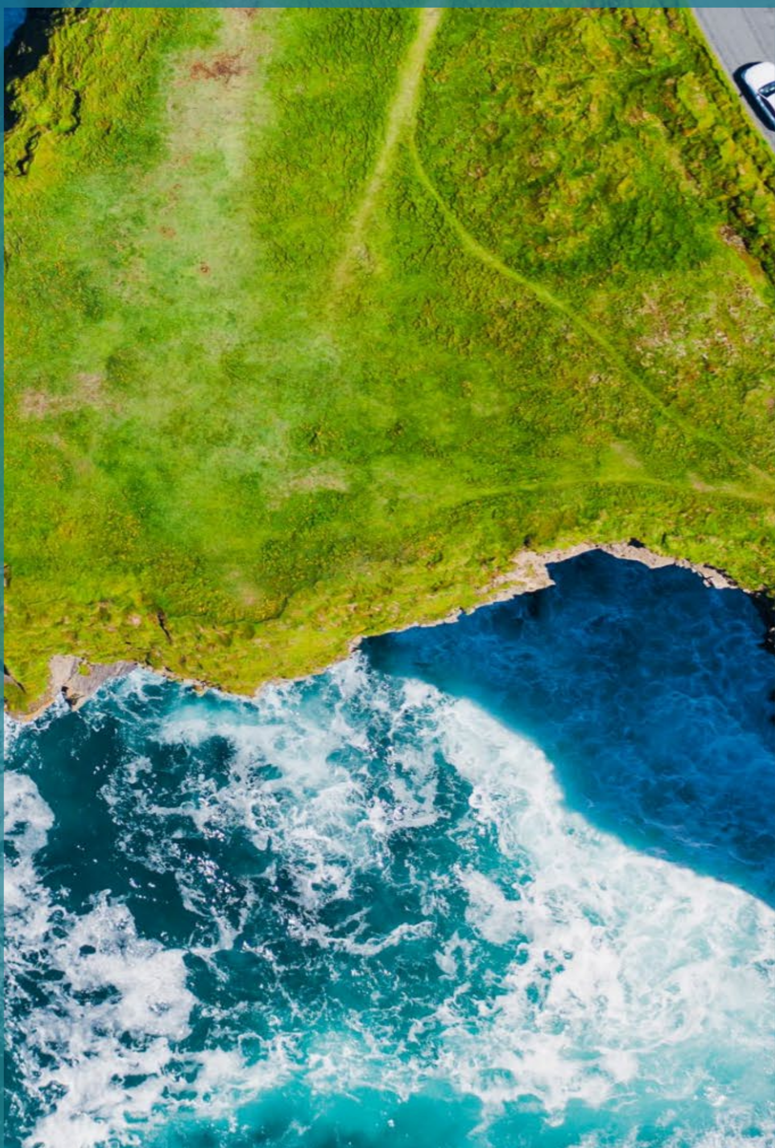
Rialtas na hÉireann
Government of Ireland

National Climate Change Risk Assessment

Main Report

June 2025



Published by the Environmental Protection Agency

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Disclaimer

Acknowledgements

This report was prepared on behalf of the EPA by KPMG Ireland. A steering committee was established to provide direction to the NCCRA process and to participate in reviews of NCCRA outputs, including this guidance document. The membership of the steering committee included representatives from: The Environmental Protection Agency, The Commission for the Regulation of Utilities, Department of Agriculture, Food and the Marine, Department of Defence - Office of Emergency Planning, Department of Environment, Climate and Communications, Department of Health, Department of Housing, Local Government and Heritage, Department of Tourism, Culture, Arts, the Gaeltacht, Sports, and Media, Department of Transport, Department of the Taoiseach, Met Éireann , National Economic and Social Council, National Parks & Wildlife Service, Office of Public Works, Teagasc.

The report was also reviewed prior to finalisation by the NCCRA expert working groups comprising representatives from the following organisations: The Environmental Protection Agency, Atlantic Seaboard North, Atlantic Seaboard South, and Eastern & Midlands Climate Action Regional Offices, Central Statistics Office, Climate Change Advisory Council, Commission For Communications Regulation, Commission for the Regulation of Utilities, County and City Management Association, Department of Agriculture, Food and the Marine, Department of Environment, Climate and Communications, Department of Health, Department of Housing, Local Government and Heritage, Department of Tourism, Culture, Arts, the Gaeltacht, Sports, and Media, Department of Transport, Dublin City University, Geological Survey Ireland, Health Service Executive, The Irish Climate Analysis and Research UnitS (ICARUS, Maynooth University), Irish Centre for High End Computing, The Marine Institute, Maritime Area Regulatory Authority, Met Éireann, National Economic and Social Council, National Parks & Wildlife Service, Office of Public Works.

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Introduction

Ireland's climate is changing in line with global trends. These changes are unprecedented, and it is now established fact that human activities are resulting in the warming of our climate system. Over the last century, Ireland's climate has become warmer, with patterns of precipitation changing, and rising sea levels. These changes in our average climate conditions are also being reflected in changes in the frequency and severity of extreme weather events. Projections indicate that changes to Ireland's climate will continue and intensify, with far reaching consequences for its environment, economy, and society.

Ireland's first National Climate Change Risk Assessment (NCCRA) provides a comprehensive national overview of the potential risks and opportunities posed by climate change for Ireland. It will play a critical role in meeting national policy objectives and supporting sectoral and local authority climate adaptation planning processes. The NCCRA integrates scientific and technical knowledge with input from expert stakeholders, to identify, assess, and prioritise climate change risks to build a comprehensive understanding of risks.

The NCCRA is delivered through three reports:

- A Summary for Policymakers which contains a summary of policy-relevant aspects of the NCCRA in non-technical and accessible language.
- A Main Report (this report) which provides an overview of the methodology, findings, and recommendations to improve climate risk assessments.
- A Technical Report which sets out the evidence base for the NCCRA and further detail on the risk assessment findings, including descriptions of exposure, vulnerability, and consequence and outlines knowledge gaps.

Approach

To assess climate risk for Ireland, the NCCRA adopts a systematic semi-quantitative risk assessment approach delivered through three stages:

- Stage 1 identified the range of potential risks and opportunities for Ireland posed by climate change and prioritised these for further detailed assessment as part of Stage 2.
- Stage 2 undertook a detailed assessment of the identified risks considering both the timing and spatial extent of potential impacts, to determine the level of consequence if each risk were to occur across 2 climate scenarios and for the present day, mid-century and late century.

- Stage 3 identified current and planned adaptation measures to manage the identified risks and determined the level of decision urgency for each risk based on ongoing and planned actions.

The NCCRA assesses risks across nine systems that represent nationally important functions across the natural, social, infrastructure, and economic domains that support human activity in Ireland. The systems include Biodiversity and Ecosystems, Built Environment, Economy and Finance, Energy, Food Production and Supply Chain, Health, Marine and Coastal Ecosystems, Social, and Water Security. This systems approach recognises that there are strong interlinkages and interdependencies between systems. Therefore, consideration is given to the potential for cascading risks to occur, where the impact of a risk on one system results in impacts on another system.

Assessment of the risk level posed to each system was considered across two climate scenarios – a moderate emissions (RCP 4.5) and high emissions scenario (RCP 8.5), and three time horizons – present to 2030, mid-century, and late-century. Potential impacts associated with each risk is determined based on the level of consequence for the system. The NCCRA integrates consequence ratings into a decision urgency framework, inclusive of adaptation effectiveness, to describe the need for action to be taken on each risk within the next five years.

Findings of the NCCRA

Stage 1 identified a total of 115 risks for Ireland across the nine systems. The more detailed Stage 2 analysis deemed 43 of these risks to be significant in terms of impact at a national level. Stage 3 then investigated the effectiveness of completed, ongoing and planned adaptation activities in addressing these risks. A total of nine risks were identified as priority risks, four of which were classified as requiring urgent action within the next five years to offset substantial impacts in the short term and potentially critical impacts in the long term. The priority risks identified as needing more action are:

- Risk of disruption and damage to energy transmission and distribution infrastructure due to extreme wind.
- Risks of disruption and damage to communication infrastructure due to extreme wind.
- Risk of disruption, damage, and loss of transport infrastructure due to sea level rise, coastal erosion, and coastal flooding.
- Risk of damage and loss of buildings due to sea level rise, coastal erosion, and coastal flooding.

Over the coming decades, the proportion of the 43 significant risks that move in consequence rating from limited to substantial to critical and to catastrophic increases. Under both scenarios the majority of risk are currently rated limited or substantial, this changes to substantial and critical by 2050, and to substantial, critical and catastrophic by 2100. Beyond 2050 the divergence between the medium and high emissions scenario also becomes increasingly apparent.

Risks in a system also have the potential to cascade and impact upon other systems. For example, extreme winds during Storm Darragh in December 2024 and Storm Éowyn in January 2025 resulted in damage and disruption to the energy system resulting in approximately 395,000 households, farms and businesses losing power. This also led to cascading impacts on other sectors, including communication networks and water treatment and supply. The NCCRA identified the cascading impacts across systems, with the Biodiversity and Ecosystem, Economy and Finance, Health, and Social systems being particularly impacted by risks from other systems.

It should be noted that the current main risk drivers for some risks are existing environmental pressures, such as pollution and habitat destruction, or population growth. However, these pressures will be increasingly compounded by climate impacts as time goes on.

The NCCRA also identifies potential transboundary impacts for Ireland related to food security, supply chains, economic stability, and human mobility that may result from impacts of climate change that occur outside the state.

While there are significant risks from climate change, there are also potential for opportunities to enhance Ireland's resilience and sustainability. The NCCRA identifies five potential opportunities as a result of projected changes in Ireland's climate. These opportunities include:

- Increased tourism and expansion of outdoor activity tourism,
- Increased hydropower generation.
- Increased shellfish growth and diversity of marine species.
- Increased growing season and improved livestock nutrition and grazing.
- Improved mental and physical health by increased time spent outdoors and reduced cold-related deaths.

Conclusions and Recommendations

The NCCRA provides the first semi-quantitative national climate change risk assessment for Ireland by identifying, assessing and prioritising climate risks for Ireland. This provides a comprehensive evidence base to inform policy and support the development of Sectoral Adaptation Plans and Local Authority Climate Adaptation Plans. More broadly, the NCCRA can support understanding of climate risk and adaption planning across government, businesses, and communities. Recognising the iterative nature of climate change risk assessment and adaptation planning, the NCCRA makes recommendations to strengthen future iterations of the NCCRA. The recommendations are split between those that enhance the methodology and scope of the NCCRA, and those that would develop the evidence base for assessment.

Recommendations which would improve the scope and methodology of the NCCRA include:

- Further integration of non-climatic drivers, such as future changes in population, land use, and urbanisation.
- Incorporation of transition risks as they interact with physical risks and are essential for understanding the full range of challenges and opportunities in moving to a low-carbon, climate-resilient economy.
- Inclusion of financial quantification to estimate the costs of climate risks, including damages, disruptions, and adaptation to strengthen consequence assessments and support the prioritisation of actions.
- Expanding transboundary risk assessment by evaluating their consequence, uncertainty, decision urgency, and their direct and indirect impacts on other systems.
- Evaluation of compound and aggregating risks by developing methodologies to capture the impacts of multiple, concurrent or sequential hazards, thereby improving the understanding of overall risk consequence.

Recommendations to develop the assessment evidence base include:

- Enhance climate and hazard data by ensuring consistency in spatial and temporal coverage, scenarios, and formats to improve integration and comparability across hazards.
- Improve exposure and vulnerability data through detailed mapping of assets, functions, and thresholds, including socio-economic and environmental sensitivities.
- Develop future projections for changes in exposure and vulnerability using national planning policies and global climate scenarios to strengthen assessment of future consequences.
- Establish a climate impacts register to systematically record the social, environmental, and economic impacts of extreme events, supporting more informed risk assessments.
- Develop a standardised approach to assess adaptation effectiveness by building an evidence base of existing and planned actions, enabling consistent evaluation of resilience and informing future risk consequence assessments.

1 Introduction

Ireland's climate is changing in line with global trends and it is now established fact that human activities are resulting in the warming of our climate system.

Over the last century, Ireland's climate has become warmer, precipitation patterns have already changed and are projected to change further, and sea levels are rising. These changes in our average climate conditions are also being reflected in changes in the frequency and severity of extreme weather events.

Climate change projections suggest that these changes will continue and intensify into the future. These changes will impact Ireland's communities and natural systems, incurring huge costs to our economy and society. Therefore, there is an urgent requirement to plan now and well into the future, and to implement adaptation solutions to reduce these risks and take advantage of opportunities. Evidence-based Climate Change Risk Assessments (CCRAs) are an essential foundation on which to build effective and robust actions, for instance, the European Union Climate Risk Assessment (EUCRA).

In Ireland, significant progress has been made in understanding climate change risks at local and sectoral scales through the development of the National Adaptation Framework, Local Authority Climate Action Plans and Sectoral Adaptation Plans. At the National level, climate change projections have been developed by Met Éireann, while the OPW provide detailed flood mapping. A wide range of other organisations and research projects have developed local and regional scale analysis of climate change risks and adaptation.

The EPA's State of the Environment Report[1] concludes that Ireland must manage a range of existing environmental issues and risks, including those associated with the energy transition, biodiversity loss, water quality, transition to a circular economy, harmful exposures to humans, and insufficient investment in infrastructure. The impacts of climate change are already exacerbating or will begin to exacerbate many of these issues as the century progresses. Understanding where, how, and when this is likely to occur is vital if we are to manage these risks and achieve a truly sustainable society.

In the context of these developments, the Irish Government has recognised the need to develop a consistent national climate change risk assessment for Ireland which identifies and prioritises climate change risks, both within and across sectors, and provides a basis for the development of consistent and integrated national and local adaptation plans and strategies. This need is explicitly recognised through Action 457 of Ireland's Climate Action Plan (2021) '*Further develop Ireland's national climate change risk assessment capacity to identify the priority physical risks of climate change to Ireland*' and Action 11

[1] Environmental Protection Agency (2024) *Ireland's State of the Environment Report 2024*. Available at: https://www.epa.ie/our-services/monitoring--assessment/assessment/state-of-environment-report-/

of the National Adaptation Framework '*Develop iterative NCCRA process and associated guidance to underpin sectoral risk assessment and adaptation planning'.*

Ireland's first National Climate Change Risk Assessment (NCCRA) was developed between 2024 and 2025. It focuses on the risks to Ireland from hazards caused, intensified, or influenced, by climate change. These include both acute hazards, such as fluvial flooding, heatwaves and wildfires, and chronic hazards such as rising sea levels, changing precipitation patterns, and long-term temperature shifts. The NCCRA adopted a systematic semi-quantitative[2] risk assessment process to advance national understanding of climate change risks, that supports the identification, assessment, and prioritisation of climate change risks. The NCCRA integrates scientific and technical knowledge, and input from expert stakeholders to provide for a comprehensive understanding of climate change risks.

Ireland's first National Climate Change Risk Assessment (NCCRA) provides a comprehensive national overview of how Ireland might be impacted by climate changes. Led by the EPA with extensive stakeholder input, the NCCRA:

- Identifies, ranks, and prioritises national climate change risks
- Identifies areas where action needs to be prioritised to make Ireland more resilient to the impacts of climate change
- Supports the prioritisation of adaptation-related investments in infrastructure and improve the robustness of policy development in climate-sensitive sectors
- Provides a consistent evidence base on which to inform the development of the National Adaptation Framework, Sectoral Adaptation Plans, and further iterations of Local Authority Climate Action Plans
- Provides a national reference for conducting and updating sectoral, local, and other stakeholder adaptation plans in Ireland.

1.1 Summary of Outputs

The outputs of the NCCRA comprise three reports and a national risk register for Ireland (Table 1.1). The purpose of the NCCRA Main Report, intended for researchers and practitioners, is to provide an overview of the methodology, key findings, and recommendations of the NCCRA. The National Climate Change Risk Register provides a summary of the risk information for each system, such as the consequence, confidence, and decision urgency, and is an Appendix of the Main Report.

[2] Semi-quantitative climate risk assessments builds upon qualitative CCRAs and are often based on nationally consistent sources of climate change in combination with qualitative information (assigned a numeric value), expert judgement and elicitation and stakeholder knowledge. They provide for the identification and prioritisation of national climate change risks to assess adaptation urgency.

The NCCRA Summary Report for Policy Makers provides a concise summary of policy-relevant aspects of the risk assessment, aimed at government officials and decision-makers. The NCCRA Technical Report, intended for sectoral and technical experts, sets out the evidence base for the assessment and further detail on the risk assessment findings, including knowledge gaps for each system as well as qualitative descriptions of exposure, vulnerability, and consequence.

Table 1.1: Overview of the NCCRA reports and their purpose.

Report	Purpose
Summary Report for Policymakers	Concise summary of policy-relevant aspects of the risk assessment in non-technical and accessible language
Main Report (this report)	Provides an overview of the methodology, findings, and recommendations to improve climate risk assessments.
Technical Report	This report sets out the evidence base for the assessment and further detail on the risk assessment findings, including knowledge gaps for each system and qualitative descriptions of exposure, vulnerability, and consequence.

The NCCRA was undertaken between January 2024 and April 2025 and therefore reflects the understanding of climate risks based on the best available evidence during this period. Climate risk assessments are inherently iterative processes, designed to evolve as new data, scientific insights, and societal developments emerge. Accordingly, this iteration of the NCCRA should be regarded as a foundational reference point to inform climate action rather than a static or exhaustive assessment. However, while future NCCRAs will enhance and deepen our understanding, they are unlikely to fundamentally alter the risks identified here.

2 Summary of the NCCRA Approach

The NCCRA Methodology was initially based on similar semi-quantitative approaches such as the UKCRA and New Zealand CRA, and was further developed with input from expert stakeholders. The methodology outlines the approach for delivering the NCCRA, combining scientific and technical information with stakeholder engagement to inform the assessment. The NCCRA was delivered through three stages as summarised below Figure 2.1 and in Figure 2.2. In the following section an overview of the methodology is provided however, the NCCRA Methodology Report (EPA, 2024) contains further detail on the approach.

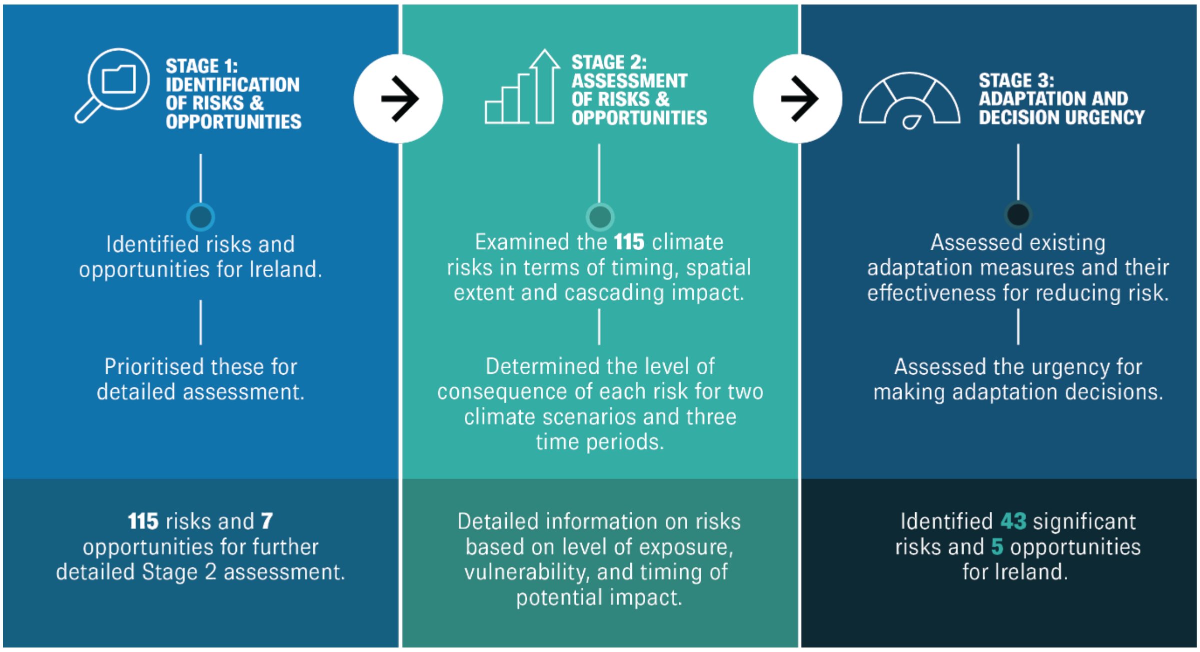


Figure 2.1: An overview of the three stages of the National Climate Change Risk Assessment.

