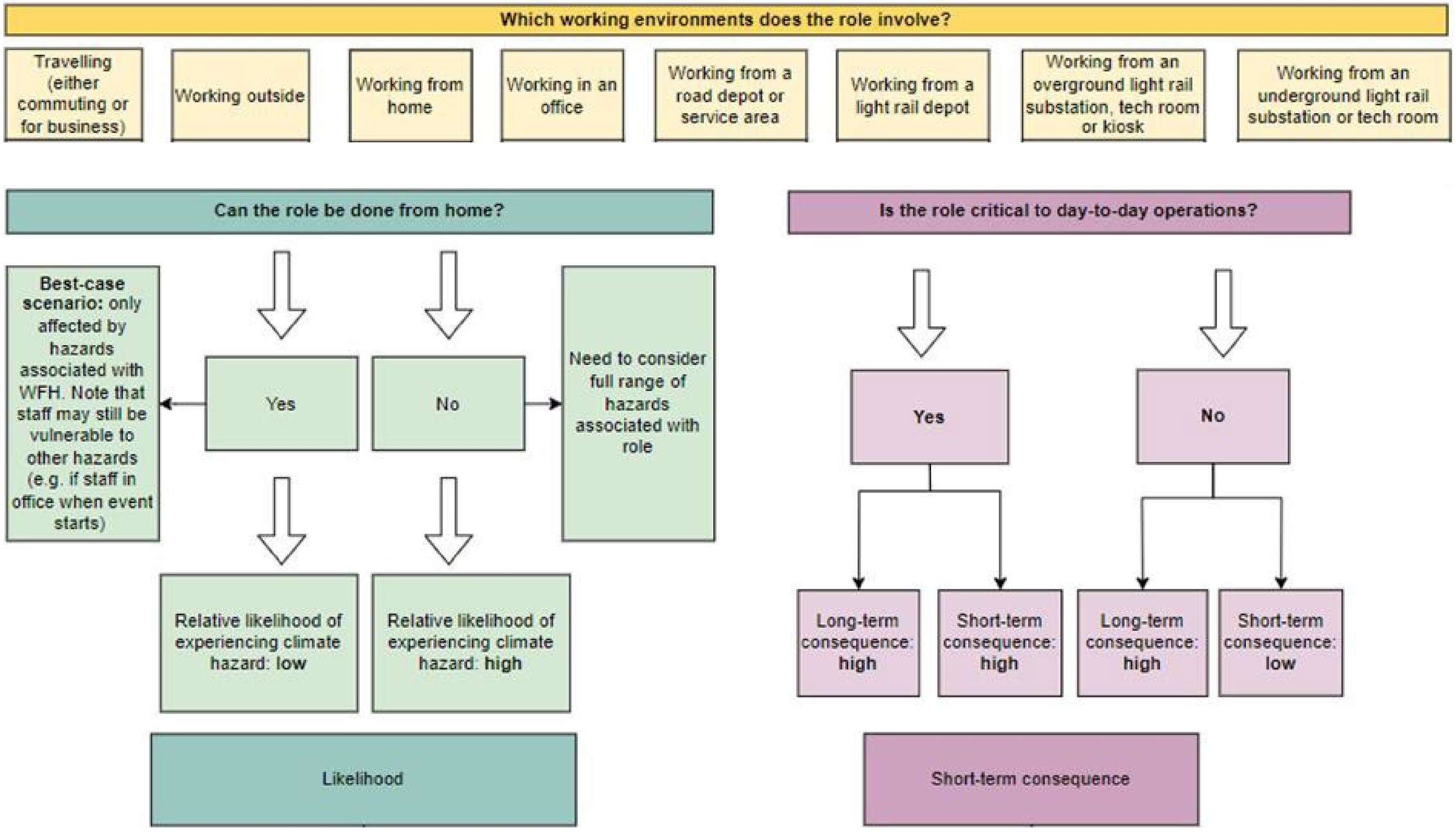

Figure 11 Role assessment workflow for the people climate risk assessment.

9.5 Step 4: Prioritisation

The fourth and final step assigns each role a risk rating of either 'high', 'medium' or 'low', as a function of the role's likelihood and consequence ratings, using the logic presented in the risk matrix in Figure 12. Final risk ratings were determined based on the level of risk associated with each role. Roles that were assigned a high risk rating were identified as being taken forward for the climate adaptation plan, along with roles of medium risk that were taken through on a case-by-case basis. The remaining roles are considered to remain under a watching brief.

The completion of the Climate Impact Screening assessment for people identified the internal roles and external stakeholders that are expected to be most vulnerable to the impacts of climate hazards, shown in the summary table (Table 18) below. Engagement with TII asset specialists helped to confirm the vulnerability ratings for each of the asset categories for people, considering the likelihood and consequence ratings of each of the stakeholders. Further engagement was conducted with TII representatives and Arup experts to finalise the people Climate Impact Screening assessment. TII had an opportunity to provide additional feedback following the workshop when they received a draft of the Climate Impact Screening assessment tool.

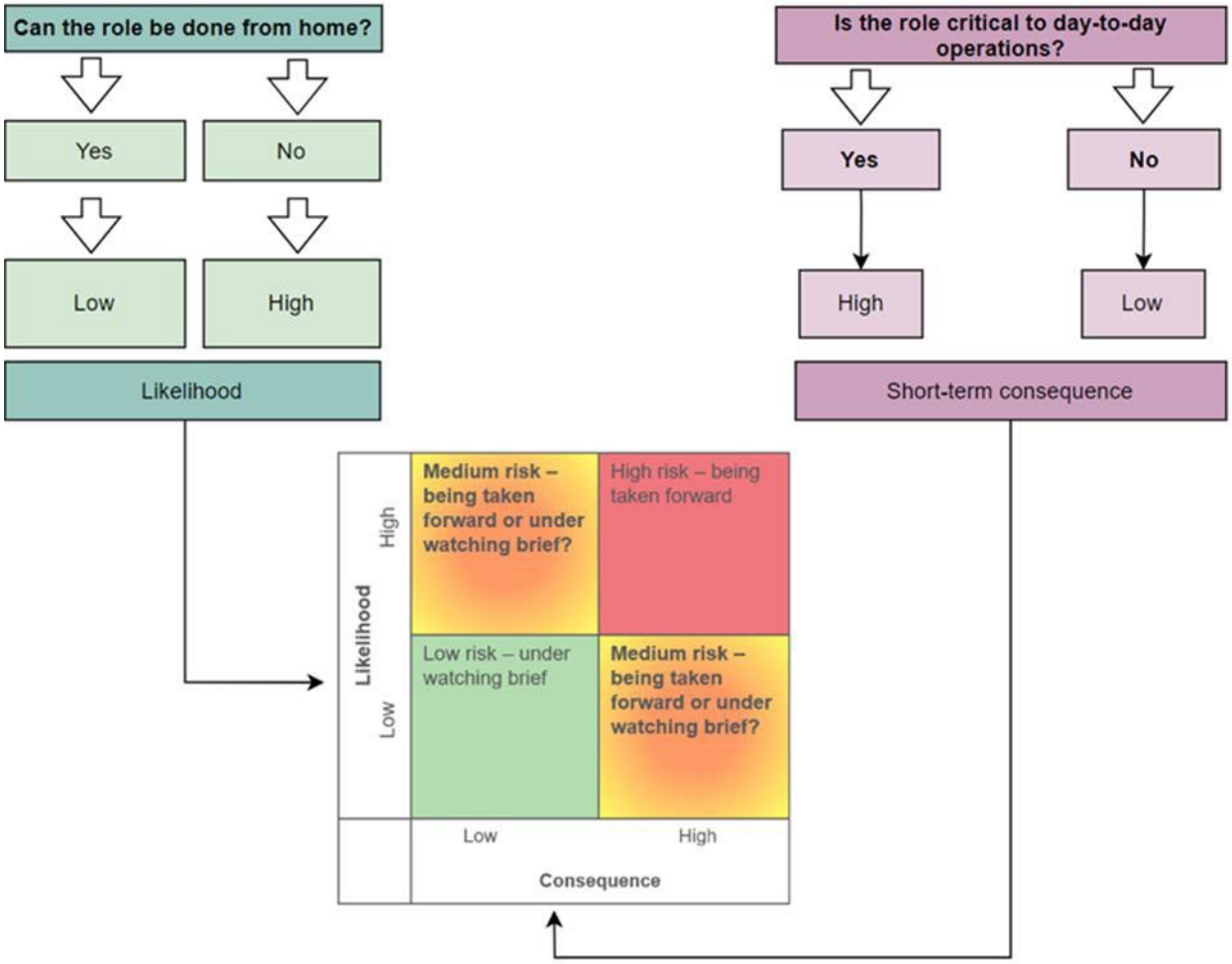

Figure 12 Risk matrix used for the People climate risk assessment.

Table 18 Summary table of climate impact screening assessment for people.