Stage 1 Risk and Opportunity Identification

The purpose of Stage 1 was to:

- Examine potential risks and opportunities for Ireland posed by projected changes in climate hazards, exposure and vulnerability
- Prioritise risks and opportunities for detailed assessment.

This was achieved through a review of academic literature and national and international reports (e.g., TRANSLATE Climate Projections, Irish Climate Change Assessment, Sectoral Adaptation Plans, Local Authority Climate Action Plans, EU Climate Risk Assessment) to develop initial risk and opportunity statements which were then ranked and prioritised in consultation with technical and sectoral experts. Stage 1 resulted in an initial risk and opportunities register that included 115 risks and 7 opportunities for further detailed assessment as part of Stage 2 activities.

Stage 2 Risk and Opportunity Assessment

The purpose of Stage 2 was to:

- Assess the 115 risks in terms of timing and spatial extent of potential impacts through further investigation of hazard, exposure and vulnerability
- Determine the level of consequence of each risk if it were to occur across future climate scenarios and three time periods (current, mid-century, and late century).

Stage 2 focused on exploring the determinants of risk (hazard, exposure, and vulnerability). Where possible, geospatial analysis was conducted to support risk evaluation across two climate scenarios (RCP8.5 and RCP4.5) and three time periods (see Section 2.1.2 for more information on climate scenarios). Additionally, a level of confidence for the hazard and consequence aspects of each risk was determined based on the level of agreement and robustness of the evidence base.

Stage 2 resulted in the development of detailed information for each risk, captured within a risk and opportunity register, and included the assessment of the consequence of each risk for current, mid-century, and late century, across two climate scenarios.

Stage 3 Adaptation and Decision Urgency

The purpose of Stage 3 was to:

- Identify current and planned adaptation measures to manage the identified risks
- Categorise the identified measures according to the 4R's of resilience (Reliability, Resistance, Recovery and Response, and Redundancy)
- Determine the level of decision urgency for each risk based on existing capacity.

Stage 3 focussed on assigning each risk a decision urgency category of either More Action Needed, Further Investigation, Sustain Current Action, or Watching Brief. Through stakeholder engagement (surveys and in-person workshops), the existing or planned measures (in place within the next five years) that reduce risks were identified (see the NCCRA Technical Report for further information). With this information, along with the level of consequence and confidence, a decision urgency was assigned.

Stage 3 resulted in the final national climate risk register, consisting of national risks and opportunities, with each risk consisting of the magnitude of consequence for each future time horizon, and the decision urgency required to manage each of the risks to an acceptable level.

	Stage 1: Identification & Prioritisation of Climate Risks and Opportunities	Stage 2: Detailed Assessment of Priority Risks and Opportunities	Stage 3: Adaptation and Decision Urgency
Purpose	Future time horizons and under an RCP8.5 scenario	Undertake a semi-quantitative assessment of priority risks, accounting for hazard, exposure, and vulnerability, to support Stage 3 assessment	Consider existing and planned adaptation measures and the adequacy of these in minimising risks to an acceptable level
Input	• Existing Information • Expert Interviews • Stakeholder Workshop	• Existing Information • Geospatial analysis • Expert Interviews • Stakeholder Workshops	• Existing Information • Geospatial analysis • Expert Interviews • Stakeholder Workshops
Process	**How could Ireland be affected by climate change?** • Development of risk statements • Based up on an 'elements at risk' approach, e.g. Electricity Network ↓ **Draft national climate risk register** ↓ **What could the consequence of these risks be?** • Magnitude of Consequence of identified risks assessed over future time horizons and with RCP8.5 • Confidence in assessment determined	**Where and when might these risks be realised?** • **Climate impact chains developed** for priority risks accounting for hazard, exposure and vulnerability to enhance understanding of risks • **Spatial assessment of priority risks** (hazard, exposure and vulnerability) undertaken for current period, 2050, and 2100 time horizons and RCP4.5 and RCP8.5 climate scenarios • **Magnitude of Consequence scores** updated	**What is the management status of current and future risks?** Review and identification of **ongoing and planned** adaptation actions **Assessment of adaptation action** using Risk Bowties ↓ **Identification of current and future adaptation actions** ↓ **What is the urgency of action?** • Risks assessed in terms of urgency of action (More action needed, further investigation, sustain current action, watching brief)
Output	**An initial national climate risk and opportunities register which prioritises climate change risks**	**Revised climate change risk and opportunity register based on level of exposure, vulnerability and timing of potential impact**	**A final national climate risk register, accounting for existing and planned adaptation, prioritised based on decision urgency**

Figure 2.2: An overview of the three stages of the NCCRA Methodology

2.1 Key Elements of the NCCRA approach

The following key elements are integral to the approach used within the NCCRA, as they provide a structured framework for evaluating climate change impacts and informing decision-making processes. Each of the following elements is explained in more detail below:

- Definition of Climate Risk
- Climate Change Scenarios
- Systems
- Consequence
- Decision Urgency
- Stakeholder Engagement.

2.1.1 Definition of Climate Risk

The NCCRA follows the conceptual risk framework for climate change risks used in the Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR6) (IPCC, 2023). In this framework, risk is a function of climate hazards, exposure to the hazard, and vulnerability of the system to the effects of the hazard (Figure 2.3 and Table 2.1). Risk is defined as the potential for adverse consequences for human or ecological systems.

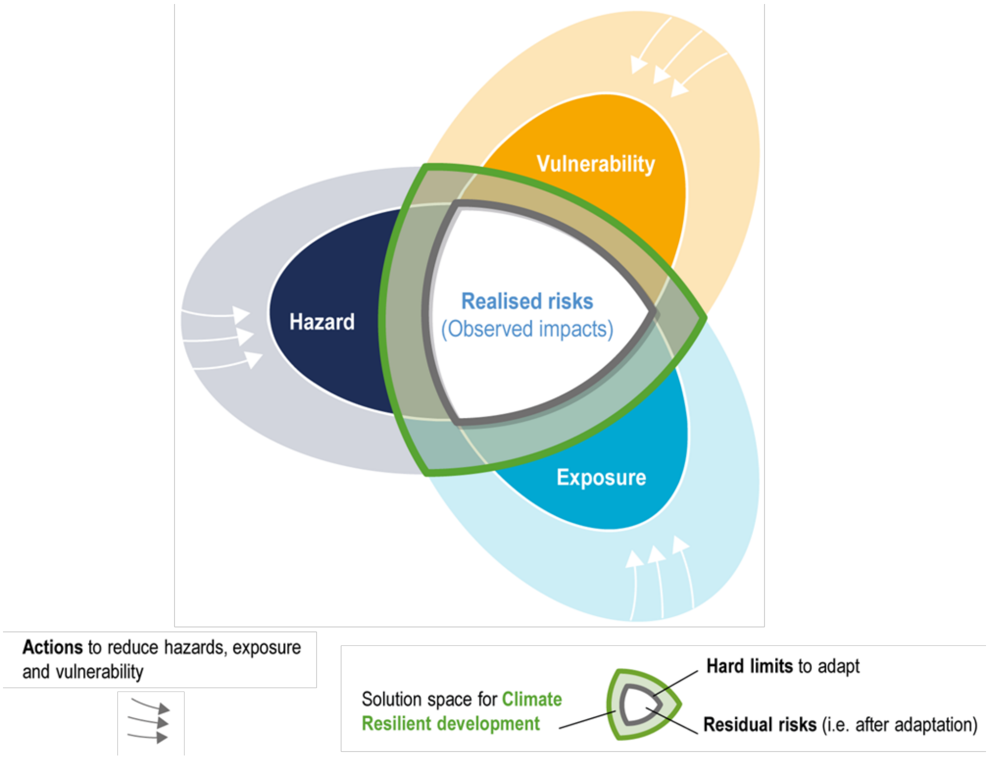


Figure 2.3: Risk is a result of the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems (amended from IPCC, 2022).

Table 2.1: Definitions of the risk determinants from the Intergovernmental Panel on Climate Change (IPCC) Risk Framework.

Risk Determinant	Definition
Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.
Exposure	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Risk	The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change, as well as human responses to climate change.

2.1.2 Climate Scenarios and Projections

Within the NCCRA, risks and opportunities have been assessed using different scenarios of climate change, reflecting different plausible futures, all of which are considered possible depending on the amounts of GHGs emitted in the years to come. A scenario is a plausible description of how the future may develop, based on a set of assumptions about key future socio-economic development such as population growth, economic trends and technological development. The NCCRA used a high-emissions scenario (RCP8.5) and a moderate emission scenario (RCP4.5)[3].

To project and explore credible future climates, the Coupled Model Intercomparison Project (CMIP) a project of the World Climate Research Programme (WCRP) has published extensive climate model simulations which give an understanding of what future changes are likely across a range of variables for the emission scenarios globally. The CMIP5 simulation, which were used in the fifth IPCC Assessment report (AR5), are based on

[3] These scenario corresponds to a radiative forcing of approximately 8.5 W/m² and 4.5 W/m² respectively by the end of the century.

Representative Concentration Pathways (RCPs) which provide scenarios of possible future emissions trajectories that encompass a range of possible climate futures. The IPCC AR5 (IPCC, 2014) used four Representative Concentration Pathways (RCPs) to represent different levels of climate change: RCP2.6, RCP4.5, RCP6.0, and RCP8.5.

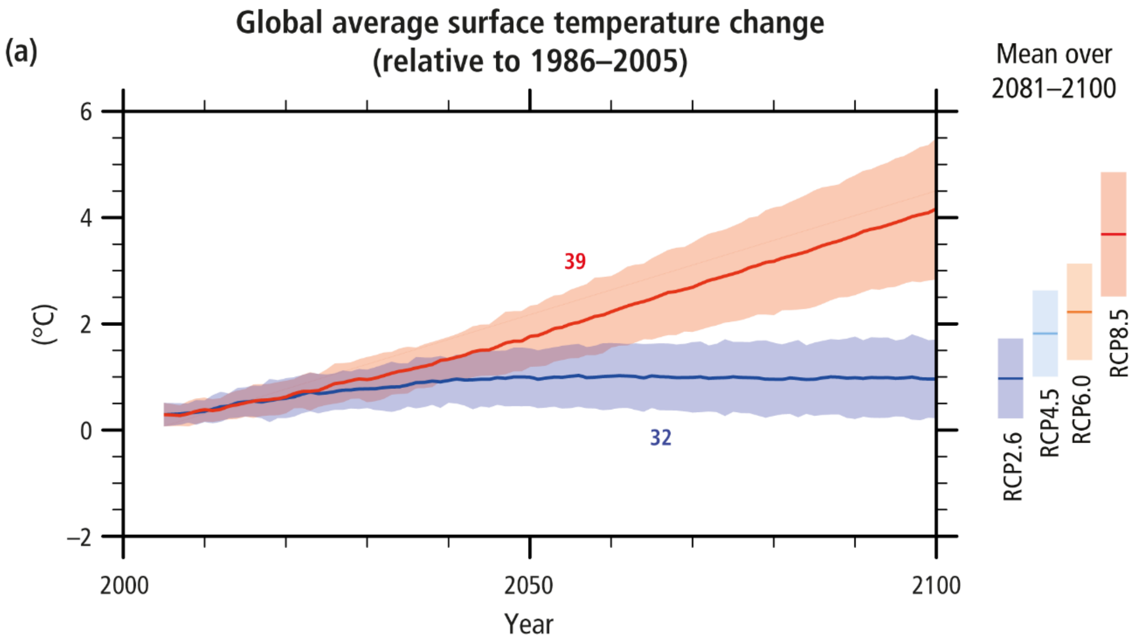


Figure 2.4: Global average surface temperature change from 2006 to 2100 as determined by multi-model simulations from the IPCC AR5 for RCP2.6 (blue) and RCP8.5 (red) with a measure of uncertainty provided (shaded). The mean and associated uncertainties averaged over 2081-2100 are given for all scenarios as coloured vertical bars at the right-hand side of the figure (IPCC, 2014).

Met Éireann has refined these global projections to develop projections for Ireland which enables localised risk assessments to be undertaken.

The NCCRA considers two of these RCPs:

- **RCP8.5:** a high concentration pathway characterised by increasing GHG emissions driven by a lack of policy changes to reduce emissions. This pathway represents increased use of land for agriculture, a heavy reliance on fossil fuels, and a high-energy intensity with a low rate of technology development (NIWA, 2019)
- **RCP4.5:** a moderate concentration pathway consistent with low levels of emissions achieved through ambitious emissions reduction strategies. This pathway represents implementation of stringent climate policies, with a lower-energy intensity, strong reforestation and decreased land for agriculture due to improvements in crop yields and dietary changes (NIWA, 2019).

RCP8.5 was used to screen risks in Stage 1, while Stage 2 considered risks under both RCP8.5 and RCP4.5.

Standardised climate projections for Ireland based upon Shared Socioeconomic Pathways (SSPs) employed through the sixth IPCC Assessment Report (AR6) are currently not available for Ireland and have not been used within the NCCRA.

2.1.3 A Systems-Based Approach

The NCCRA methodology adopts a systems-based approach to classify, identify, and assess risks and opportunities. Within the NCCRA, a system is defined as a group of interacting or interrelated elements that provide nationally important functions (DCCEEW, 2023). The systems employed in the NCCRA are varied and multi-faceted and are based on the EU Climate Risk Assessment to ensure alignment and consistency at the European level. The systems within the NCCRA include Biodiversity and Ecosystems, Built Environment, Economy and Finance, Energy, Food Production and Supply Chain, Health, Marine and Coastal Ecosystems, Social, and Water Security (Table 2.2). These systems encompass the wide range of natural, physical, and human elements, which make up Ireland's natural world, society, and economy.

Each of the systems in Table 2.2 are made up of a series of sub-systems. Sub-systems describe distinct elements of systems. For example, the system 'Built Environment' is made up of four different sub-systems which describe the built world – buildings, communication infrastructure cultural heritage, recreational amenities, transport infrastructure, and water services infrastructure. Table 2.2 shows the systems and their related sub-systems, employed as part of the NCCRA.

The elements within each system will evolve in the future, in response to environmental, societal, technological, economic, and policy drivers that will differ across low, medium, and high emissions scenarios. For example, under a low emissions scenario, the 'Energy' system is projected to transition to a new low carbon electricity system (generation, storage and network).

Each of the sub-systems in Table 2.2 are comprised of elements at risk. Elements at risk are objects, persons, animals, plants, activities, and processes of value to Ireland, that may be exposed to climate change and potentially impacted, negatively or positively, directly, or indirectly. For instance, within the Built Environment system, and under the transport infrastructure sub-system, elements at risks include road, rail, ports/harbours, and airports/runways. Another example would be within the Biodiversity and Ecosystem system, where the forest sub-system is made up two elements at risk – managed forests and unmanaged forests.

Table 2.2: The systems used within the National Climate Change Risk Assessment.

System	Description	Subsystems
Biodiversity and Ecosystems	Encompasses diverse natural habitats and their ecological functions	Forests, Freshwater Systems, Peatland, Terrestrial Ecosystems
Built Environment	Includes human structures and systems supporting daily life	Buildings, Communication, Cultural Heritage, Recreational, Transport Infrastructure, Water Services Infrastructure
Economy and Finance	Includes finance, insurance, and public economic stability	Finance and Insurance, Economic Stability
Energy	Covers the production, conversions, and distribution of energy resources	Energy Generation and Conversion, Energy Transmission and Distribution
Food Production and Supply Chain	Involves the processes and systems for growing and distributing food	Food Production, Supply Chain
Health	Pertains to medical services and overall human well-being	Healthcare, Human Health
Marine and Coastal Ecosystems	Relates to oceanic and coastal habitats and their biodiversity	Coastal Ecosystems, Marine Ecosystems
Water Security	Focuses on the availability and management of water resources for domestic and non-domestic use	Water Supply
Social	Encompasses societal structures and governance systems	Governance, Society

2.1.4 Consequence

Climate change risk assessment requires an emphasis on potential consequence rather than likelihood. Risks were rated with reference to the three determinants of risk (hazard, exposure and vulnerability) using magnitude of consequence criteria, based on the EU CRA (European Environment Agency, 2024). Figure 2.5 below shows the magnitude of consequence criteria to be employed as part of the NCCRA.

The level of consequence for each risk is based on the following criteria:

- **Damage:** The level of losses or harm caused by the risk. Losses and harm are wide ranging and can include economic damage, impacts on people, and impacts on natural capital, species, habitats, and heritage

- **System Functionality:** The degree to which the risk affects the system's ability to perform its intended functions
- **Extent and Pervasiveness:** The scope of the risk's impact, indicating how geographically widespread the effects are within the system, and the degree to which multiple elements within a system are affected
- **Cascading Effects**: The potential for the risk to cause secondary impacts to occur as a result of the initial risk event, which can propagate through interconnected systems leading to additional impacts.

Risk Severity	Damage	System Functionality	Extent and Pervasiveness	Cascading Effects
Catastrophic	Very large and frequent	Irreversible loss	Very large extent or very high pervasiveness	Irreversible cascading effects beyond system boundaries
Critical	Large and frequent	Long-term disturbance	Large extent and high pervasiveness	Long-term cascading effects beyond system boundaries
Substantial	Substantial losses	Temporary or moderate disturbance	Moderate extent or pervasiveness	Temporary cascading effects beyond system boundaries
Limited	Limited or rare losses	No significant disturbance	Limited extent or pervasiveness	No cascading effects beyond system boundaries

Figure 2.5: Magnitude of consequence criteria based on the EU CRA (European Environment Agency, 2024). See Appendix A for additional criteria.

2.1.5 Decision Urgency

The NCCRA uses decision urgency ratings to identify the need for adaptation decision-making. Urgency is defined as "*a measure of the degree to which further action is needed in the next five years to reduce a risk or realise an opportunity from climate change*" (Committee on Climate Change, 2022). There are four levels of urgency described in Figure 2.6. Informed by risk identification, hazard confidence, consequence confidence and current adaptation effectiveness. A level of Decision Urgency was assigned to each risk (see Appendix B for the process to allocate a decision urgency).

More Urgent

Risk Severity	Damage
More Action Needed	**New, stronger or different Government action, whether policies, implementation activities, capacity building or enabling environment for adaptation – over and above those already planned – are beneficial in the next five years to reduce climate risks or take advantage of opportunities. This will include different responses according to the nature of the risks and the type of adaptation:** • Addressing current and near-term risks or opportunities with low and no regret options (implementing activities or building capacity). • Integrating climate change in near-term decisions with a long lifetime or lock-in. • Early adaptation for decisions with long lead-times or where early planning is needed as part of adaptive management.
Further Investigation	**On the basis of available information, it is not known if more action is needed or not. More evidence is urgently needed to fill significant gaps or reduce the uncertainty in the current level of understanding in order to assess the need for additional action.**
Sustain Current Action	**Current or planned levels of activity are appropriate, but continued implementation of these policies and plans is needed to ensure that the risk continues to be managed in the future.**
Watching Brief	**The evidence in these areas should be kept under review, with continuous monitoring of risk levels and adaptation activity (or the potential for opportunities and adaptation) so that further action can be taken if necessary.**

Less Urgent

Figure 2.6: The criteria to assign urgency to each risk (Committee on Climate Change, 2022).