Asset group (TII director ate or organisation and team)	Asset sub-group	Stak.eholder: Internal / ezternal	Final priorit rating
Board	Board and E,ecutive Committee	Internal	Medium risk - being taken forward
Board	Corporate Comms	Internal	Medium risk - being taken forward
Commercial Ooerations	Liaht Rail	Internal	Medium risk - under watching brief
Commercial Operations	Liaht Rail: Operations	Internal	**Hinh risk.- beinntak.en forward**
Commercial Operations	Liaht Rail: Marketina	Internal	Low risk - under watchina brief
Commercial Ooerations	Tollina Business	Internal	Low risk - under watchina brief
Commercial Ooerations	PPP Procurement & Finance	Internal	Low risk - under watchina brief
Commercial Operations	Financial Operations	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Roads Caoital Proaramme	Internal	Low risk - under watchina brief
Capital Proaramme Manaaemen	Public Transport Capital Proaramme	Internal	Medium risk - under watching brief
Caoital Proaramme Manaaemen	Public Transport Capital Programme: Public Transport Construction	Internal	Medium risk - under watching brief
Caoital Proaramme Manaaemen	Public Transport Capital Programme: Public Transport Construction - Traffic	Internal	Medium risk - under watching brief
Caoital Proaramme Manaaemen	Public Transport Capital Programme: Public Transport Construction - Projects Communicationslliaison	Internal	Medium risk - under watching brief
Capital Proaramme Manaaemen	Public Transport New Scheme Plannina: Drawina Control	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Public Transport New Scheme Plannina: Surveuina	Internal	Medium risk - under watching brief
Capital Proaramme Manaaemen	Public Transport Capital Proaramme: Enaineerina Desian	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Public Transport Capital Proaramme: Roads & Drainaae	Internal	Low risk - under watchina brief
Capital Proaramme Manaaemen	Public Transport Capital Proaramme: Structural Desian	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Public Transport Capital Proaramme: Track	Internal	Low risk - under watchina brief
Capital Proaramme Manaaemen	Public Transport Capital Proaramme: Utilities	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Public Transport Capital Proaramme: Architecture	Internal	Low risk - under watchina brief
Capital Proaramme Manaaemen	Public Transport Capital Programme: Power & Systems Enaineerina	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Public Transport Capital Programme: Rolling Stock Enaineerina	Internal	Low risk - under watchina brief
Capital Proaramme Manaaemen	Public Transport Capital Programme: Network Enhancements	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Project Services: Quality & Document Control	Internal	Low risk - under watchina brief
Capital Proaramme Manaaemen	Project Services: Programme Manaaement	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Proiect Services: Risk	Internal	Low risk - under watchina brief
Caoital Proaramme Manaaemen	Proiect Services: Commercial	Internal	Low risk - under watchina brief
Capital Proaramme Manaaemen	Land & Propertu Acauistion	Internal	Low risk - under watchina brief
Network Manaaement	Network Operations: Traffic Manaaement	Internal	Medium risk - being taken forward
Network Manaaement	Network Operations: Motorways Ooerations & Maintenance	Internal	Medium risk - being taken forward
Network Manaaement	Network Operations: Tunnels Ooerations & Maintenance	Internal	Medium risk - being taken forward
Network Manaaement	Network Operations: PPP Ooerations	Internal	Medium risk - being taken forward
Network Manaaement	Network Operations: Maintenance & \1inter	Internal	Medium risk - being taken forward
Network Manaaement	Network Ooerations	Internal	Medium risk - being taken forward
Network Manaaement	Pavement Engineering & Asset Manaaement	Internal	Low risk - under watchina brief