2.1.6 Stakeholder Engagement

Stakeholder engagement formed an integral part of the NCCRA. Stakeholders identified for participation were drawn from all adaptation sectors, and included agencies, partners and organisations directly involved in climate change risk and adaptation. Consequently, four stakeholder groups participated throughout the NCCRA (see Appendix C for more information on the organisations within each group):

- Project Steering Committee was central to guiding the high-level structure as well as providing strategic direction of the NCCRA.
- Climate/Socio-Economic Expert Working Group This working group consisted of organisations, agencies, and bodies, which develop and provide climate and/or socio-economic information that informed the development of the NCCRA.
- Thematic Expert Working Group this working group was made up of organisations and bodies which will be using the output of this risk assessment. This group also provided invaluable cross-sectoral insights in terms of climate change risk, opportunity, mitigation, and adaptation.
- Wider Stakeholders Group provided additional expert insights to inform the identification, assessment, and prioritisation of risks.

Stakeholders with engaged through a range of activities throughout the NCCRA process. Table 2.3 summarises these activities.

Table 2.3: Summary of the stakeholder activities throughout the NCCRA.

NCCRA Stage	Engagement Activity	Stakeholders
Methodology Development	• Online information webinar • Method development workshops	• Expert Working Groups • Expert Working Groups
Stage 1: Identification and Prioritisation of Climate Risks and Opportunities	• Call for Evidence Online Survey • Risk Identification Workshop	• Expert Working Groups • Wider Stakeholders Group • Expert Working Groups
Stage 2: Detailed Assessment of Priority Risks and Opportunities	• Risk Assessment Development Workshop • Risk Assessment Update Workshop	• Expert Working Groups • Wider Stakeholders Group • Expert Working Groups
Stage 3: Adaptation and Decision Urgency	• Adaptation Survey • Adaptation and Urgency Workshop	• Expert Working Groups • Wider Stakeholders Group • Expert Working Groups
Report Review	• Multiple rounds of review of the Technical Report • Review of Main Report • Online survey review of Summary for Policy Makers	• Steering Committee • Expert Groups • Steering Committee • Expert Groups • Expert Groups

More information on the Stakeholder Engagement process can be found in the supplementary NCCRA Consultation Report.

2.2 Aspects outside the scope of the NCCRA

While the NCCRA provides a comprehensive assessment of climate risks at the national level, there are certain aspects that fall outside its scope. These include detailed local-level impacts, non-climatic factors, transboundary risks, transition risks, and low-likelihood high-impact events. While these limitations are common across many climate risk assessments, understanding them is crucial for interpreting the findings of the NCCRA. The following sections outline these aspects in more detail.

2.2.1 National Scale Assessment

The NCCRA is a national scale assessment, with the consequence of a risk assessed on its impact to the entire country. The level of exposure to each risk was assessed on eight subregions (NUTS3[4] regions), with the overall consequence of the risk aggregated at the national level. However, to fully determine the impacts of a risk at a local level would require additional and more focussed climate risk assessments to be undertaken.

2.2.2 Changes in Non-Climate Related Factors

Future climate risks are driven by the change in climate, however, there are also a number of non-climatic factors that can alter future levels of risk. Non-climatic factors of climate change risk encompass urbanisation, pollution, socio-economic processes, population growth, economic development, and land use and land cover change. The NCCRA included, where possible, the potential change in exposure and vulnerability as a result of future population change and an ageing population, however, other non-climatic factors were not included.

2.2.3 Transboundary Risks

Due to insufficient data and information, the NCCRA does not fully assess the potential consequences of transboundary risk for Ireland. However, the NCCRA identifies key transboundary risk where sufficient evidence is available. See Section 5.3 for more information on International Dimensions which can serve as the basis for further investigation.

[4] NUTS3 regions are small territorial units used for specific diagnoses and statistical purposes within the European Union. The Nomenclature of Territorial Units for Statistics (NUTS) divides each EU country into three levels: NUTS1 (major socio-economic regions), NUTS2 (basic regions for regional policies), and NUTS3 (small regions for specific diagnoses).

2.2.4 Transition Risks

The NCCRA also recognises that transitioning to a low-carbon economy can entail extensive policy, legal, technology and market changes to address climate change mitigation and adaptation requirements, and depending on the nature, speed, and focus of these changes, these changes may pose varying levels of financial and reputational risks and opportunities for Ireland’s economy and society (IPCC, 2020). In addition, the transition may result in increased pressure on environmental resources, e.g., potential impacts to the marine environment due to development of offshore renewables. The first NCCRA has a focus of assessing physical risks only and does not include transition risks.

2.2.5 Low-Likelihood High-Impact

Climate change poses numerous challenges, but among the most concerning are Low Likelihood, High Impact events. These are extreme occurrences that, while unlikely, or of undetermined probability, can have devastating consequences. For instance, the Atlantic Meridional Overturning Circulation (AMOC) is a crucial component of the global ocean circulation system, responsible for transporting warm water from the tropics to the North Atlantic[5]. A significant weakening or collapse of the AMOC could lead to drastic climate changes, including severe cooling in Northern Europe, increased storminess, and shifts in precipitation patterns. For Ireland, this could mean harsher winters, more frequent and intense storms, and disruptions to marine ecosystems. The NCCRA did not consider Low-Likelihood, High-Impact events in determining risks and their consequences due to the uncertainties associated with these phenomena. The assessment focused on scenarios that do not include these types of events, adhering to the Representative Concentration Pathways (RCP) 4.5 and 8.5, which may underestimate the consequences of some risks. Separate research is ongoing on these type of Low-Likelihood, High Impact events to better understand how they may impact Ireland.

[5] Further information on the AMOC is available at https://www.met.ie/the-evolution-of-the-atlantic-meridional-overturning-circulation-amoc

3 Climate Change in Ireland

It is now unequivocal that human activity has led to widespread and rapid change in all components of the climate system which are unprecedented over many centuries to many thousands of years. Global annual average surface temperatures have increased by ~1.15°C from the period 1850 - 1900 to 2013 - 2022 and this warming is mainly due to increased greenhouse gas concentrations as a result of fossil fuel combustion (Forster et al. 2023). Human induced climate change is also modifying the frequency and intensity of extremes globally and this is particularly the case for heatwaves and extreme precipitation. Since 1900, global sea level has risen by 0.2 m and the rate of global sea level rise is accelerating (IPCC, 2021).

3.1 Ireland's Changing Climate

Ireland's climate is continuing to warm in line with global warming with annual average surface temperatures approximately 1°C higher than the early 20th century (Thorne et al., 2023) and 7 of the top 10 warmest years on the island occurring since 2005 (Met Éireann, 2024). Sea surface temperatures across the North Atlantic have continued at or near record levels contributing to higher-than-average temperatures and increased moisture content in the atmosphere (Met Éireann, 2025). There has been an increase in heavy precipitation extremes across the island, with relative increases in the frequency and intensity of these events attributed to global warming. Sea levels are rising across all coastal areas, and recent studies have highlighted higher rates of sea level rise than the global average since the late 20th century in Cork and Dublin.

3.2 Overview of Climate Change Projections

Observed changes in Ireland are projected to continue and intensify into the future. Projected changes in the frequency and intensity of climate hazards pose significant risks to Ireland's communities and environment, with adaptation required to increase resilience to climate change impacts. The climate change projections used in this report have been obtained from Met Éireann, OPW, IPCC and the EPA (Appendix D).

Ireland's Changing Climate

Met Éireann, the Office of Public Works, the EPA, and the Intergovernmental Panel on Climate Change (IPCC) have developed projections that inform the NCCRA based on two emissions scenarios: a moderate emissions scenario (RCP4.5), and a high emission scenario (RCP8.5). The NCCRA assesses risk for three time periods: up to 2030 (current), 2050 (mid-century), and 2100 (late-century). Below we provide an overview of project changes in Ireland's climate by mid-century (2050) under a high emissions scenario:

Ireland's climate is projected to get warmer with average temperature increasing across all seasons and on an annual basis, while the number of heatwaves is also projected to increase.

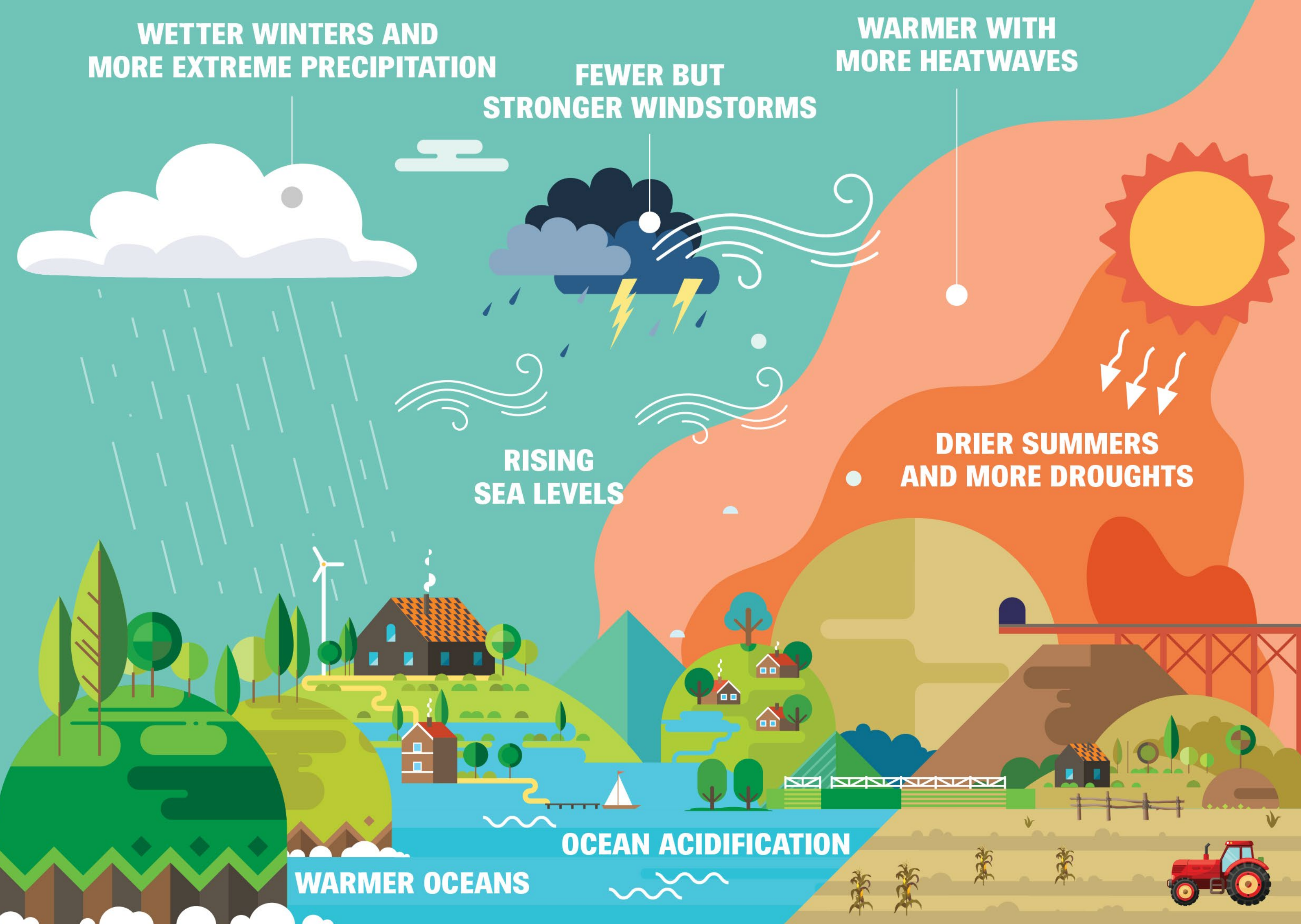
Ireland is projected to become wetter overall with an increase in average annual rainfall.

Increased seasonality in rainfall is projected with wetter winters and drier summers, with **more frequent droughts projected** for Summer and Spring months.

Sea levels are projected to continue to rise around Ireland's coastal areas with an average increase of 0.26 m by mid-century and 0.65 m by end of the century, increasing exposure to coastal flood risks.

Ireland's oceans are projected to **become more acidic**.

A minor decrease in average windspeeds is projected for Ireland. While northern Europe could be affected by **fewer but stronger windstorms**, projections are uncertain.



4 Climate Change Risks

The NCCRA identified a total of 115 risks across all systems. Nine of these risks have been classified as priority risks for Ireland. This is based upon whether a consequence of Critical was reached in either the current (present to 2030) or mid-century (2050) time period. These criteria were selected as it prioritises the risks that would result in a high level of impact on the country in a relatively short timeframe and may increase to Catastrophic level of impact by late century (2100) if no action is taken. The priority risks are described in Figure 4.1 below.

4.1 Current Risks

The analysis undertaken in the NCCRA identifies risks E15 and BE11 as priority risks for Ireland in the present day. Both these risks are associated with the impact of extreme wind on key infrastructure networks (energy and communication infrastructure). These cascading risks are deemed a priority for Ireland, as they provide key functions that other systems require to continue to operate. While climate projections show potentially limited changes in extreme wind events in the future, there is a high degree of uncertainty associated with the projections. Extreme events over recent years have shown however, that Ireland has high exposure to the impacts of extreme wind in these sectors. The current level of impact experienced means that the consequence is therefore assessed as Critical now and in the future.

Energy Infrastructure and Extreme Wind (E15): Extreme winds pose a risk to energy transmission and distribution infrastructure. High winds have knocked down power lines and caused structural failures in transmission towers. Debris carried by strong winds has damaged components, leading to power outages and significant repair costs. Power outages have cascading effects on systems reliant on electricity. The Built Environment system is affected by the loss of power due to the temporary loss of services, such as heating, ventilation, air conditioning, traffic lights, railway signals, broadband connectivity, and mobile communications. Water Services Infrastructure relies on electricity for pumping and distribution, impacting activities such as public health if water supply is lost. In the Food Production and Supply Chain system, electricity is crucial for irrigation, refrigeration, and processing, so power outages can lead to crop losses and spoilage of perishable goods. The Health system depends on electricity for life-saving equipment, lighting, and electronic health records with home-based health equipment users being particularly vulnerable. The Social System experiences disruptions to internet, phone systems, and data centres, causing significant disruption to people and businesses.

Priority Risks

HAZARD	RISK ID	RISK	CONSEQUENCE			DECISION URGENCY
			CURRENT	MID CENTURY	LATE CENTURY	
Extreme Wind	E15	Risk of disruption and damage to energy transmission and distribution infrastructure due to extreme wind				
Extreme Wind	BE11	Risk of disruption and damage to communication infrastructure due to extreme wind				
Coastal Erosion and Flooding	BE23	Risk of disruption, damage, and loss of transport infrastructure due to sea level rise, coastal erosion, and coastal flooding				
Coastal Erosion and Flooding	BE01	Risk of damage and loss of buildings due to sea level rise, coastal erosion, and coastal flooding				
Flooding	BE03	Risk of damage and loss of buildings due to extreme precipitation and flooding (fluvial, surface water, and groundwater)				
Flooding	BE26	Risk of disruption and damage to transport infrastructure due to extreme precipitation and flooding (fluvial, surface water, and groundwater)				
Flooding	H11	Risk to human health (physical injury and mental health) due to increases in average precipitation, extreme precipitation, and flooding (fluvial, surface water, and groundwater)				
Heat	H15	Risk to human health (physical and mental health) due to extreme heat				
Heat	H14	Risk to human health due to increases in average temperature (e.g., increased aeroallergen levels, higher rates of skin cancer, and decreased indoor air quality)				

CONSEQUENCE

Limited Substantial Critical Catastrophic

DECISION URGENCY

Watching Brief Further Investigation Sustain Current Action More Action Needed

EMISSIONS SCENARIO

If there is difference in consequence between scenarios, two consequences are shown

HIGH
MEDIUM

Figure 4.1: The priority risks for Ireland identified through the National Climate Change Risk Assessment based on timing of impact and level of consequence.

Communication Infrastructure and Extreme Wind (BE11): Extreme wind events have severely impacted communication infrastructure by damaging communications towers, and breaking utility poles. Fallen trees have disrupted overhead lines, leading to interruptions in internet, telephone, and other services. These impacts affect other subsystems, within the Built Environment, for instance the water services infrastructure, transport, and buildings subsystems. Repairing and replacing damaged infrastructure is both costly and time-consuming. The loss of power and communications are interlinked, as telecommunications networks cannot function without electrical power. This can lead to temporary cascading effects affecting the Health system, by disrupting and damaging the system's communications infrastructure by impacting, emergency response, public safety, and healthcare. Furthermore, loss of communications can also impact the Energy system, if sufficient redundancy is not provided by disrupting generation and transmission/distribution control systems. The loss of telecommunications can also affect the Social system, where it can cause significant business disruption and impact social connectivity, leading to isolation.

4.2 Mid-Century Risks

By mid-century, the changes in precipitation patterns and increasing sea levels, will result in an increase in the frequency and severity of coastal hazards (coastal flooding and coastal erosion) and flooding (river, surface water, and groundwater). The Built Environment is particularly exposed to these risks, with transport infrastructure (BE23, BE26), buildings (BE01, BE03) and people (H11) highly exposed, with the consequence of these risks increasing to critical by mid-century, with potential to reach catastrophic levels of consequence by the end of the century.

Transport Infrastructure and Coastal Hazards (BE23): Transport infrastructure (roads, railway, ports/harbours) in coastal areas is at risk from sea level rise, coastal erosion, and coastal flooding. Coastal erosion can damage foundations and infrastructure, potentially requiring permanent relocation of assets. Coastal flooding of transport infrastructure results in temporary disruptions, physical damage, saltwater corrosion, increased maintenance needs, and significant economic impacts due to repair costs and disruption. There are temporary to long-term cascading effects on the Food Supply and Supply Chain system, due to disruption in logistics, the Health system, where there they may be difficulty accessing healthcare, and the Social system, whereby it can result in business disruption and disruption to education.

Buildings and Coastal Hazards (BE01): Ireland's coastal regions are increasingly exposed to the impacts of sea level rise, coastal erosion, and coastal flooding, which pose significant risks to buildings and infrastructure. Rising sea levels cause more frequent and severe flooding, leading to structural damage to buildings through water damage and corrosion of building materials. Rising sea levels are also a driver for coastal erosion which can weaken foundations and damage buildings. As a result of this risk, there is potentially temporary cascading effects on the Health System. This may include damage to healthcare infrastructure, leading to costly repairs and reconstruction, and business interruption due to the unavailability of healthcare services, affecting employee health and productivity. Flooding can also lead to the release of hazardous materials from healthcare facilities, contaminating water bodies and ecosystems impacting revenues from tourism.

Buildings and Flooding (BE03): Extreme precipitation and flooding are increasing risks to buildings. Heavy rainfall can cause structural damage, water damage, promote mould growth, and create electrical hazards. Flooding can soften ground conditions, leading to foundation failure and structural collapse. Overwhelmed drainage systems can lead to water intrusion and prolonged dampness, fostering mould growth and deteriorating indoor air quality. As a result of this risk, there is potentially temporary cascading effects on the Health system. This may include damage to healthcare infrastructure, leading to costly repairs and reconstruction. This in turn leads to business interruption due to the unavailability of healthcare services, affecting employee health and productivity. Flooding can also lead to the release of hazardous materials from healthcare facilities, contaminating water bodies and ecosystems, and impacting revenues from tourism.