Network Manaaement	Structures Engineering & Asset Manaaement	Internal	Low risk - under watchina brief
Network Manaaement	Network Data	Internal	**Hiahrisk- beinataken forward**
Professional Services	Strateaic & Transoort Plannina	Internal	Low risk - under watchina brief
Professional Services	Archaeoloau & Heritaae	Internal	Low risk - under watchina brief
Professional Services	Research & Standards	Internal	Low risk - under watchina brief
Professional Services	Environmental Policy & Compliance	Internal	Low risk - under watchina brief
Professional Services	Safetu Roads & Tunnels	Internal	Low risk - under watchina brief
Professional Services	Rail & Occuoational Safetu	Internal	Low risk - under watchina brief
Coroorate Services	Facilities & SuPPort Services	Internal	**Hiahrisk- beinataken forward**
Coroorate Services	Reaulatoru & Administration	Internal	Low risk - under watchina brief
Coroorate Services	Procurement	Internal	Low risk - under watchina brief
Coroorate Services	IT	Internal	Medium risk - beina taken
Business Services	Finanoe/Aoooountina	Internal	Medium risk - being taken forward
Business Services	HR	Internal	Medium risk - beina taken
Business Services	Board Secretarial	Internal	Low risk - under watchina brief
Business Services	Leaal & Governance	Internal	Medium risk - under watching brief
Business Services	Internal Audit	Internal	Low risk - under watchina brief
Business Services	Land Use Plannina	Internal	Low risk - under watchina brief
Local Authorities	Greenwaus manaaement	E,ternal	Medium risk - being taken forward
Local Authorities	Roads fine. winter maintenancel	E,ternal	**Hinhrisk- beinataken forward**
Local Authorities	Fire services	E,ternal	1u; i..;; .i...1-,. .ft, ...
Local Authorities	Environment Section	E,ternal	Low risk - under watchinh brief
Local Authorities	County and City Management Association fCCMAI	E,ternal	Low risk - under watchina brief
Local Authorities	Reaional Assemblies	Esternal	Low risk - under watchina brief
Local Authorities	Plannina	E,ternal	Low risk - under watchina brief
Government Deoartments	Deoartment of Transoort	E,ternal	Low risk - under watchina brief
Government Departments	Department of Housing, Local Government and Heritaae	E,ternal	Low risk - under watohina brief
Government DePartments	DePartment of Justice	E,ternal	Low risk - under watchina brief
Government Deoartments	Deoartment of Education	E,ternal	Low risk - under watchina brief
Government Departments	Department of Environment, Climate and Communications	E,ternal	Low risk - under watchina brief
State Aaencies	fNTAI	E,ternal	Low risk - under watchina brief
State Aaenoies	NTA E,eo Tearn	E,ternal	Low risk - under watohina brief
State Aaencies	Inland Fisheries	E,ternal	brief
State Aaenoies	NP\1S (National Parks & \1ildlife Servicel	E,ternal	Medium risk - under watching brief
State Aaencies	Irish \1ater	Esternal	**Hiahrisk- beinataken forward**
State Aaencies	Forestru Services	E,ternal	**Hiahrisk- beinataken forward**
State Aaencies	NSAI (National Standards Authoritu Of Irelandl	E,ternal	Low risk - under watchina brief
State Aaencies	Irish Rail	Esternal	**Hiahrisk- beinataken forward**
State Aaencies	Dublin Bus	E,ternal	**Hinhrisk- beinntaken forward**
State Aaencies	3rd Level Institutions funiversities etc.l	E,ternal	Low risk - under watchina brief
State Aaencies	SEAi (Sustainable Energy Authoritu of Irelandl	E,ternal	Low risk - under watchina brief
State Aaencies	\1aterwaus Ireland	E,ternal	**Hinhrisk- beinat.,ken forw.ord**
State Aaencies	OP\1fOffice for Public \1orksl	E,ternal	**Hiahrisk- beinataken forward**
State Aaencies	EPA (Environmental Protection Aaencul	E,ternal	**Hiahrisk- beinat.oken forw.ord**
State Aaencies	GSI fGeoloaical Surveu Irelandl	Esternal	brief
State Anencies	National Biodiversit11 Ireland	E,ternal	brief
State Aaenoies	Heritaae Council	E,ternal	Low risk - under watohina brief
State Aaencies	Teagasc (The Agriculture and Food Develoomeni Authoritul	E,ternal	Low risk - under watchina brief
State Aaencies	Pesticide Registration and Control Division	E,ternal	Medium risk - under watching brief
State Aaencies	Gas Networks Ireland	Esternal	**Hiahrisk- beinataken forward**
State Aaencies	Eirarid	E,ternal	**Hiahrisk- beinataken forward**
State Aaenoies	Coillte fForestrul	E,ternal	**Hinhrisk- beinataken forward**
State Aaencies	Bord na Mona fThe Peat Boardl	E,ternal	**Hiahrisk - beina taken forward**
State Aaencies	National Asset Management Aaencu fNAMAI	External	**Hiahrisk - beina taken forward**
State Aaencies	An Bord Pleanala (The Planning Boardl	External	**Hiahrisk - beina taken forward**
State Aaencies	Enterorise Ireland	External	Low risk - under watchina brief
State Aaencies	National Monuments Service	External	Medium risl:. - under watching brief
State Aaencies	National Museum of Ireland	External	Medium risl:. - under watching brief
State Aaencies	Commission for Railway Reaulation fCRRI	External	Low risk - under watchina brief
State Aaencies	Health and Safety Authority fHSAI	External	Medium risk - being taken forward
State Aaencies	Railway Accident Investigation UnitfRAIUI	External	**Hinhrisk - beinntaken forward**
State Aaencies	An Garda Siochana fPolicel	External	**Hinh risk • beinn taken forward**
State Aaencies	NISO (National Irish Safety Oraanisation1	External	Low risl:. - under watchina brief
State Aaencies	IDA	External	Low risk - under watchina brief
State Aaencies	RSA fDrivina test1	External	Medium risk - under watching brief
State Aaencies	Health Service Executive	External	**Hiahrisk• beina taken forward**
State Aaencies	ESB Networks Ireland	External	**Hiahrisk• beina taken forward**
Environmental NGOs	Environmental NGOs	External	Medium risk - under watching brief
Soecial Interest Grouo	IRHA (Irish Road Haulage Associationl	External	Low risl:. - under watchina brief
Soecial Interest Grouo	Enaineers Ireland	External	Low risl:. - under watchina brief
Soecial Interest Grouo	CIF (Construction Industry Federationl	External	Low risl:. - under watchina brief
Soecial Interest Grouo	Irish Asphalt Pavement Producers Association flAPAI	External	Low risk - under watchinq brief
Soecial Interest Grouo	CILT Chartered Institute of Loaistics & Transoort Irelandl	External	Low risk - under watchina brief
Soecial Interest Grouo	Roual Irish Academu	External	Low risl:. - under watchina brief
Soecial Interest Grouo	Cuclina	External	Medium risk - under watching brief
Soecial Interest Grouo	AA	External	**Hiahrisk• beina taken forward**
Soecial Interest Grouo	Ports	External	Medium risk - being taken forward
Soecial Interest Grouo	Airoorts	External	Medium risk - being taken forward
Soecial Interest Grouo	Develooers	External	Medium **risk -** under watching brief
Soecial Interest Grouo	IBEC (Business Membership and lobbuina arouol	External	Low risl:. - under watchina brief
Soecial Interest Grouo	IFA flrish Farmers' Associationl	External	Low risk - under watchina brief
Soecial Interest Grouo	Irish Barrier Association flBAI	External	Medium 11sk - under watching brief
Public & Public Reoresentative	Gener al Public	External	Medium r1s1:. - under watching brief
Public & Public Reoresentative	Land Owners	External	Medium risk - under watching brief
Public & Public Reoresentative	Elected Officials	External	**Hiahrisk• beina taken forward**
Businesses	Kiosk or service area businesses	External	Medium risk - being taken forward
Contractors	Main Contractors	External	**Hinh risk • beinn taken forward**
Contractors	PPP Cos	External	**Hinhrisk• beinntaken forward**
Contractors	PPP Cone	External	**Hinhrisk• beinntaken forward**
Contractors	MMARC	External	**Hiahrisk• beina taken forward**
Contractors	Arch Contractors	External	Medium risk - being taken forward
Contractors	Luas Ooerator	External	**Hiahrisk• beina taken forward**
Consultants	Consultants	External	Medium risk - being taken forward