Transport Infrastructure and Flooding (BE26): Extreme precipitation and flooding (fluvial, surface water, and groundwater flooding) poses a risk to transport infrastructure. Flooded roads and railways can cause significant delays and diversions, while prolonged flooding can lead to extended closures of key transport routes. Floodwaters can erode foundations, wash away road surfaces, and cause bridge collapses. Railway tracks can be undermined or washed away, leading to derailments and service interruptions. Extreme precipitation can compromise runway integrity and disrupt ground services at airports. Inadequate drainage system capacity can result in flooding of airport infrastructure or inundation of surface and underground infrastructure such as electrical systems. Flooded runways and taxiways can render an airport inoperable. There are temporary and long-term cascading effects on the Food Supply and Supply Chain, whereby the disruption of damage and transport infrastructure can result in logistics disruption. The Health System can be impacted as there can be difficulty accessing healthcare, and the Social system is impacted due to business disruption and disruption to education.

Human Health and Flooding (H11): Increases in average precipitation, extreme precipitation, and flooding (fluvial, surface water, and groundwater) in Ireland pose significant risks to human health, both physically and mentally. Flooding threatens physical health, leading to injuries and fatalities. Floodwaters can cause drowning, while physical injuries can result from debris and damaged structures. There can also be impacts on mental health, with individuals affected by flooding may experience post-traumatic stress disorder (PTSD), depression, and ongoing anxiety. The disruption of social networks and support systems due to displacement can exacerbate these mental health issues. Long-term displacement can also lead to chronic stress and a sense of insecurity, further impacting mental well-being. The psychological effects of flooding can persist for years, affecting overall quality of life and community resilience. Furthermore, the increased frequency and severity of flooding can place significant pressure on healthcare services. The surge in emergency department visits and hospital admissions during and after flood events, can temporarily overwhelm healthcare facilities.

4.3 Late Century Risks

By the late century the emerging hazard of extreme heat becomes a priority risk. This is due to an increase in the frequency and severity of extreme heat events, combined with the increase in exposure due to an increase in population, and an increase in the vulnerable population, i.e., those over 65-years old. Consequently, the consequences of extreme heat on human health (H15) could increase to catastrophic by the end of the century. Furthermore, the increase in average temperatures will also impact human health (H14) resulting in Critical levels of consequence by the mid-century and the end of the century.

Human Health and Extreme Heat (H15): Extreme heat in Ireland can pose a risk to human health, particularly to vulnerable groups such as older adults, children, and those with chronic illnesses. It can lead to serious conditions such as heat exhaustion and heat stroke. Extreme heat can further increase the risk of dehydration, affecting overall health, and can exacerbate symptoms of chronic diseases. Additionally, extreme heat can aggravate pre-existing health conditions, including cardiovascular, respiratory, cerebrovascular, and neurological disorders. As a result of these impacts on human health, during and after heatwaves events, there may be an increase in emergency department visits and hospital admissions temporarily overwhelming healthcare facilities.

Human Health and Increasing Temperatures (H14): In Ireland, rising average temperatures pose several health risks. Increased aeroallergen levels due to longer pollen seasons can exacerbate respiratory conditions like asthma and allergies. Additionally, higher temperatures encourage more outdoor activities, resulting in greater exposure to ultraviolet (UV) radiation and potentially higher rates of skin cancer. Indoor air quality may also decline as warmer temperatures increase the concentration of pollutants and allergens, posing further respiratory challenges.

4.4 Decision Urgency

Each of the identified risks were evaluated based on the level of decision urgency needed within the next five years to reduce the risk and enhance resilience. Below is a summary of the areas where more action and further investigation is deemed necessary to manage the impacts of climate change.

More Action Needed

The NCCRA identified three priority risks that require additional action in the next 5 years to increase resilience.

- Risk of disruption and damage to **energy transmission and distribution infrastructure** due to **extreme wind (E15)**: As demonstrated through the unprecedented number of power outages during Storm Éowyn, current measures are deemed insufficient to offset adverse impacts with more action needed to increase the resilience of the energy transmission and distribution infrastructure, ensuring the delivery of essential services.
- Risks of disruption and damage to **communication infrastructure** due to **extreme wind (BE11)**: Communications infrastructure throughout Ireland is exposed to windstorms and measures currently in place are deemed insufficient to offset the adverse impacts posed. There is more action needed to ensure resilience of communications infrastructure to wind damage and cascading impacts such as loss of power (E15).
- Risk of disruption, damage, and loss of **transport infrastructure** due to **sea level rise, coastal erosion, and coastal flooding (BE23)**: Ireland's coastline is already experiencing impacts of coastal erosion and flooding with projections indicating a further increase in potential impacts due to projected sea level rise. Transport infrastructure is concentrated in coastal areas with Dublin and southeast particularly exposed to the impacts of coastal erosion and flooding. More action is needed to enhance the resilience of transport infrastructure at the coast and to ensure that the best available estimates of potential coastal change and associated hazards and risks are identified, refined and updated on an ongoing basis.

Further Investigation

Many risks assessed as part of the NCCRA still require further investigation, research or data in order to reduce uncertainty in our current level of understanding of how they will impact Ireland before it would be possible to accurately assess if further action to address them is required. Potential areas for further investigation include:

- Increasing understanding of the relationships between changing climate conditions and potential impacts across all systems to support more robust assessments. For instance, for Health system related risks (H14), there is a requirement for more detailed assessment of the impacts of changing climate conditions on levels of exposure to UV radiation, aero-allergens and air quality.

- Determining how different communities and populations could be more vulnerable to identified risks, such as determining the socio-economic and health factors that may make people more vulnerable to extreme heat and flooding events, is an area for further investigation.

5 Overview of Significant Risks by System

The National Climate Change Risk Assessment identifies 115 risks and five potential opportunities due to projected changes in climate conditions. There are a total of 43 significant risks identified for Ireland, nine of which are considered priority risks. A risk that has a consequence of Critical or above in any time period or scenario, is termed a significant risk. Risks are categorised into nine different systems. These systems make up Ireland's society and economy, encapsulating multiple economic sectors:

Biodiversity & Ecosystems
Encompasses diverse natural habitats and their ecological functions.

Built Environment
Includes human structures to support daily life, including buildings, transport, and communications.

Energy
Covers the production, conversion on energy system, and distribution of energy resources.

Economy and Finance
Includes the financial and insurance markets and economic stability

Food Production and Supply Chain
Involves the processes and systems for growing and distributing food.

Health
Includes medical services and overall human well-being.

Marine and Coastal Ecosystems
Relates to oceanic and coastal habitats and their biodiversity.

Social
Encompasses societal structures and governance systems

Water Security
Focuses on the availability and management of water resources.

115 IDENTIFIED RISKS

43 SIGNIFICANT RISKS

5 OPPORTUNITIES

RISKS BY SYSTEM

Biodiversity & Ecosystems	Built Environment	Economy and Finance	Energy	Food Production and Supply Chain	Health	Marine and Coastal Ecosystems	Social	Water Security
17	37	3	15	11	17	8	2	5

Figure 5.1 and Figure 5.2 show the conseuqence of the 115 risks across each of the nine systems for the mid-century and late-century for the high emissions scenario.

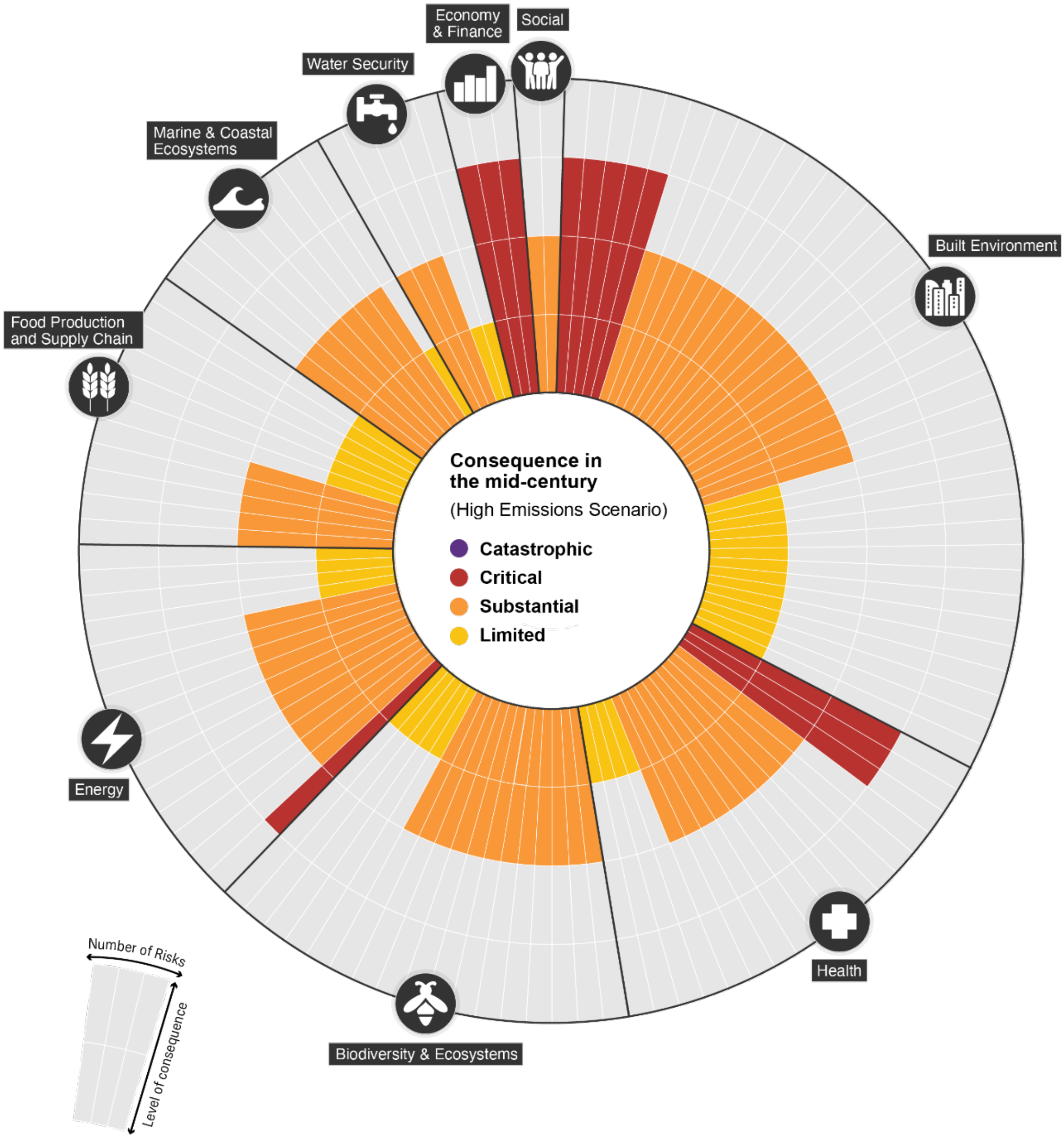


Figure 5.1: Summary of all 115 risk consequences within each system for the high emissions scenario by mid-century.

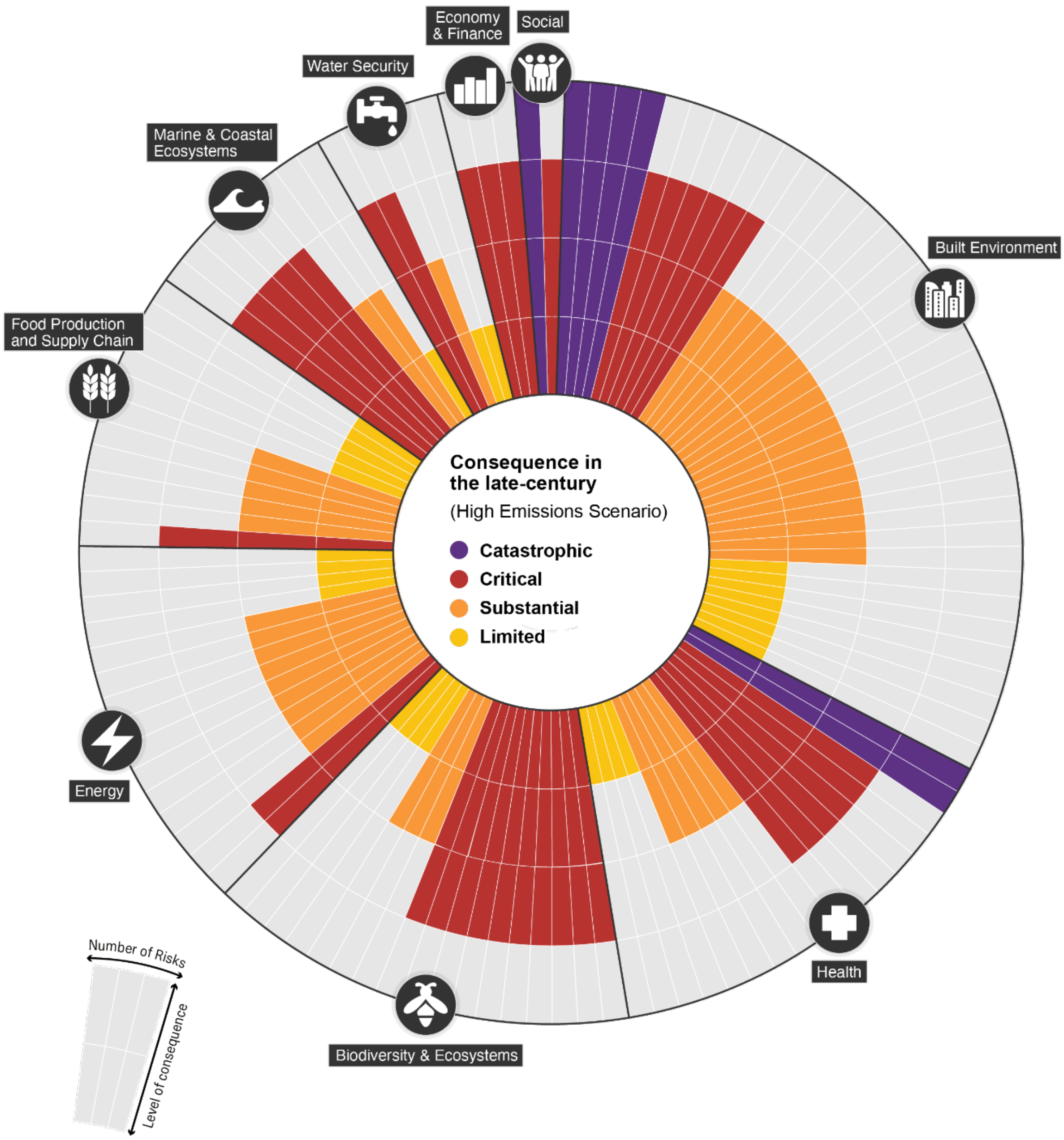


Figure 5.2: Summary of all 115 risk consequences within each system for the high emissions scenario by late century.

Due to the impacts of climate change, the consequence of each risk may change into the future. Figure 5.3 shows this change through time for the priority risks, with the difference between the two scenarios become apparent by late-century.

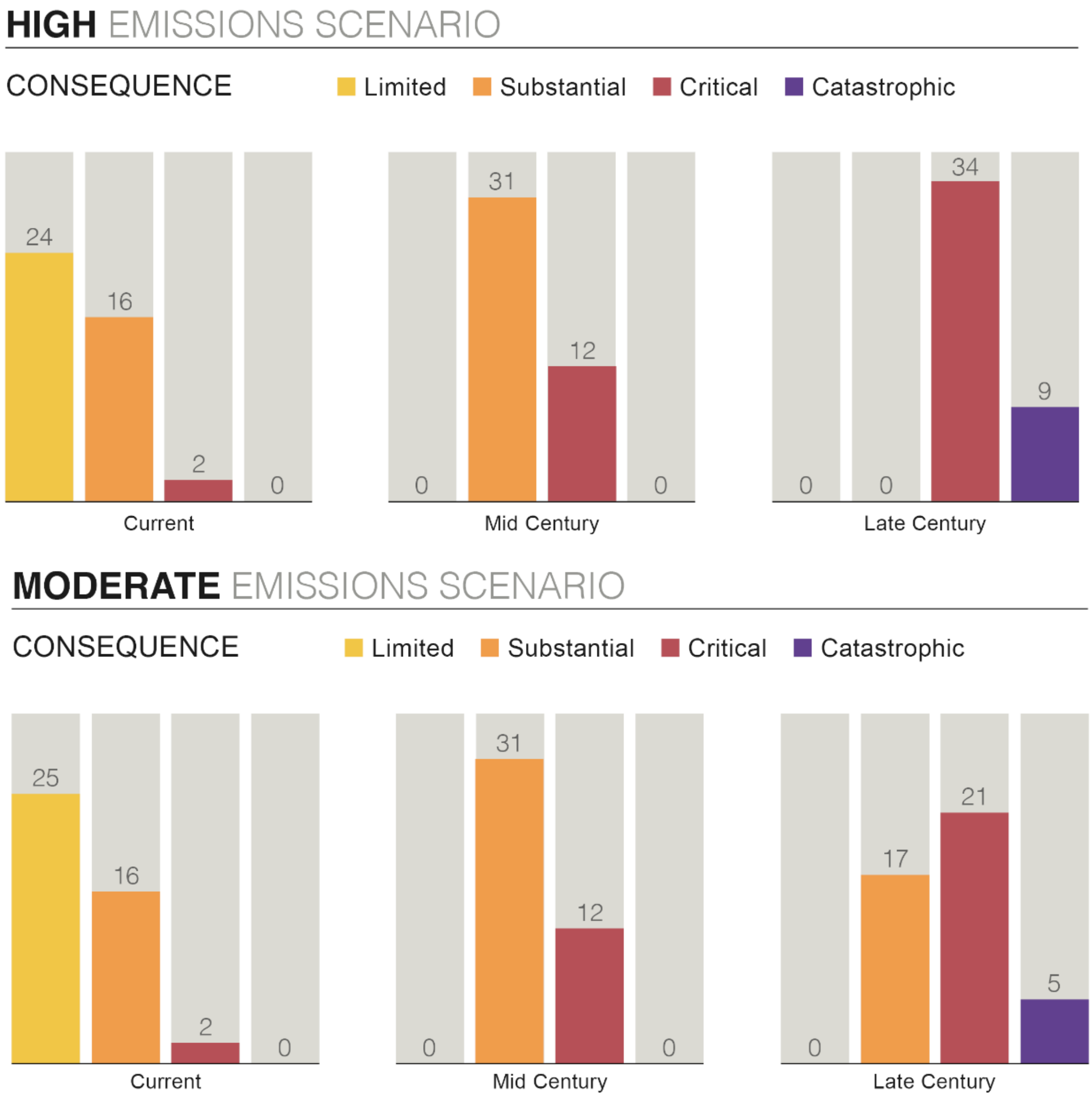


Figure 5.3: The change on consequence through time for the 43 significant risks for the high emissions (RCP8.5) and moderate emissions (RCP4.5) scenarios.