Table 19 presents the roles that were found to be most affected by climate hazards (high risk). Three are internal TII teams, while the remaining 25 are external organisations, including critical infrastructure providers, local authorities and state agencies.

Table 19 TII teams and external stakeholders identified as being at high risk from climate impacts.

TII division / External stakeholder type	TII team / External stakeholder	Internal TII team or external organisation?
Commercial Operations	Light Rail: Operations	Internal
Network Management	Network Data	
Corporate Services	Facilities & Support Services	
Local Authorities	Roads (inc. winter maintenance)	External
	Fire services	
State Agencies	Irish Water	
	Forestry Services	
	Irish Rail	
	Dublin Bus	
	Waterways Ireland	
	OPW (Office for Public Works)	
	EPA (Environmental Protection Agency)	
	Gas Networks Ireland	
	Eirgrid	
	Coillte (Forestry)	
	Bord na Mona (The Peat Board)	
	National Asset Management Agency (NAMA)	
	An Bord Pleanala (The Planning Board)	
	Railway Accident Investigation Unit (RAIU)	

TII division / External stakeholder type	TII team / External stakeholder	Internal TII team or external organisation?
	An Garda Siochana (Police)	
	Health Service Executive	
Special Interest Group	AA	
Public & Public Representative	Elected Officials	
Contractors	Main Contractors	
	PPP Cos	
	PPP Conc	
	MMARC	
	Luas Operator	

Table 20 presents the roles that were found to be at medium risk from climate impacts (medium risk, being taken forward). 11 are internal TII teams such as the board and network management, while the remaining eight are external organisations, including businesses and consultants within the TII supply chain.

Table 20 TII teams and external stakeholders identified as being at medium risk (being taken forward) from climate impacts.

TII division / External stakeholder type	TII team / External stakeholder	Internal TII team or external organisation?
Board	Board and Executive Committee	Internal
Board	Corporate Comms	
Network Management	Network Operations: Traffic Management	
Network Management	Network Operations: Motorways Operations & Maintenance	
Network Management	Network Operations: Tunnels Operations & Maintenance	
Network Management	Network Operations: PPP Operations	
Network Management	Network Operations: Maintenance & Winter Operations	
Network Management	Network Operations	
Business Services	Finance/Accounting	
Business Services	HR	

TII division / External stakeholder type	TII team / External stakeholder	Internal TII team or external organisation?
Corporate Services	IT	
Local Authorities	Greenways management	External
State Agencies	Health and Safety Authority (HSA)	
Special Interest Group	Ports	
Special Interest Group	Airports	
Businesses	Kiosk or service area businesses	
Contractors	Arch Contractors	
Consultants	Consultants	

10. Disclaimer on climate data

In preparing this screening template we have used climate model outputs obtained from external sources including Met Eireann, Climate Ireland and the EPA. Such models can help consider possible future climate scenarios or outcomes, but no model that attempts to project the future can do so with certainty. Actual events may not occur as projected, and the differences may be material. As such, this assessment does not make any representation or warranty, express or implied, regarding the accuracy or completeness of any such forward-looking advice, or any models, projections, forecasts, opinions or estimates.

Any advice, including forward-looking advice, is time-sensitive at the time of writing. Climate models are constantly updated and there may be material differences between climate models used at the time of writing and climate models generated later.

11. Conclusion

This report has presented Arup's approach to and findings from undertaking Climate Impact Screening assessments for each of TII's six key asset groups: national roads; light rail; rural cycleways and national and regional greenways; buildings; land; and people.

The asset-hazard pairings being taken forward for prioritisation for each asset group are outlined in the following summary tables throughout the report: Table 7, Table 9, Table 11, Table 13, Table 15, and Table 18. The level of priority for each asset-hazard pairing and associated justifications is detailed further in the attached Climate Impact Screening assessment Excel files for each asset group.

A summary of the key findings for each of these asset groups is presented in Table 21 below. These assessments mark the completion of Stages 2 and 3 of TII's approach to climate adaptation, or actions 1.2 and 1.3 as described in TII's Climate Adaptation Strategy.

Table 21 Summary of key findings across the six asset categories' Climate Impact Screening assessments

Asset category	Key findings
National Roads	The key climate hazards that were found to have the highest level of vulnerability for the national roads' asset group include; engineered slope failure, coastal erosion, fluvial flooding and pluvial flooding. The asset categories within the national roads network that are highly vulnerable across all climate hazards are drainage and structures.
Light Rail	The key climate hazards that were found to have the highest level of vulnerability for the light rail asset group include: fluvial flooding, pluvial flooding, extreme heat and groundwater flooding. The asset categories within the light rail network that are highly vulnerable across all climate hazards are ballasted track, underground and overground ESS's/ kiosks and tech rooms.
Rural Cycleways and National and Regional Greenways	The key climate hazards that were found to have the highest level of vulnerability for the rural cycleways and national and regional greenways asset group include: flooding (coastal, fluvial and pluvial), engineered slope failure, and coastal erosion. The asset categories within the rural cycleways and national and regional greenways network that are highly vulnerable across all climate hazards are the different types of pavement and structures. The asset workshop highlighted that older structures assets have been found to be sensitive to certain climate hazards, due to their significant age and having been adopted from the historic rail network. This will be an important consideration when looking at the more detailed assessment, which will aim to distinguish between older structures and more recent, purpose-built structures.
Buildings	The key climate hazards that were found to have the highest level of vulnerability for the buildings' asset group include; flooding (coastal, fluvial, pluvial and groundwater), and extreme heat.

Asset category	Key findings
	The asset categories within the buildings asset group that are highly vulnerable across all climate hazards are drainage, utilities, server rooms and ICT equipment.
Land	The key climate hazards that were found to have the highest level of vulnerability for the land asset group include natural landslides and engineered slope failure. Most of the asset categories within the land asset group are vulnerable to all listed climate hazards.
People	The TII divisions at risk from the impacts of climate events are: **Commercial Operations**; Network Management; Corporate Services; Business Services and the Board. There are a significant number of external organisations that are critical to TII's day-to-day operations and vulnerable to the impacts of climate events. These include local authorities, consultants and contractors, other modes of transport and public transport operators.

12. Next steps

The output from each of the Climate Impact Screening assessments – bar the people asset group - is a final list of prioritised climate hazard-asset pairings, which have been identified as requiring further investigation. This list of climate hazard-asset pairings will be taken forward as the scope of a more detailed climate risk assessment, which will aim to provide additional insights into the likelihood and consequence of a climate hazard impacting the assets, adopting a geospatial approach where possible.

The detailed climate risk assessment will use spatial information, make use of climate model data such as that from TRANSLATE[24] and consider asset specific characteristics where possible. The aim of the detailed climate risk assessment is to provide a sufficient level of detail on the climate risks such that tangible climate adaptation measures and actions can be developed, forming climate action plans for each of the asset groups – Stage 5 in the TII climate adaptation approach (Figure 13).

For the people asset group, the assessment presented and summarised within this report represents the completion of both the Climate Impact Screening and the Priority Impact Assessment. As such, the next step for this asset group will be to develop a climate action plan with climate adaptation measures that address the identified risks.