5.1.1 Biodiversity and Ecosystems

The Biodiversity and Ecosystems systems relates to the diverse set of natural habitats and their various ecological functions, and is comprised of several sub-systems, including forests, freshwater systems, peatlands, and terrestrial ecosystems. Ireland's biodiversity and ecosystems are already experiencing significant pressures and of the 59 habitats listed for Ireland in EU Habitats Directive (92/43/EEC), most have an unfavourable status with almost half showing ongoing declines (NPWS, 2019a). There are a total of 17 risks identified for this system, with 10 deemed significant. The significant risks identified for this system are as follows:

- Freshwater Systems are at risk of deterioration in water quality due to flooding (B07), leading to runoff from agricultural lands, carrying sediments, nutrients, and contaminants into freshwater systems, degrading water quality. Climate change (B08) is expected to alter freshwater temperatures, increasing nutrient enrichment and algal blooms, and reducing dissolved oxygen levels. Drought conditions (B09) can lead to higher pollutant concentrations, hydromorphological changes, and harmful algal blooms, stressing freshwater wildlife and affecting biodiversity
- Peatlands are at risk of degradation and loss from extreme heat and drought (B10). These conditions dry out peatlands, leading to carbon release, increased fire risk, vegetation loss, erosion, and altered hydrology. The loss of vegetation and altered hydrology can also lead to habitat loss for many species, further impacting biodiversity
- Forests are at risk of wildfires (B04) as changing climate conditions, such as altered precipitation and drought, can create conditions suitable for wildfires more frequently. This can cause extensive damage to forest stands, biodiversity, and the broader ecosystem. Phenological changes (B05) due to climate change may lead to altered competitive interrelationships in forest ecosystems. Climate change effects on forest ecosystems (B03) will be cumulative and interactive, in some instances making species more susceptible to insects and diseases due to changing site conditions
- Terrestrial ecosystems are at risk of invasive species, resulting in causing habitat disturbance (B16) as climate change is altering environmental conditions, such as milder winters and warmer summers, making Ireland more favourable for these species to thrive disrupting local ecosystems and outcompeting native flora and fauna. Phenological changes (B17) may lead to mismatches in food availability and other resources, causing stress on species and reducing reproductive success and survival rates. Extreme heat and drought conditions (B14) weaken soil structure, making it prone to erosion, and affect soil microbial communities, disrupting nutrient cycling and degrading soil health.

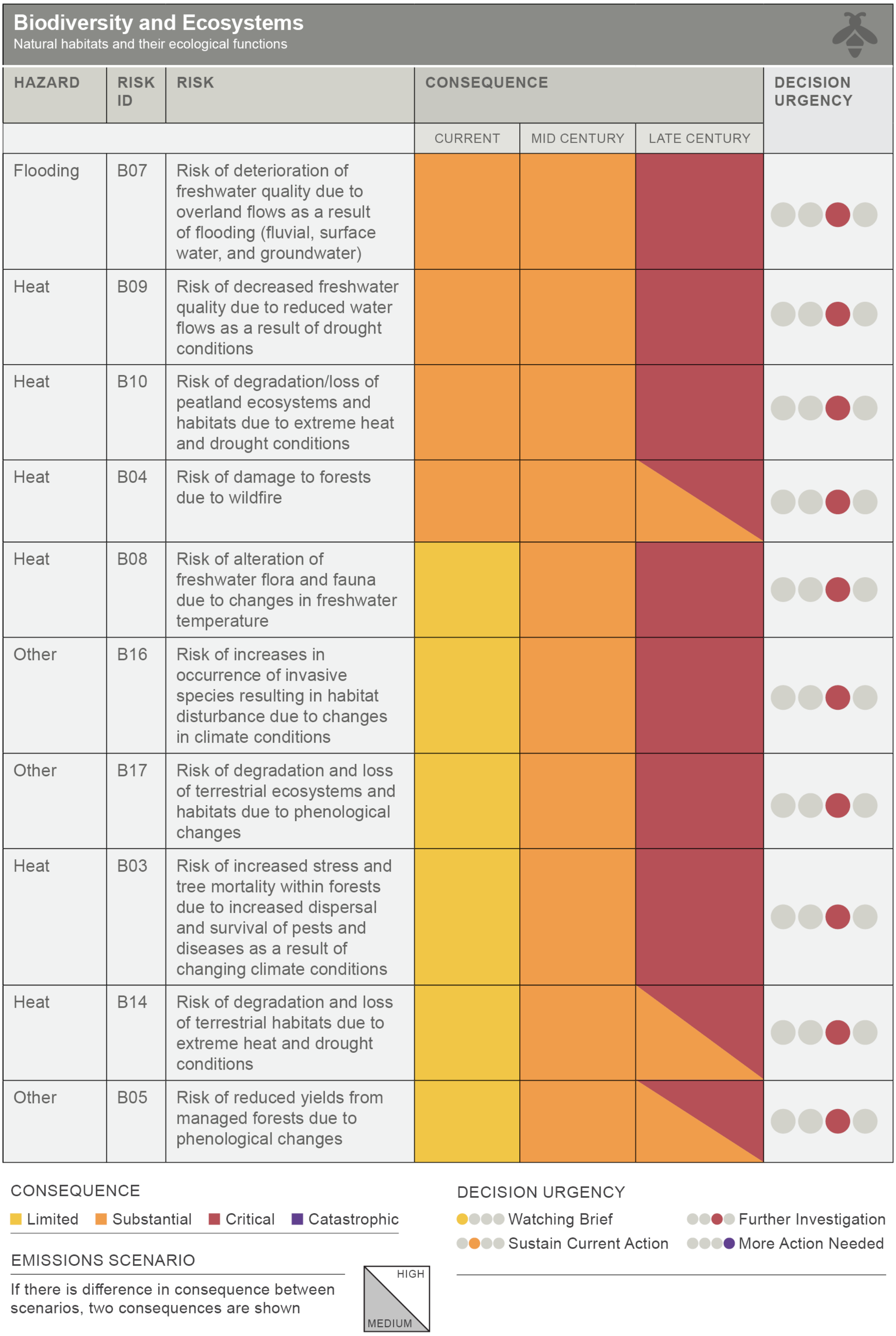


Figure 5.4: Significant climate risks for the Biodiversity and Ecosystems System.

5.1.2 Built Environment

The Built Environment encompasses human-made structures and systems supporting daily life, and includes the subsystems of buildings, cultural heritage, transport infrastructure, recreational, communication, and water services infrastructure. The Built Environment system contains much of Ireland's critical infrastructure. Consequently, the risks within the Built Environment system have a high number of cascading impacts upon other systems (see section 5.2 for further information). There are a total of 37 risks identified for the Built Environment system, with 10 deemed significant. The significant risks identified for this system are as follows:

Buildings: Extreme precipitation and flooding (BE03) increase the risk of structural damage, water damage, mould growth, and electrical hazards. Heavy rainfall can soften ground conditions, leading to foundation failure and structural collapse. Coastal regions (BE01) face risks from sea level rise, coastal erosion, and coastal flooding, causing structural damage and corrosion. Increasing temperatures (BE04) lead to more frequent heatwaves, causing buildings to overheat and deteriorating building materials.

Transport Infrastructure: Coastal areas (BE23) are at risk from sea level rise, coastal erosion, and coastal flooding, causing damage and requiring relocation of assets. Extreme precipitation and flooding (BE26) pose risks to transport infrastructure, causing delays, diversions, and closures. Floodwaters can erode foundations, wash away road surfaces, and cause bridge collapses. Extreme heat (BE27) impacts roads, railways, and airports, causing deformation and requiring frequent maintenance.

Communication Infrastructure: Extreme wind events (BE11) and flooding (BE08) pose significant risks to communication infrastructure. High winds can damage towers and utility poles, while flooding can interrupt services and cause physical damage, however, communication infrastructure with sufficient design standards may limit the impact of these hazards. Both hazards can lead to disruptions in services, hindering emergency responses, disrupting businesses, and isolating communities. Repairing the damage is costly and time-consuming.

Water Services Infrastructure: Higher temperatures (BE34) can cause operational issues by enhancing conditions for algal blooms, accelerating eutrophication, stressing infrastructure, and increasing evaporation. Additionally, higher temperatures can lead to increased corrosion, reduced efficiency of treatment processes, thermal pollution, and increased risk of pathogen proliferation.

Built Environment

Human structures and systems supporting daily life

HAZARD	RISK ID	RISK	CONSEQUENCE: CURRENT	CONSEQUENCE: MID CENTURY	CONSEQUENCE: LATE CENTURY	DECISION URGENCY
Extreme Wind	BE11	Risk of disruption and damage to communication infrastructure due to extreme wind	Critical	Critical	Critical	More Action Needed
Coastal	BE23	Risk of disruption, damage, and loss of transport infrastructure due to sea level rise, coastal erosion, and coastal flooding	Substantial	Critical	Catastrophic	More Action Needed
Coastal	BE01	Risk of damage and loss of buildings due to sea level rise, coastal erosion, and coastal flooding	Substantial	Critical	Catastrophic	More Action Needed
Flooding	BE03	Risk of damage and loss of buildings due to extreme precipitation and flooding (fluvial, surface water, and groundwater)	Substantial	Critical	Catastrophic	Further Investigation
Flooding	BE26	Risk of disruption and damage to transport infrastructure due to extreme precipitation and flooding (fluvial, surface water, and groundwater)	Substantial	Critical	Catastrophic	Further Investigation
Flooding	BE32	Risk of disruption and damage to water services infrastructure due to flooding (fluvial, surface water, and groundwater)	Substantial	Substantial	Critical	Further Investigation
Heat	BE27	Risk of disruption and damage to transport infrastructure due to extreme heat	Limited	Substantial	Critical	Further Investigation
Flooding	BE08	Risk of disruption and damage to communication infrastructure due to flooding (fluvial, surface water, and groundwater)	Limited	Substantial	High: Critical / Medium: Substantial	Sustain Current Action
Heat	BE04	Risk of overheating within buildings due to extreme heat	Limited	Substantial	High: Critical / Medium: Substantial	Further Investigation
Heat	BE34	Risk of operational issues (i.e. changes to water treatment operations) for water services infrastructure due to increases in average temperature	Limited	Substantial	High: Critical / Medium: Substantial	Further Investigation

CONSEQUENCE

Limited · Substantial · Critical · Catastrophic

DECISION URGENCY

Watching Brief · Further Investigation · Sustain Current Action · More Action Needed

EMISSIONS SCENARIO

If there is difference in consequence between scenarios, two consequences are shown

HIGH / MEDIUM

Figure 5.5: Significant climate risks for the Built Environment System.

5.1.3 Economy and Finance

The Economy and Finance System encompasses the management of the economy and finance to ensure economic stability and sustainable growth. The Economy and Finance System subsystems include financial and insurance markets, and economic stability. The risks within the Economy and Finance system are a result of the cumulative risks and impact across the other eight systems. There are three risks identified for this Economy and Finance system, all of which were deemed significant.

Financial and Insurance Markets: Due to climate change, there is likely to be an increase in the frequency and severity of extreme events. This will lead to a rise in the number of insurance claims, which in turn drives up insurance premiums (EC01). Additionally, the protection gap (the difference between total economic losses from extreme events and the portion covered by insurance) is widening, potentially resulting in individuals and businesses unable to obtain or adequate coverage, leaving them vulnerable to financial losses. The increased frequency and severity of extreme weather events can lead to higher probabilities of default (EC02) as businesses and individuals struggle to recover from damages and disruptions. This financial strain can result in missed loan payments and bankruptcies. Additionally, climate change can devalue assets, such as properties in flood-prone regions, which may see a decline in value due to the heightened risk of damage and the rising costs of insurance. This devaluation can impact the overall financial health of asset portfolios and the broader economy.

Economic Stability: The increased frequency and severity of extreme events can lead to reduced tax revenues as economic activities are disrupted (EC03). Additionally, the government may face higher expenditure to repair infrastructure, provide disaster relief, and implement climate adaptation measures. The financial strain from increased government spending and reduced revenues can lead to lower credit ratings, making borrowing more expensive. This increased cost of borrowing can further strain public finances, creating a cycle of financial instability.

Economy and Finance
Financial and insurance markets and economic stability

HAZARD	RISK ID	RISK	CONSEQUENCE			DECISION URGENCY
			CURRENT	MID CENTURY	LATE CENTURY	
Other	EC01	Risk of increased insurance claims and premia and widening protection gap due to climate change				
Other	EC02	Risk of increased probability of default and loss of asset value due to climate change				
Other	EC03	Risk of reduced tax revenues, increased government expenditure, lower credit ratings and increased cost of borrowing due to climate change				

CONSEQUENCE

Limited · Substantial · Critical · Catastrophic

EMISSIONS SCENARIO

If there is difference in consequence between scenarios, two consequences are shown

HIGH
MEDIUM

DECISION URGENCY

Watching Brief · Further Investigation · Sustain Current Action · More Action Needed

Figure 5.6: Significant climate risks for the Economy and Finance system.

5.1.4 Energy

The Energy system covers the production, conversion, and distribution of energy resources. The Energy system is made up of two sub-systems – energy generation and conversion, and energy transmission and distribution infrastructure. Many systems are reliant upon the provision of electricity for day-to-day operations, and even a short disruption in delivery of energy can have a large cascading impact regionally and nationally (see section 5.2 for further information). There are a total of 15 risks identified for the Energy system, with two deemed significant. The significant risks identified for this system are as follows:

Energy Generation and Conversion: Increases in temperature and extreme heat (E04) is a risk for energy generation and conversion infrastructure due to the rising demand for cooling, such as air conditioning. As temperatures rise, the demand for air conditioning increases, leading to higher energy consumption, especially during peak hours, which can strain power grids and increase the risk of blackouts.

Energy Transmission and Distribution: Extreme winds pose a risk to energy transmission and distribution infrastructure (E15), leading to potential damage and disruptions. Extreme wind has damaged energy transmission and distribution infrastructure by knocking down power lines and causing structural failures in transmission towers. Additionally, debris carried by strong winds has damaged components. This damage leads to disruption in the energy supply, resulting in power outages and significant repair costs.

Energy
Production, conversions, and distribution of energy resources

HAZARD	RISK ID	RISK	CONSEQUENCE			DECISION URGENCY
			CURRENT	MID CENTURY	LATE CENTURY	
Extreme Wind	E15	Risk of disruption and damage to energy transmission and distribution infrastructure due to extreme wind				
Heat	E04	Risk of increased cooling demand (i.e. air conditioning) on energy generation and conversion infrastructure due to increases in temperature and extreme heat				

CONSEQUENCE

Limited · Substantial · Critical · Catastrophic

DECISION URGENCY

Watching Brief · Further Investigation · Sustain Current Action · More Action Needed

EMISSIONS SCENARIO

If there is difference in consequence between scenarios, two consequences are shown

HIGH

MEDIUM

Figure 5.7: Significant climate risks for the Energy System.

5.1.5 Food Production and Supply Chain

The Food Production and Supply Chain system involves the processes and systems for growing and distributing food. Given the strong relationship between Food Production and ecosystems, this system is impacted by risks within the Biodiversity and Ecosystems, and Marine and Coastal Ecosystem systems (see section 5.2 for further information). There are a total of 11 risks identified for the Food Production and Supply Chain system, with one deemed significant.

Food production: Changes in climate conditions pose risks to crop yields (F03). Higher temperatures can stress crops, leading to reduced growth and lower yields. Heat stress can affect photosynthesis, nutrient uptake, and water use efficiency, ultimately reducing the overall productivity of crops. Additionally, changing climate conditions can alter rainfall patterns, resulting in droughts or excessive rainfall. Droughts can lead to water scarcity, soil degradation, and increased vulnerability to pests and diseases, while excessive rainfall can cause flooding, soil erosion, waterlogging of soils, and nutrient leaching. Both extremes can harm crops, disrupting planting and harvesting schedules, and reducing the quality and quantity of agricultural produce. These impacts can threaten food security, increase food prices, and affect the livelihoods of farmers and communities dependent on agriculture.

Food Production and Supply Chain
The processes and systems for growing and distributing food

HAZARD	RISK ID	RISK	CONSEQUENCE			DECISION URGENCY
			CURRENT	MID CENTURY	LATE CENTURY	
Other	F03	Risk of reduced crop yields due to changes in climate conditions				

CONSEQUENCE
Limited Substantial Critical Catastrophic

EMISSIONS SCENARIO
If there is difference in consequence between scenarios, two consequences are shown
HIGH
MEDIUM

DECISION URGENCY
Watching Brief Further Investigation
Sustain Current Action More Action Needed

Figure 5.8: Significant climate risks for the Food Production and Supply Chain System.

5.1.6 Health

Health describes both the medical services as well overall human well-being. Based on this, the Health system is split into two sub-systems – healthcare and human health. The health services sub-system focuses on the risks from climate to change to healthcare services and facilities. These medical and care facilities provide service delivery, and encompass information systems, medical products, and technologies. The Human Health sub-system focusses on the physical and mental health of the public and includes both acute and chronic risks. There are a total of 17 risks identified for the Health system, with four deemed significant.

Human Health: Increases in average precipitation, extreme precipitation, and flooding (H11) in Ireland, pose significant risks to human health, both physically and mentally. Flooding can cause injuries, fatalities, and mental health issues such as PTSD, depression, and anxiety. Displacement disrupts social networks, exacerbating mental health problems. Flooding also puts pressure on healthcare services, overwhelming facilities during and after events.

Rising average temperatures (H14) pose several health risks. Longer pollen seasons increase aeroallergen levels, exacerbating respiratory conditions like asthma and allergies. Higher temperatures lead to more outdoor activities, increasing UV radiation exposure and skin cancer rates. Indoor air quality may decline as warmer temperatures concentrate pollutants and allergens.

Extreme heat (H15) poses health risks, particularly to vulnerable groups such as older adults, children, and those with chronic illnesses. It can cause heat exhaustion, heat stroke, dehydration, and exacerbate chronic diseases, including cardiovascular, respiratory, cerebrovascular, and neurological disorders.

Warmer temperatures (H16) expand the range of vectors and speed up their life cycles, increasing populations. More rainfall creates breeding sites for mosquitoes, while droughts concentrate water sources, bringing vectors and hosts closer together. This increases the incidence of diseases like Lyme disease and West Nile virus, straining healthcare services. Warmer climates extend the disease transmission season and affect vector behaviour, increasing disease spread.

Healthcare: Extreme precipitation and flooding pose significant risks to healthcare services and facilities in Ireland (H03). Floodwaters damage physical healthcare structures, equipment, and supplies, introducing health risks for patients and staff. The associated stress exacerbates mental health issues, and disrupts medical supply delivery, leading to shortages and increased infection risks. Blocked access routes and contaminated floodwaters further endanger healthcare staff, fostering burnout and fatigue.

Extreme heat poses a risk to healthcare services and facilities in Ireland, increasing demand and operational challenges (H04). It can lead to heat-related illnesses, surging emergency visits and hospital admissions. Vulnerable populations face higher risks, potentially resulting in increased morbidity and mortality. Moreover, chronic conditions are exacerbated, elevating the likelihood of hospitalisations. Health disparities in rural and remote areas may be worsened by extreme heat due to limited access to healthcare services.

Extreme heat poses risks to healthcare services and facilities in Ireland, causing service disruptions and infrastructure damage (H05). Healthcare staff are vulnerable to heat-related illnesses, potentially resulting in staffing shortages and increased pressure on remaining personnel. Heating, ventilation, and air conditioning systems may struggle during extreme heat, facing possible failures and leaving facilities inadequately cooled. Prolonged heat can deteriorate healthcare infrastructure, increasing maintenance costs and affecting equipment quality. Medications and supplies requiring specific storage conditions may also degrade under prolonged exposure to heat.

Rising temperatures, shifting precipitation patterns, and extreme weather events contribute to the proliferation of resistant bacteria in Ireland, posing a threat to public health (H06). Warmer temperatures support the survival and transmission of pathogens like Salmonella and Campylobacter, which can develop resistance, resulting in more infections and increased antibiotic usage. Climate change can disrupt ecosystems, creating environments conducive to the spread of resistant bacteria. Floods and extreme weather can contaminate water sources, aiding the dissemination of resistant strains. Vulnerable populations, such as the elderly, children, and individuals with existing health conditions, are disproportionately impacted, potentially leading to heightened morbidity and mortality rates.

Health

Medical services and overall human well-being

HAZARD	RISK ID	RISK	CONSEQUENCE: CURRENT	CONSEQUENCE: MID CENTURY	CONSEQUENCE: LATE CENTURY	DECISION URGENCY
Flooding	H11	Risk to human health (physical injury and mental health) due to increases in average precipitation, extreme precipitation, and flooding (fluvial, surface water, and groundwater)				
Heat	H15	Risk to human health (physical and mental health) due to extreme heat				
Heat	H14	Risk to human health due to increases in average temperature (e.g., increased aeroallergen levels, higher rates of skin cancer, and decreased indoor air quality)				
Flooding	H03	Risk of disruption and damage to healthcare services and facilities due to extreme precipitation and flooding (fluvial, surface water and groundwater)				
Heat	H04	Risk of increased demand on healthcare services and facilities due to extreme heat				
Heat	H05	Risk of overheating in healthcare services and facilities due to extreme heat				
Other	H06	Risk of increased antimicrobial resistance due to changes in climate conditions				
Other	H16	Risk of increased vector-borne diseases (e.g., West Nile virus) due to changes in climate conditions				

CONSEQUENCE

Limited | Substantial | Critical | Catastrophic

EMISSIONS SCENARIO

If there is difference in consequence between scenarios, two consequences are shown

HIGH / MEDIUM

DECISION URGENCY

Watching Brief | Further Investigation | Sustain Current Action | More Action Needed

Figure 5.9: Significant climate risks for the Health System.

5.1.7 Marine and Coastal Ecosystems

Marine and Coastal Ecosystems relate to oceanic and coastal habitats and their biodiversity. Therefore, this system is split into two subsystems of marine ecosystems and coastal ecosystems. The marine ecosystem sub-system consists marine life as its key element at risk. Coastal ecosystems are the main element at risk from climate of the coastal ecosystem sub-system. There are a total of eight risks identified for the Marine and Coastal Ecosystems system, with five deemed significant.

Marine Ecosystems: Changes in average ocean conditions (M03, M04, M06), such as variations in temperature, pH, salinity, de-oxygenation, and circulation, significantly impact marine ecosystems. These changes favour invasive species, disrupt habitats, and stress native species. Warmer waters expand infectious agents' range, while lower pH weakens marine organisms' shells. Fluctuations in salinity and de-oxygenation create hypoxic conditions, disrupting food webs. Ocean acidification affects calcification in marine organisms, weakening their shells and skeletons. Changing average ocean conditions can cause thermal stress, impact reproductive rates, and disrupt osmoregulation. Hypoxia and acidification cause mass die-offs, forcing species migration and altering community structures, affecting nutrient cycling, habitat structure, food web dynamics, and productivity. Trophic guild dynamics are disrupted, affecting energy and nutrient flow.

Ocean acidification (M07) increases mortality for cold-water coral reefs and shellfish in Ireland. Acidic conditions weaken coral skeletons and shellfish shells, leading to higher mortality rates and ecosystem decline.

Phenological changes (M08), such as shifts in breeding, migration, and blooming, can impact marine ecosystem functioning and habitats. These changes disrupt synchronisation between species and their environment, leading to mismatches in food availability, altered predator-prey relationships, and reduced reproductive success. Key climate drivers include rising sea temperatures, ocean acidification, sea-level rise, marine heatwaves, changes in salinity, cold spells, and hypoxia.

Marine and Coastal Ecosystems

Oceanic and coastal habitats and their biodiversity

HAZARD	RISK ID	RISK	CONSEQUENCE			DECISION URGENCY
			CURRENT	MID CENTURY	LATE CENTURY	
Changes in average ocean conditions	M03	Risk of marine habitat and ecosystem disturbances due to changes in average ocean conditions				
Changes in average ocean conditions	M04	Risk of decreases in reproduction rates of marine species due to changes in average ocean conditions				
Changes in average ocean conditions	M06	Risk of species distribution shifts and changes in ecosystem dynamics due to changes in average ocean conditions				
Ocean acidification	M07	Risk of increased mortality of cold-water coral reefs and shellfish due to ocean acidification				
Changes in phenology	M08	Risk of degradation and loss of marine ecosystems and habitats due to phenological changes				

CONSEQUENCE

Limited · Substantial · Critical · Catastrophic

EMISSIONS SCENARIO

If there is difference in consequence between scenarios, two consequences are shown

HIGH / MEDIUM

DECISION URGENCY

- Watching Brief
- Further Investigation
- Sustain Current Action
- More Action Needed

Figure 5.10: Significant climate risks for the Marine and Coastal Ecosystems System.

5.1.8 Social

The Social system describes societal structures and governance systems. In this sense, the Social system refers to the way in which civil society and communities respond to climate change risks. It concerns community wellbeing, social cohesion, as well as trust and equality in society. The Social system is split into two sub-systems – governance and society. There are a total of two risks identified for the Social system, both of which were deemed significant.

Governance: Climate change maladaptation (S01) in Ireland may compromise emergency responses and erode public trust in government. Ineffective adaptation strategies can exacerbate social justice issues, disproportionately affecting vulnerable populations such as low-income communities, the elderly, people with disabilities, and marginalised groups. Delayed or inadequate emergency services during extreme weather events can lead to increased casualties and property damage. Government inaction or ineffective policies can erode public confidence, leading to social unrest and decreased cooperation with authorities. Inequitable distribution of resources during climate crises can deepen existing inequalities, leaving vulnerable communities disproportionately affected. Ensuring equitable and effective climate policies is crucial to maintaining public confidence and safeguarding all citizens.

Society: Climate change impacts (S02) in Ireland risk exacerbating societal inequalities by affecting community wellbeing, employment, education, and social services. Vulnerable populations may face heightened challenges, deepening existing disparities. Addressing these issues through inclusive and equitable adaptation strategies is essential to mitigate adverse effects and promote social cohesion. Risks include increased mental health issues, reduced access to healthcare, job losses in climate-sensitive sectors like agriculture and tourism, disruptions to schooling, and strain on social services. These impacts can increase the vulnerability of the population, exacerbating risks across all systems.

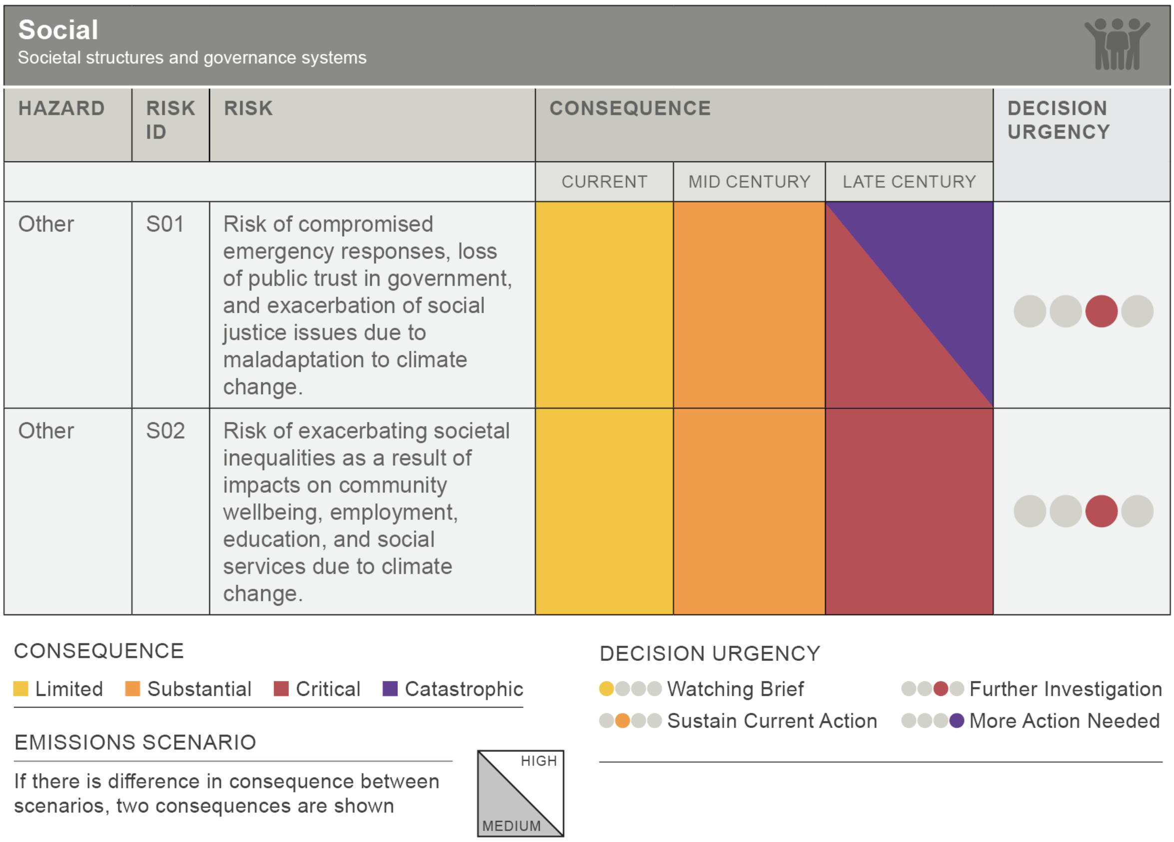


Figure 5.11: Significant climate risks for the Social System.

5.1.9 Water Security

The Water Security system focuses on the availability and management of water resources. The main sub-system of Water Security therefore is water supply. The elements of water supply at risk of climate change are agricultural use, civil and domestic use, economy, energy use, environment, industry and service use, and water quality. There are a total of five risks identified for the Marine and Coastal Ecosystems system, with two deemed significant.

Water Supply: Extreme precipitation events (WS03) can lead to overland flows of pollutants into watercourses, risking water supply quality. Communities relying on surface water sources are vulnerable to contamination from agricultural runoff, industrial discharges, and urban pollutants, during heavy rainfall. Contaminated water supplies can cause health issues, increased treatment costs, and disruptions to daily life, especially for vulnerable populations. Drought conditions and extreme heat (WS05) pose risks to water supply and increase water demand. Communities relying on surface and groundwater sources are vulnerable to reduced water availability during dry periods. Reduced water supply can lead to restrictions, agricultural losses, and increased competition for resources, affecting both urban and rural populations.

Water Security
Availability and management of water resources

HAZARD	RISK ID	RISK	CONSEQUENCE			DECISION URGENCY
			CURRENT	MID CENTURY	LATE CENTURY	
Flooding	WS03	Risk of water supply contamination as a result of overland flows of pollutants to watercourses due to extreme precipitation				
Heat	WS05	Risk of reduced water supply and increases in water demand due to drought conditions and extreme heat				

CONSEQUENCE
Limited | Substantial | Critical | Catastrophic

EMISSIONS SCENARIO
If there is difference in consequence between scenarios, two consequences are shown
HIGH
MEDIUM

DECISION URGENCY
Watching Brief | Further Investigation | Sustain Current Action | More Action Needed

Figure 5.12: Significant climate risks for the Water Security System.

5.2 Cascading Risks

Climate change poses a multitude of cascading risks as a result of direct impacts in a system. These interconnected risks can trigger a chain reaction of adverse effects, where disruptions in one system can lead to significant consequences in others. All of the systems are impacted by risks in other systems, with the Health and Social systems particularly affected (Figure 5.14). This section explores the specific risks associated with each system and the cascading impacts these risks can have on other systems.

Biodiversity and Ecosystems: Landslides can result in disruption to infrastructure and decrease water quality, while pests and diseases in forests can harm the economy and jobs related to the sector. Wildfires can affect respiratory health and reduce the supply of timber. Degradation of terrestrial habitats can lead to soil degradation, loss of pollinators, and impact water flow and quality.

Built Environment: Sea level rise, coastal erosion, and flooding can damage buildings, resulting in the release of hazardous materials into the environment, while extreme precipitation and flooding can cause property loss and business disruption. Overheating due to extreme heat can increase energy use for cooling, and cause heat stress for people. Extreme wind can disrupt access to healthcare and cause health service interruptions. Loss of communication can affect emergency response, public safety, and social connectivity. Damage and loss to cultural heritage can lead to business interruption and impacts on tourism and community well-being. Additionally, damage and disruption to water services infrastructure can lead to decreases in water quality, impacts on physical health, and business disruptions. Stress on dam and reservoir infrastructure can hinder hydroelectric power production and water access. Operational issues from the inability to discharge water into depleted bodies can further degrade water quality and impact health and business operations. The potential increase in the damage and disruption of infrastructure due to climate change can lead to an increase in the number of insurance claims and the decrease or loss of property and infrastructure value.

Economy and Finance: The Economy and Finance system is a receptor of risks due to cascading impacts from other systems. Increased insurance claims can result from damage to infrastructure within the built environment, energy, and health systems. Additionally, the loss of crops and livestock within the food production system can lead to insurance claims, while health impacts on people can increase health-related insurance claims. The increased frequency and severity of hazard events can lead to higher levels of damage and disruption, resulting in increased expenditure by individuals, businesses, and the government. This can cause higher levels of default and a reduction or loss of asset values. Ultimately, the increased level of damage and disruption due to climate change could lead to reduced tax revenues, increased government expenditure, lower credit ratings, and higher borrowing costs, destabilising the national economy.

Energy: The energy system faces significant risks that can disrupt and damage energy generation, conversion, transportation, and distribution infrastructure. These disruptions can lead to power outages that can affect water services, buildings, transport infrastructure, food production, healthcare, communications, and water security. An example of these cascading impacts is described in Figure 5.13. Increased cooling demands and accelerated ageing of infrastructure can further strain the energy system. Reduced power generation and efficiency can impact water quality, crop preservation, patient care in hospitals, and access to drinking and industrial water. Power loss can also affect internet, phone systems, and data centres, leading to business and social disruptions. The potential increase in the damage and disruption of energy related infrastructure due to climate change can lead to an increase in the number of insurance claims and the decrease or loss of infrastructure value.

Food Production and Supply Chain: The food production system faces various risks that can impact aquaculture, commercial fish stocks, crop yields, and livestock. Reduced aquaculture yields and decreases in commercial fish stocks can negatively affect coastal economies and livelihoods. Changes in climate conditions can reduce crop yields and agricultural productivity, leading to economic instability and loss of livelihoods, particularly in rural communities. Loss of nutrients and sediment due to precipitation can reduce water quality and harm aquatic life, while increased activity and transmission rates of vector-borne diseases among livestock can further impact rural economies and social systems. Heat stress and wildfires can damage crops and livestock, affecting respiratory health and increasing input costs for irrigation and fertilisers. The potential increase in the damage and disruption of food production operations and assets can lead to an increase in the number of insurance claims and the decrease or loss of asset value.

Health: The health system faces various risks that can disrupt and damage healthcare services and facilities. Coastal flooding, extreme cold, precipitation, and wind can damage healthcare infrastructure, leading to costly repairs, business interruptions, and social isolation due to relocation. Increased temperatures and extreme heat can raise demand on healthcare services, cause overheating in facilities, and increase antimicrobial resistance, impacting both human and animal health. Changes in climate conditions can lead to physical injuries, mental health issues, and illnesses from algal blooms and pathogens in marine waters. Drought conditions can reduce water supply, affecting hygiene practices. Wildfires can cause respiratory health impacts, while increased temperatures can lead to higher rates of skin cancer, decreased indoor air quality, and heat stress. Vector-borne diseases may also increase due to climate changes. An increase in the impact of human health can lead to an increase in the number of health-related insurance claims.

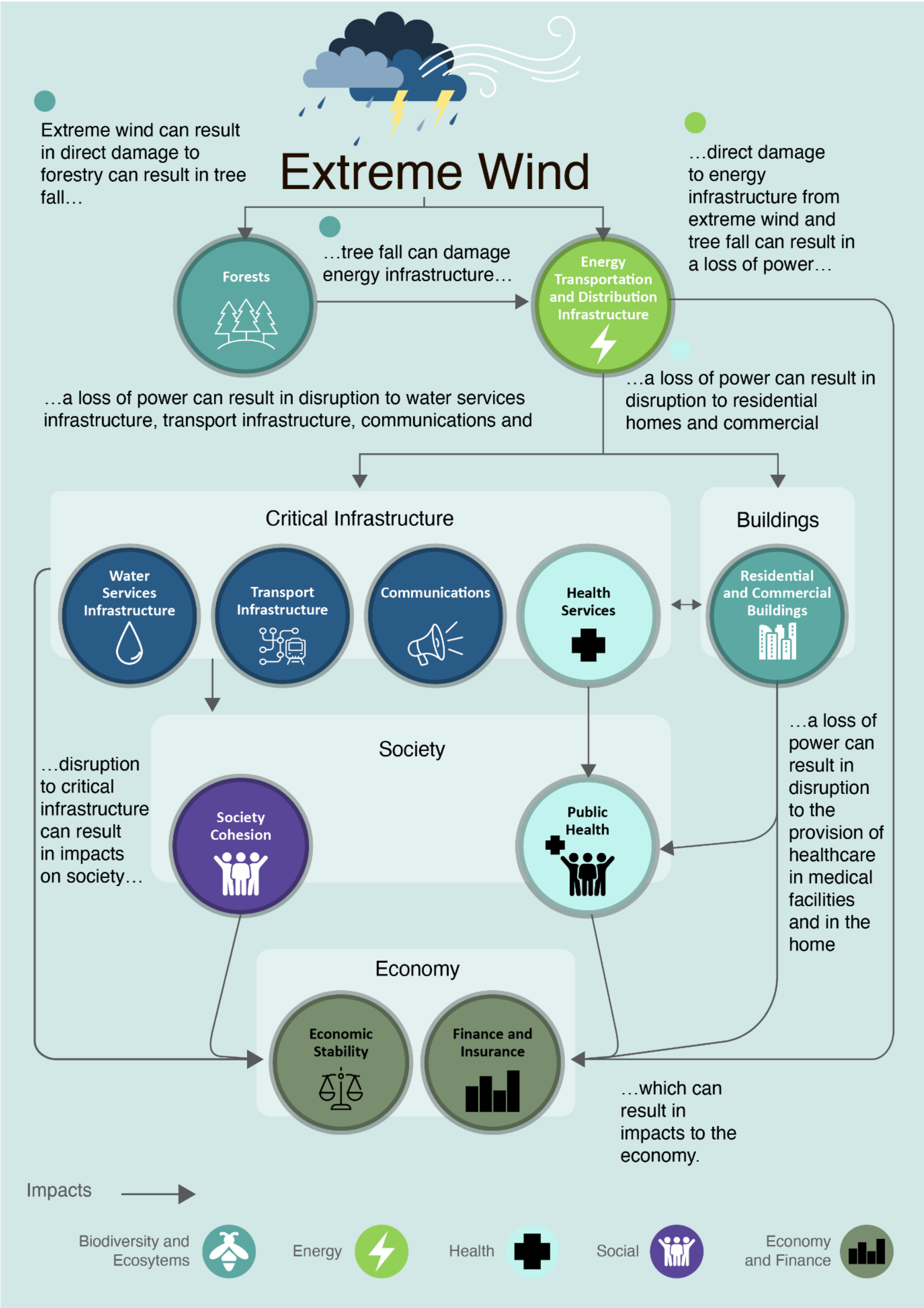


Figure 5.13: An example of the cascading impacts of a loss of electricity due to extreme wind.

Marine and Coastal Ecosystems: Marine and coastal ecosystems face various risks that can lead to degradation and loss of habitats, impacting species and ecological balance. These disruptions can affect coastal protection ecosystem service, increase saline contamination of agricultural land, spread waterborne diseases, and degrade landscapes important for tourism and recreation. Changes in average ocean conditions can disturb marine habitats, reduce commercial fish stocks, and spread marine-borne diseases, negatively impacting coastal economies and livelihoods. Decreases in reproduction rates of marine species, seafood contamination, species distribution shifts, and increased mortality of cold-water coral reefs and shellfish can further strain the commercial fishing industry, leading to economic instability and loss of cultural identities. Phenological changes can also degrade marine ecosystems and habitats, highlighting the interconnectedness of marine and coastal ecosystems with other systems and the importance of resilience and adaptation strategies to ensure environmental and economic stability.

Social System: The social system faces risks that can compromise emergency responses, erode public trust in government, and exacerbate social justice issues due to maladaptation to climate change. These risks can have temporary and long-term impacts on the built environment, including damage to buildings and infrastructure. Additionally, societal inequalities may be exacerbated, affecting community well-being, employment, education, and social services. These impacts can lead to increased demand for healthcare services and affect physical and mental health well-being.