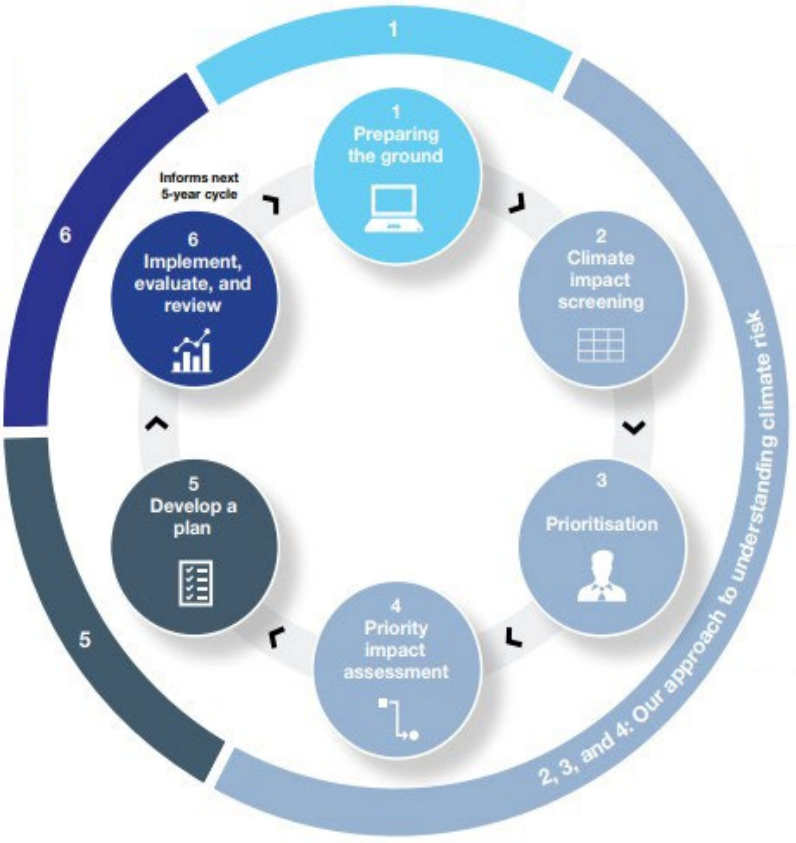

Figure 13 TII's climate adaptation approach, adapted from the Sectoral Planning Guidelines for Climate Change Adaptation. Taken from the TII Climate Adaptation Strategy[25].

[24] Met Éireann (2023) TRANSLATE. Accessed here on 4th July 2023: https://www.met.ie/science/translate.
[25] Transport Infrastructure Ireland. Climate Adaptation Strategy. Transport Infrastructure Ireland. [online] 2022. [cited 29 June 2023.] https://www.tii.ie/technical-services/environment/changing-climate/Climate-Adaptation-Strategy-2022_v2.pdf.

Appendix A

A1 Summary table of governance and engagement

Asset group	Date of engagement
Initial meetings	
Greenways	20 March 2023
Buildings	21 March 2023
Roads	22 March 2023
Land	23 March 2023
People	24 March 2023
Light rail	27 March 2023
People	26 April 2023
Internal Arup meetings	
Roads	27 March 2023
Buildings	30 March 2023
Land	30 March 2023
Light rail	30 March 2023
Greenways	31 March 2023

Asset group	Date of engagement
People	17 April 2023
Workshops – presentation of first draft to TII asset group leads	
Greenways	25 April 2023
Light rail	26 April 2023
Roads	26 April 2023
Buildings	3 May 2023
Land	23 May 2023
GIS	1 June 2023
Greenways	2 June 2023
People	7 June 2023

A2 Climate Impact Screening Assessment excel tool template

Bonneagar Iompair Eireann
Ii r 11 ii, d

Bonneagar Iompair Eireann
Ionad Gn6 Gheata na Pairce
Sraid Gheata na Pairce
Baile Atha Cliath 8
Eire, 008 DK10

Transport Infrastructure Ireland
Parkgate Business Centre
Parkgate Street
Dublin 8
Ireland, 008 DK10

D www.tii.ie

info@tii.ie

II +353 (0)1 646 3600

+353 (0)1 646 3601