Water Security: The water security system faces various risks that can lead to contamination and reduced supply. Saline intrusion, overland flows of pollutants, and flooding can contaminate water supplies, impacting species, habitats, and agricultural productivity. Increased demand on water supply due to extreme conditions can strain water services infrastructure, leading to operational issues and maintenance needs. Drought conditions and extreme heat can reduce water supply and increase demand, causing habitat loss, species decline, and higher risks of waterborne diseases and harmful algal blooms.

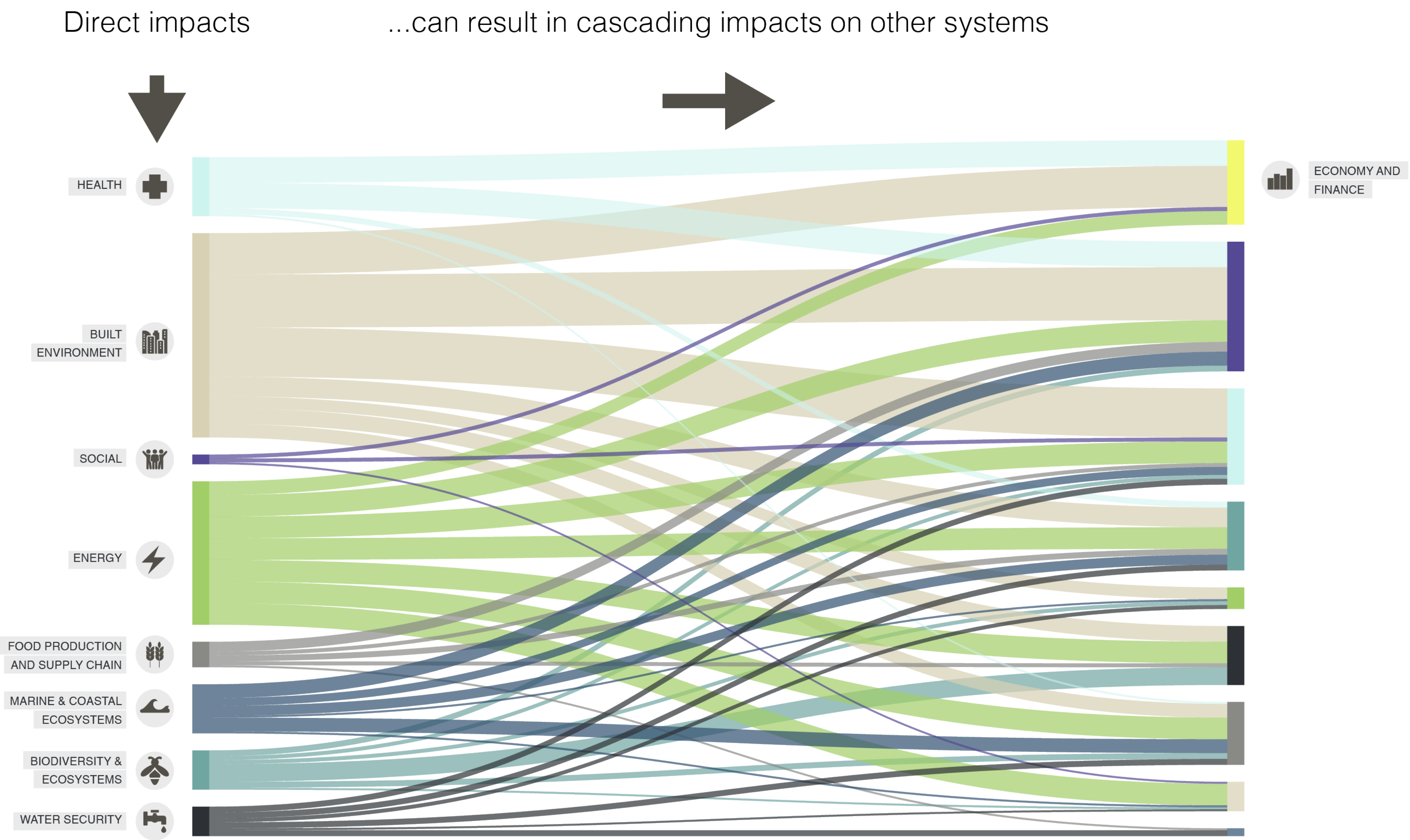


Figure 5.14: The potential cascading impacts on other systems as a result of direct impacts within a system. The thickness of the connecting line is proportional to the number of impacts identified. See Appendix E for underlying data used to create this figure.

5.3 International Dimensions

Climate change will have impacts across the world, and these extra-national or transboundary impacts could have important consequences for Ireland. Climate change impacts experienced overseas pose risks for Ireland, highlighting how global factors and cross-border interactions shape national climate change risks. Such risks include the global impacts of climate change on food security, supply chains, economic stability, and human mobility.

- Risks to global food security poses a significant risk. Ireland relies heavily on imports for vegetables, fruits, grains, fertilisers, and animal feed. Disruptions in the supply of food, i.e., due to extreme weather events, can lead to shortages, increased food prices, and potential food insecurity, especially for vulnerable households
- Climate change is increasingly recognised as a threat to global supply chains, impacting logistics, manufacturing, and energy networks. These disruptions can lead to significant economic losses and supply shortages worldwide, including in Ireland.
- Climate change poses significant risks to Ireland's economy by disrupting global financial systems where extreme weather events can increase financial exposure for insurance companies, banks, and investment firms, affecting Ireland's financial stability
- Extreme weather events caused by climate change can lead to forced displacement and changes in international migration patterns.

6 Opportunities

Climate change, while presenting significant risk, also opens up a range of opportunities that can be leveraged to enhance Ireland's resilience and sustainability. By strategically addressing these opportunities, Ireland can drive economic growth, improve public health, and promote environmental sustainability. These opportunities for Ireland are outlined below.

O1: Opportunity of changes in average temperature to tourism leading to increased tourism and expansion of outdoor activity tourism

There is an emerging opportunity for an increase in tourism due to warmer climates that can lead to longer tourist season, thereby attracting more visitors during the off-peak season. This can contribute to more stable employment opportunities within the tourism sector, opening up new markets and untapped destinations. Given our landscape, with some of the best hiking and trekking routes, there is a significant opportunity to attract adventure enthusiasts and nature lovers. Coastal regions can become hubs for a variety of water sports and prolonged periods of camping. The potential for increased tourism can drive investment in local infrastructure, including hotels, restaurants, and transportation networks, boosting the local economy. The tourism industry can leverage this opportunity to promote sustainable practices and market destinations as eco-friendly to attract environmentally conscious travellers. However, this can also potentially lead to increased footprint and risks related to impact on the Biodiversity and Ecosystem System (i.e., B15) and increased tourism in peak seasons can put a strain the Water Security System (i.e., WS05).

O2: Opportunity for increased hydropower generation due to increases in precipitation

While there is a significant risk of increased flooding, there is also an opportunity for energy generation by harnessing the increase in precipitation, potentially flood waters, to produce sustainable energy. Improved energy output and efficiency gains in power generation can be achieved by enhancing the capacity of hydropower plants from utilisation of excess water. Reliance on fossil fuels can be reduced by using hydropower as an energy source contributing to sustainable energy production. The development and expansion of hydropower infrastructure can create jobs, stimulate local economies, and attract investment. However, the construction of these plants can disrupt the local ecosystems affecting natural habitats, leading to a loss of biodiversity. Another potential hazard can be the displacement of local communities resulting from building these facilities, thus leading to socio-economic challenges.

O3: Opportunity of changes in average ocean temperature and salinity to fisheries/aquaculture increasing shellfish growth and introducing diverse marine species

Changes in average ocean temperature and salinity due to climate change could benefit Ireland's fisheries and aquaculture by enhancing shellfish growth and introducing diverse marine species. Warmer and more saline waters can create favourable conditions for shellfish development and attract new species to Irish waters. However, these changes also pose risks such as the potential for harmful algal blooms (i.e., M05), the displacement of native species (i.e., M06), and ocean acidification (i.e., M07). Examples include increased shellfish yields and the introduction of commercially valuable species, alongside the need for monitoring and management to mitigate ecological disruptions. More research is needed to better understand the opportunities and risks climate change could pose to the seafood sector.

O4: Opportunity of changes in average temperature to food production increasing the growing season, and improving livestock nutrition and grazing

Climate change presents opportunities for Ireland's food production by potentially extending the growing season and enhancing livestock nutrition and grazing. Increased average temperatures can lead to longer growing seasons, allowing for multiple crop cycles and improved pasture quality. However, these benefits come with risks such as heat stress on crops and livestock (i.e., F03 and F06), and the potential for new pests and diseases. Examples include higher yields of certain crops, improved forage quality for livestock, but also the need for adaptive measures to mitigate heat stress and pest management.

O5: Opportunity of changes in average temperature to human health leading to improved physical and mental health by increasing time outdoors and reducing cold-related deaths

Changes in average temperature due to climate change can positively impact human health in Ireland by encouraging more outdoor activities and reducing cold-related deaths. Warmer temperatures increase opportunities for outdoor recreation and physical activity, while also decreasing the incidence of cold-related illnesses. Benefits of this increased outdoor time include improved physical fitness and mental well-being However, these benefits come with risks such as heatwaves, which can lead to heat-related illnesses and exacerbate existing health conditions (i.e., H14). Additionally, increased exposure to tickborne illnesses, which may rise under a warmer climate.

7 Knowledge Gaps

Climate change poses significant risks to various sectors and communities, necessitating comprehensive risk assessments to inform effective adaptation strategies. However, several knowledge gaps and uncertainties hinder our ability to accurately assess and address these risks. Improvements in data and research in these areas could form the basis for examination and integration into a future of iteration of the NCCRA. Key areas of insufficiency and challenges encountered during the NCCRA include:

Projections for Key Climatic, Atmospheric, Terrestrial, and Oceanic Variables: National downscaled projections are currently unavailable for several key climatic, atmospheric, and oceanic variables, including humidity, sea level rise, extreme wind, fire weather, ocean chemistry, and drought. While additional TRANSLATE outputs developed by Met Éireann, ocean climate projections by the Marine Institute, and river flow projections by the EPA are in progress, data gaps remain. These gaps limit our ability to accurately assess the risks associated with these variables. Addressing these gaps is essential for developing a comprehensive understanding of climate-related risks. See the NCCRA Technical Report for more information.

Projections for Key Geophysical Hazards: National downscaled projections accounting for climate change are currently unavailable for several key geophysical hazards, including coastal erosion, landslides, groundwater flooding, and surface water/pluvial flooding. This gap in data limits our ability to accurately assess the risks associated with these hazards. Addressing these gaps is essential for developing a comprehensive understanding of climate-related risks.

The OPW Flooding Scenarios: For the CFRAM Programme, the OPW adopted two indicative potential futures for flood risk assessment: the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS). A future timeframe is not directly assigned to the MRFS and HEFS. Therefore, for use within the NCCRA, the timing of changes associated with precipitation and mean sea level within the MRFS and HEFS scenarios need to be aligned with the RCP4.5 and RCP8.5 scenarios to be consistent with the NCCRA Methodology. This alignment allows the identification of a representative flood extent data layer to be used within the NCCRA. However, global sea level rise information and proxy variables from TRANSLATE (Winter precipitation change) were used to support this alignment. Consequently, there is uncertainty associated with the timing of changes in coastal and fluvial flooding extent due to this approach.

Climate Extremes: The methodology used to develop the TRANSLATE national downscaled climate projections utilises detrending, which is performed on all RCM 30-year output time series to distil the climate change into a single 30-year climatology rather than a year-by-year changing climate. While this method can enhance the clarity of underlying patterns and provide for the more reliable calculation of internal climate variability, extreme events, and other indices over the 30-year climatology, it can also inadvertently remove extreme events from the dataset associated with interannual variability. By eliminating these extremes, detrending can lead to projections that underestimate the frequency and intensity of such events, potentially resulting in an underassessment of risk. TRANSLATE 2 and 3 are in development which aim to preserve interannual variability and extreme events while still providing accurate projections of climate trends are therefore needed to enhance future climate risk assessments.

Climate Tipping Points: The uncertainty associated with climate tipping points presents significant challenges for their inclusion in national climate risk assessments. Tipping points, such as the collapse of ice sheets or the thawing of permafrost, are characterised by abrupt, irreversible changes that can have far-reaching and severe impacts. Predicting the precise thresholds and timing of these events is inherently difficult. This unpredictability makes it challenging to integrate tipping points into national risk assessments, which typically rely on more stable and predictable climate projections. As a result, there is a risk of underestimating the potential impacts and not adequately preparing for these high-impact, low-probability events. Additionally, gradual changes linked to phenomena such as the AMOC (Atlantic Meridional Overturning Circulation) that may precede, but not in themselves meet the definition criteria of a tipping point, need to be incorporated into our projections to ensure comprehensive risk assessments.

Exposure and Vulnerability Data: For some risks, it was not possible to undertake spatial analysis due to limited availability of spatial information on asset locations and/or asset function. The absence of thresholds, e.g., operating temperatures, ecosystem tipping points, further exacerbates the challenge of determining the degree of exposure, making it difficult to consistently define and measure risk levels across different elements at risk. Moreover, the lack of detailed vulnerability data, including socio-economic factors, infrastructure and environmental sensitivities, e.g., which marine species are more sensitive to changing ocean conditions, and adaptive capacities, hinders the ability to accurately assess the potential impacts on various populations and systems. Further information on thresholds, vulnerability, and spatial information on exposure would enhance future national risk assessments.

Uncertainty in Changes in Exposure and Vulnerability: Assessing climate risks is complicated by the uncertainty associated with changes in exposure and vulnerability, such as population growth, demographic shifts, and land use changes. Population and demographic changes can significantly alter the vulnerability of communities, as shifts in age, income, and density affect how different groups experience and respond to climate hazards. Additionally, land use changes, driven by urbanisation, agricultural expansion, or deforestation, can modify the landscape in ways that influence the severity and distribution of climate impacts. For example, urban expansion can increase surface runoff and flood risk, while land use change can exacerbate soil erosion. These dynamic factors introduce variability and uncertainty into risk assessments, making it challenging to predict future exposure accurately. At the national level, understanding the specific vulnerabilities of various exposures is challenging; however, these vulnerabilities can change over time due to climate change, economic and demographic changes, and technological advancements. Thus, a more comprehensive understanding of changing vulnerability is essential for improved risk assessment.

Consideration of Policy Changes: When assessing climate risks, it is crucial to consider the impacts of evolving government policies, such as urban densification (e.g., Project Ireland 2040), renewable energy promotion driven by policies to reduce greenhouse gas emissions (e.g., Climate Action Plan 2025), decarbonizing the built environment, sustainable farming practices (e.g., Food Vision 2030), promotion of electric vehicles and public transit (e.g., National Sustainable Mobility Policy), nature-based water solutions (e.g., Water Action Plan 2024), and enhancing green spaces (e.g., Ireland's 4th National Biodiversity Action Plan 2023–2030). These policies can shape exposure to climate hazards like heatwaves and flooding, alter energy infrastructure resilience, influence land use and water resource management, impact transportation emissions and infrastructure needs, and enhance biodiversity. Integrating the potential impacts of these policies into comprehensive climate risk assessments is vital for developing adaptive strategies.

Assessment of Acute Compounding Risks: The current risk assessment approach evaluates acute hazards as single events, focusing on potential risks and cascading impacts on systems. However, the NCCRA was not fully able to consider the compounding and aggregating impacts of acute risks occurring sequentially or concurrently. For example, a prolonged drought can increase wildfire likelihood, and subsequent heavy precipitation can lead to severe flooding due to hydrophobic soil. This sequence of events demonstrates how interconnected hazards can compound overall risk. While chronic risks, such as reduced crop yields due to climate changes, were considered where feasible, the lack of a fully integrated risk assessment limits our understanding of complex, multi-hazard scenarios.

Assessing Adaptation Effectiveness: The current risk assessment approach focuses on the effectiveness of adaptation measures at the national scale (which includes local and subnational level) and was conducted through literature review and stakeholder consultation. However, most existing analysis of adaptation action has been undertaken at the sector level or project level and scaling of this data to inform national-level assessment is challenging. In addition, quantitative information in combination with robust methodologies (e.g. Cost-benefit analysis) for assessing the effectiveness of ongoing and planned adaptation measures is needed to enhance future national risk assessments.

Financial Implications of Climate Risks: Climate change results in direct and indirect financial costs for both the public and private sectors, including response and repair costs, business interruptions, and adaptation actions. Assessing these financial implications is crucial for economic stability, informed decision-making, risk management, and regulatory compliance. However, the NCCRA did not include a comprehensive financial assessment due to challenges such as predicting economic impacts across sectors, extensive data collection, and modelling. The valuation of non-market impacts and the need to consider long-term projections further complicate financial assessments.

8 Recommendations

This section presents key recommendations to inform and strengthen future iterations of the NCCRA.

8.1.1 NCCRA Scope and Methodologies

To enhance the robustness and comprehensiveness of future iterations of the NCCRA, improvements related to non-climatic risk drivers, incorporation of transition risks, including financial assessments, and expanding the assessment of transboundary risks are recommended. By focusing on these areas, a future iteration of the NCCRA can provide a more detailed and accurate understanding of the multifaceted nature of climate risks. The following recommendations outline specific actions to improve the assessment scope and methodologies used in the NCCRA.

1) **Further integrate non-climatic drivers**: Non-climatic drivers include factors such as urbanisation, pollution, socio-economic processes, population growth, economic development, and land use changes. These drivers interact with climatic changes to influence the overall level of risk, often exacerbating the impacts of climate hazards. Trends related to population were included in the NCCRA where possible, however, for future iterations, it is recommended other non-climatic drivers should be included to ensure that risk assessments account for the complex interplay between climatic and non-climatic factors, leading to a more robust and comprehensive national risk assessment.
2) **Incorporation of transition risks**[6]: Incorporating transition risks into national climate change risk assessments is essential for a comprehensive understanding of the challenges and opportunities associated with moving to a low-carbon economy. Transition risks can vary significantly depending on the nature, speed, and focus of the transition. Ireland should also assess transition risks because policy and delivery changes often need to respond to physical and transition risks simultaneously. For example, the energy sector must decarbonise, driving structural changes to power generation, and expanding and changing the location of energy distribution and transmission networks. At the same time, it must improve its resilience to physical hazards. Physical and transition risks often need to be considered together because measures taken to mitigate one type of risk can influence the other. For instance, transitioning to renewable energy sources can reduce greenhouse gas emissions (a transition risk) while also enhancing the resilience of the power grid to extreme weather events (a physical risk), or the potential impact of offshore renewables on the marine environment. Trade-offs will be required, and transition and physical risk

[6] Transition risks relate to the risks associated to transitioning to a lower-carbon economy, which may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change.

should be looked at in a combined way when feasible. While the NCCRA has assessed physical risks, it has not included transition risks, and therefore it is recommended in future iterations of the NCCRA that transition risks are included to ensure a more comprehensive assessment of climate risks and opportunities.

3) Incorporation of financial quantification: Financial quantification involves estimating the direct and indirect costs associated with climate risks, including response and repair costs, business interruptions, and adaptation actions. This process is challenging due to the lack of financial related data and information and methodologies that may not fully capture the complexity of the impacts of a risk. However, for future iterations of the NCCRA, it is recommended that financial quantification is included where to possible, to improve the assessment of consequence and to inform prioritisation of action.

4) Expand the assessment of transboundary risks: Transboundary climate risks are those that cross national boundaries and can affect multiple countries through shared natural resources, ecosystems, trade links, finance, and human mobility. The NCCRA did consider transboundary risks through the International Dimensions risk, however, no assessment of the level of consequence of these risks was conducted. For future iterations of the NCCRA, it is recommended the approach to transboundary risks is expanded to include an assessment of consequence, uncertainty, decision urgency, and the direct and indirect impacts on other systems. This would ensure a more comprehensive assessment of climate risks and opportunities. The approach taken to addressing transboundary risks under a future EUCRA and proposed European Climate Action Plan could offer useful guidance for another iteration of the NCCRA.

5) Evaluate compounding and aggregating risks: Developing methodologies to assess the compounding and aggregating impacts of sequential or concurrent hazards is crucial. Climate hazards often do not occur in isolation and by considering multi-hazard scenarios, risk assessments can better understand complex risk interactions and provide a more comprehensive view of potential climate impacts. The NCCRA included cascading effects of risks where possible, however, for future iterations, it is recommended to expand this to include compounding and aggregating risks to improve the assessment of risk consequence resulting in a more comprehensive assessment of climate risks.

8.1.2 Developing the Evidence Base

To improve the robustness of the NCCRA and to support the widening scope of the NCCRA, it will be required to enhancing the quality and range of climate and hazard data, improve exposure and vulnerability data, develop projections for changes in exposure and vulnerability, and develop approaches to assess adaptation effectiveness. The following recommendations outline specific actions to improve data collection and integration in the NCCRA.

1) **Continue development of climate and hazard data:** A range of climate and hazard data was utilised throughout the NCCRA; however, several hazards have either no data or limited data available, and evidence related to tipping points and high-impact, low likelihood events is limited. Additionally, the available data was not always consistent in terms of format, scenario, or time horizon. These inconsistencies can hinder the accuracy and reliability of risk assessments. For future iterations of the NCCRA, it is recommended that climate and hazard data be developed with consistent spatial and temporal alignment, as well as climatic scenarios (see NCCRA Technical report for further information). Ensuring that all data sets are harmonised in terms of geographic coverage, timeframes, and climate projections will provide a more cohesive and accurate assessment of climate risks. This approach will facilitate better integration of data, improve the comparability of different hazards, and enhance the overall robustness of the risk assessment process.
2) **Improve exposure and vulnerability data:** For future iterations of the NCCRA, it is recommended that improved information on asset locations, functions, and impact thresholds be developed to enhance understanding of exposure and vulnerability to climate risks. This includes spatial mapping of the locations of elements at risk within each sub-system and system, such as, critical infrastructure, residential areas, and natural resource. Comprehensive vulnerability data should also be gathered, including socio-economic factors, environmental sensitivities, and adaptive capacities. Furthermore, identification and development of functional thresholds of these, e.g., temperature limits for infrastructure, would be highly beneficial. This information will provide a more robust evidence base on which to assess the level of consequence of each risk.
3) **Develop projections for changes in exposure and vulnerability:** If non-climatic drivers are to be included in future iterations of the NCCRA, there is a need to develop models that can project these changes into the future under a range of climatic scenarios. Existing information such as long-term national planning and policies, combined with global climate scenarios such as the National Framework for Greening the Financial System, could be used to develop non-climatic scenarios. Improving this evidence base will improve the robustness of the assessment of consequence of risks over future time periods.
4) **Establish a climate impacts register**: The assessment of climate risk is informed by understanding the possible impacts when an event occurs. Currently, there is not a consistent and systematic record of the impacts of extreme events in Ireland. This information to gain insights into the social, environmental, economic impacts

of a hazard, to better inform future climate risk assessment and adaptation action. Such an impacts register should be structured to take risk information from and provide impact information to the national climate change risk register.

5) **Develop a standardised approach to assess adaptation effectiveness:** The existing level of resilience to manage each risk is crucial to determining the current and future levels of risk consequence. However, currently, there is no consistent approach to measuring and assessing this resilience. Within the NCCRA, a qualitative approach was developed based upon the four Rs of resilience (reliability, resistance, recovery and response, and redundancy), however, for future iterations of the NCCRA, it is recommended that a standardised approach be developed to assess national resilience to each risk. This will require an evidence base of existing and future adaptation actions, detailing information such as the types of adaptation actions implemented, their costs, and their observed and designed outcomes. By improving the understanding of resilience, the assessment of current and future consequence can be improved.

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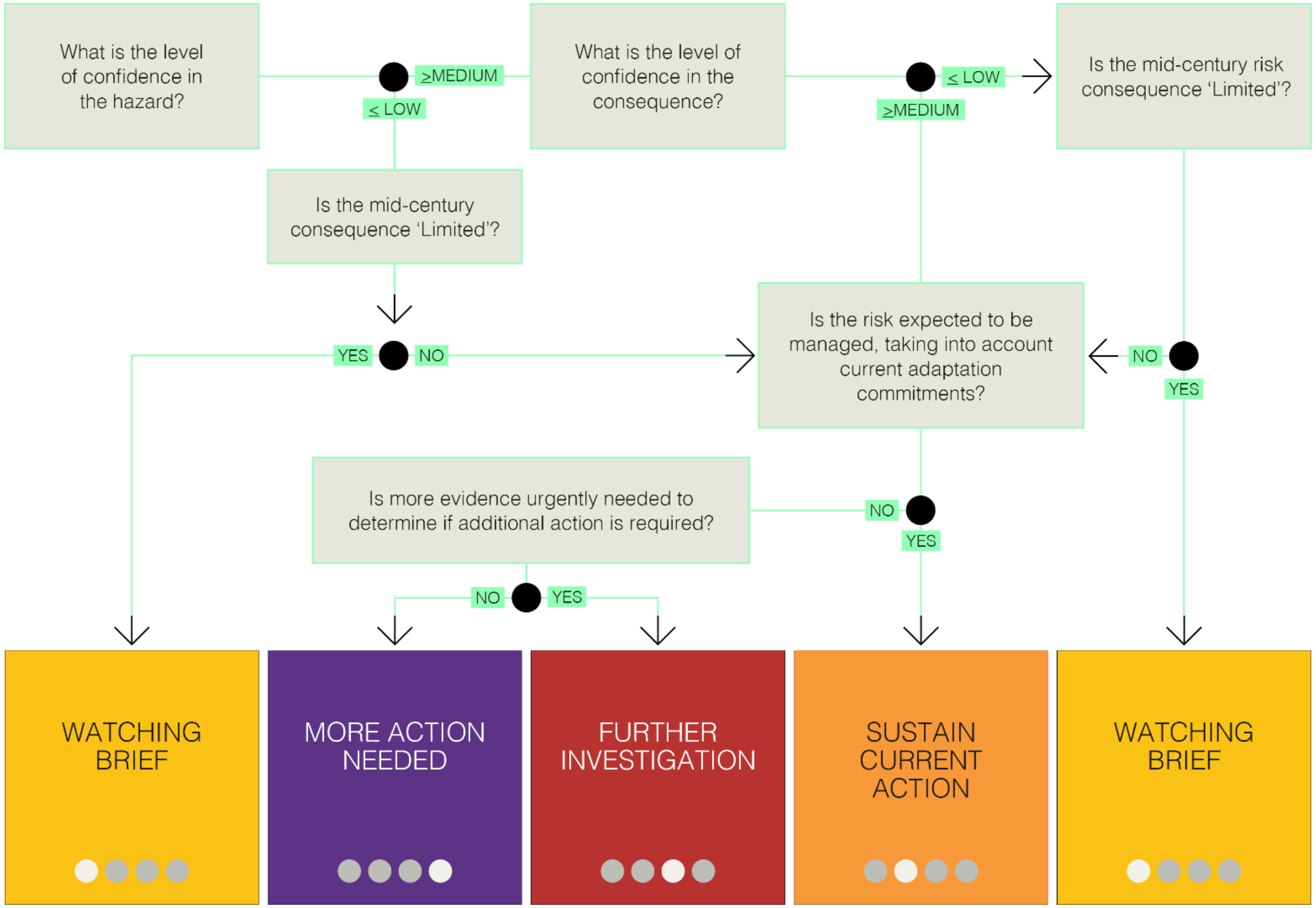
Appendix A: Additional Risk Consequence Criteria

Risk Severity	Economic Damage	Impact on People	Other Impact Categories
Catastrophic	At least 1% of GNI* (IE: €2.91 bn)	> 100 deaths or >1,000 health impacts or >10,000 people affected	• >710,000 ha of land lost or severely damaged (10% of land area)
Critical	0.25-1% of GNI* (IE: ca €727.5 mn - 2.91 bn)	>10 - 100 deaths or >100 - 1,000 health impacts or >1,000 - 10,000 people affected	• 71,000 ha to 710,000 of land lost or severely damaged • Major impact (10% or more) on valued habitat or landscape types; • Major impacts on or loss of species groups; • Major impact (10% or more) on an individual natural capital asset and associated goods and services; • Major loss or irreversible damage to iconic heritage assets
Substantial	0.05-0.25% of GNI* (IE: ca €145.5 mn - 727.5 mn)	>1 - 10 deaths or >10 - 100 health impacts or >100 - 1,000 people affected	• 7,100 to 71,000 ha of land lost or severely damaged • Intermediate impact (1-10%) on valued habitat or landscape types; • Intermediate impacts on or loss of species groups; • Intermediate impact (1-10%) on an individual natural capital asset and associated goods and services; • Medium loss or irreversible damage of iconic heritage assets.
Limited	<0.05% of GNI* (IE: ca < €145.5 mn)	≤1 death and ≤10 health impacts and ≤100 people affected	• Less than 7,100 ha of land lost or severely damaged • Minor impact (less than 1%) on valued habitat or landscape types; • Minor impacts on loss of species groups; • Minor impact (less than 1%) on an individual natural capital asset and associated goods and services; • Low loss or irreversible damage to iconic heritage assets.

Appendix A: Risk consequence for different types of impacts — benchmarks based on annualised impacts. Based on EU CRA (2024) with absolute thresholds adjusted for the 2023 Irish GNI*, population or area (2024). See the NCCRA Methodology Report for further information.

Appendix B: Decision Urgency Decision Tree



Appendix B: The decision tree used to determine the level of decision urgency. See the NCCRA Technical Report for further information.

Appendix C: Stakeholders Engaged

NCCRA Steering Committee

Steering Committee Members
Commission for Regulation of Utilities
Department of Agriculture, Food and Marine
Department of Defence - Office of Emergency Planning
Department of Environment, Climate and Communications
Department of Health
Department of Housing, Local Government and Heritage
Department of Tourism, Culture, Arts, the Gaeltacht, Sports, and Media
Department of Transport
Department of the Taoiseach
Environmental Protection Agency
Met Éireann
National Economic and Social Council
National Parks and Wildlife Service
Office of Public Works
Teagasc

NCCRA Expert Working Groups

Climate / Socio-economic Working Group

Climate / Socio-economic Working Group Members
CSO
Environmental Protection Agency
Geological Survey Ireland
ICARUS
ICHEC
Marine Institute
Met Éireann
OPW

Thematic Working Group

Thematic Working Group Members
Climate Action Regional Offices
Climate Change Advisory Council
Commission for Regulation of Utilities
ComReg
County and City Management Association
DCU
Department of Agriculture, Food and Marine
Department of Environment, Climate and Communications
Department of Health
Department of Housing, Local Government and Heritage
Department of Tourism
Department of Transport
Environmental Protection Agency
HSE
MARA
National Economic and Social Council
National Parks and Wildlife Service

In addition to the expert insight of these groups, a total of 95 wider stakeholder organisations supported the development of the NCCRA through consultation and engagement.

Appendix D: Summary of Climate Change Projections

Table D: Climate change projections for Ireland. See the NCCRA Technical Report for further information (statistics and maps) on each hazard.

	Hazard	Change by 2050 (RCP8.5)	Hazard Confidence	Data Source
Heat	Average Temperature	Nationally, daily mean temperature is projected to increase by 1.5°C (1.1-1.9°C) by 2050s. with the Mid-East region experiencing the largest increase (1.6°C (1.2-2.0°C)). Considering the seasonality, highest daily mean temperature increase is expected in autumn (2.7°C (1.7-2.7°C)), and lowest is in spring (1.0°C (0.5-1.3°C)).	High	TRANSLATE
Heat	Extreme Heat	Summer Days: Nationally, summer days are projected to increase by 4.7 days (2.5-6.7 days) by 2050 with the Midland region experiencing the largest increase (6.4 days (3.4-8.8)). Heatwaves: Nationally, there is an increase in the number of heatwave events by 0.15 (0.04-0.28 per year) by 2050, with the South-East region experiencing the largest increase (0.25 per year (0.1-0.4)).	High	TRANSLATE
Heat	Wildfire	All regions in Ireland are projected to experience a small increase in FWI, with the Southern region (0.62) showing the highest increase from the 1981-2010 baseline	Low	Climate-ADAPT
Cold	Extreme Cold	Frost Days: Nationally, number of frost days are expected to decrease by 21.6 days (-27.8- -15.5) by 2050, minimum temperature also expected to increase during this period. with the Border region experiencing the largest decrease (-25.3 days (-32.6 - -18.2)) in number of frost days. Icing Days: Nationally, the number of icing days is expected to decrease by 0.30 days (-0.36- -0.20) by 2050, with the Mid-East region experiencing the largest decrease (-0.38 days) in number of frost days.	High	TRANSLATE
Precipitation	Changes in Precipitation	Annual Precipitation: Nationally, mean annual precipitation is expected to increase by 4.8 % (-0.22 – 10.3%) by 2050, with the Dublin region experiencing the largest increase (6.7%). Seasonal Precipitation: The winter season is projected to have the highest increase in precipitation of 12.5% (3.7-22.2%), and the summer season is expected to see a decrease in precipitation of -5.5% (-15.6-4.9%).	Low	TRANSLATE
Precipitation	Extreme Precipitation	Max 5 Day Precipitation: Nationally, there is a projected increase in maximum 5-day precipitation by 6.9% (-3.1-18.0%) by 2050, with the Mid-East (9.5% (-3.1-22.8%)) region experiencing the largest increase. Very Wet Days: Projections for very wet days also indicate a small increasing trend of 0.74 days per year (0.25 – 1.26 days per year).	Low	TRANSLATE

	Hazard	Change by 2050 (RCP8.5)	Hazard Confidence	Data Source
	Drought	Wet Day: Nationally, mean annual number of wet days are expected to decrease by 2.61% (-6.21 – 1.11%) by 2050, with the East region experiencing the largest decrease (-3.28%). SPEI-3: SPEI-3 shows lower values (<-1) and higher prevalence of drought conditions in summer season, followed by the spring season with milder drought condition. In winter and autumn seasons, and in all zones, with all positive SPEI-3 values, indicating absence of drought episodes. Compared to reference values of SPEI-3, there is an increase in drought condition pronounced in spring and summer, with a mostly decreasing trend in autumn season.	Low	TRANSLATE HydroPredict (Meresa and Murphy, 2023)
Flooding	Flooding	NIFM: Nationally, under the 1% AEP scenario, NIFM projects that 2.29% of the total land area could be at risk of flooding by 2050. The Midlands region is most at risk, with 3.06% of the total land area impacted. CFRAM: Nationally, under the 1% AEP scenario, CFRAM projects that 1.73% of the total land area could be at risk of flooding by 2050. The Midlands region is most at risk, with 3.36% of the total land area impacted.	Medium	OPW NIFM OPW CFRAM
Flooding	Surface Water Flooding	Very Wet Days: Very wet days (above 30 mm of precipitation) indicate a small increasing trend of 0.7 days per year (0.3 – 1.3 days per year). Max 1 Day Precipitation: Nationally, maximum 1-day precipitation is projected to increase by 22.7% (10.8 – 36.1%), with the Dublin (26.3% (12.0-42.6%) and region experiencing the highest increase.	Low	TRANSLATE
Flooding	Groundwater Flooding	No projected changes available.	Low	McCormack et al. (2020)
Coastal	Sea Level Rise	Sea levels around Ireland are projected to increase with the sea level rise of 0.26 m (South West) for 2041-2060 with a maximum sea level rise of 0.35 m (0.17 - 0.60 m) by 2060 (longitude: 50, latitude: -10).	High	Fox-Kemper et al. (2021), Kopp et al. (2023), Garner et al. (2021)
Coastal	Coastal Flooding	Nationally, under the 1% AEP scenario, NCFHM projects that 0.95% of the total land area could be at risk of coastal flooding by 2050. The Dublin region is most at risk, with 2.41% of the total land area impacted.	High	OPW NCFHM
Coastal	Coastal Erosion	The length of coastline projected to be at risk of coastal erosion in Ireland by 2050 is 328 km. The South-West (85 km) and South-East (46 km) regions are most at risk. However, the effects of climate change have not been included within this assessment (ICPSS, RPS Consulting Engineers (2010)).	Low	Irish Coastal Protection Strategy Study

	Hazard	Change by 2050 (RCP8.5)	Hazard Confidence	Data Source
Wind	Extreme Wind	Overall, Ireland is projected to experience a small decrease in extreme wind days, with the Northern and Western region showing the largest decrease (-0.61 days) from the 1981-2010 baseline. There is a projected small reduction in the 10-m wind speed of -1.6 – -3.3% (mean value -2.6%) compared to the 1981-2000 baseline.	Very Low	Nolan and Flanagan (2020) Climate-ADAPT
Marine	Ocean Acidification	The projected mean change in pH at the surface for 2041-2060 relative to 1995-2014: Inland Waters: -0.17 Transitional Waters: -0.17 Exclusive Economic Zone: -0.16	Medium	TRANSLATE
	Sea Surface Temperature	The projected mean change in sea surface temperature for 2041-2060 relative to 1995-2014: Inland Waters: 0.8°C (0.6-1.2°C) Transitional Waters: 0.8°C (0.6-1.2°C) Exclusive Economic Zone: 0.7°C (0.5-1.1°C)	Low	CMIP6
Other	Lightning	No projections are available for 2050.	Very Low	Kahraman et al (2022)
	Changes in Phenology	Growing Season Length: Nationally, growing season length is projected to increase by 19.8 days (-15.6 – 43.8) by 2050, with the Border (26.5 days (15.6-57.2 days)) region experiencing the highest increase. Growing Season Start: Considering the growing season start, it is projected to occur earlier by -7.9 days (-21.4 – 25.5) by 2050.	Medium	TRANSLATE

Appendix E: Cascading Risks Summary

Risk Source		Risk Impacts								
System	Sub-system	Biodiversity and Ecosystems	Built Environment	Economy and Finance	Energy	Food Production and Supply Chain	Health	Marine and Coastal	Social	Water Security
Biodiversity and Ecosystems	Forests		1	0	0	0	1	0	3	1
	Freshwater Systems		0	0	2	0	1	0	0	3
	Peatlands		0	0	0	0	0	0	0	1
	Terrestrial Ecosystems		0	0	0	3	0	0	0	4
Built Environment	Buildings	3		4	3	0	6	0	5	0
	Communication	0		5	2	0	5	0	5	0
	Cultural Heritage	0		0	0	0	1	0	3	0
	Recreational	0		0	0	0	0	0	0	0
	Transport Infrastructure	0		7	0	7	6	0	7	0
	Water Services Infrastructure	7		5	1	0	7	0	7	8
Economy and Finance	Finance and Insurance	0	0		0	0	0	0	0	0
	Economic Stability	0	0		0	0	0	0	0	0
Energy	Energy Generation and Conversion	6	6	2		6	6	0	6	6
	Energy Transmission and Distribution	5	5	5		5	5	0	5	5
Food Production and Supply Chain	Food Production	3	0	0	0		2	1	5	2
Health	Healthcare Services	3	0	6	0	1		0	6	0
	Human Health	0	0	7	0	0		0	7	0
Marine and Coastal Ecosystems	Coastal Ecosystems	1	1	0	1	1	2		1	1
	Marine Ecosystems	4	0	0	0	6	2		6	0
Social	Governance	0	1	1	0	0	1	0		0
	Society	0	0	1	0	0	1	0		0
Water Security	Water Supply	3	1	0	2	3	3	3	0	

Appendix E: The potential cascading impacts on other systems as a result of direct impacts within a system. This information is used to develop Figure 5.14

ISBN: 978-1-80009-283-9