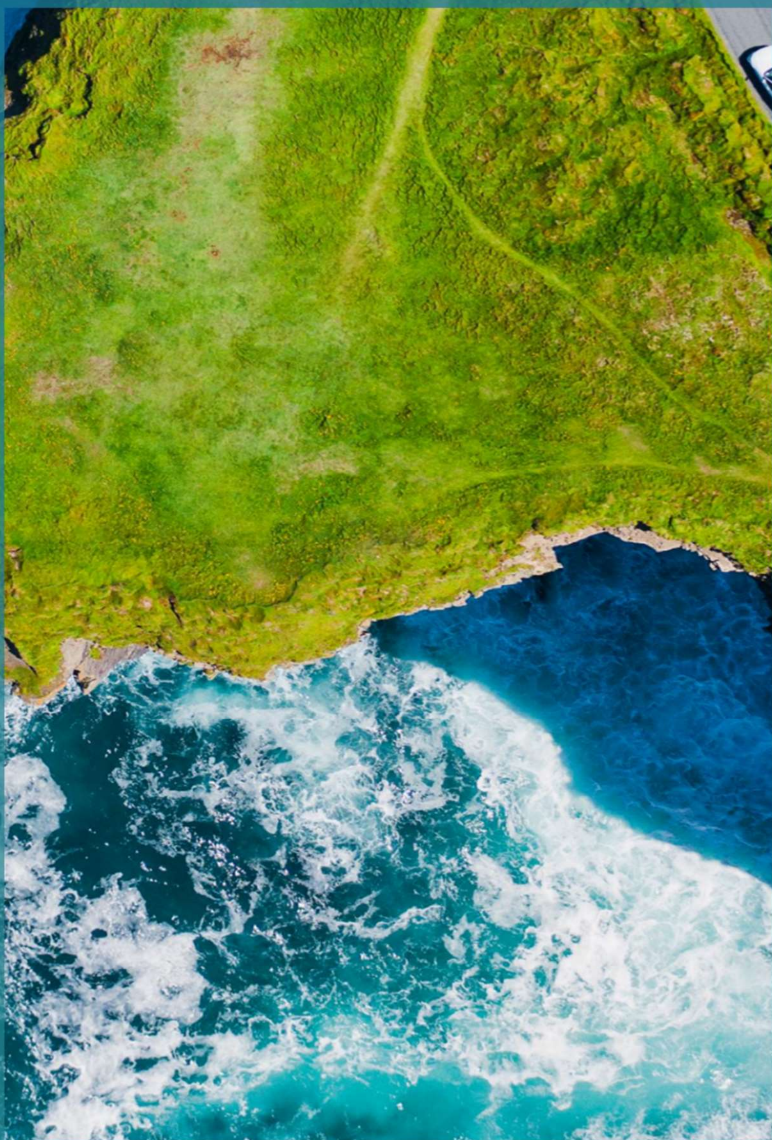
Rialtas na hÉireann
Government of Ireland

National Climate Change Risk Assessment

Technical Guidance for Sectoral Risk Assessments

—

September 2024



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The Guidance 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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1 Introduction

Ireland's climate is changing in line with global trends and this trend is expected to continue. Climate Change Risk Assessment (CCRA) forms a pre-requisite for the development of evidence based and robust climate change adaptation plans, providing an essential basis on making decisions on whether risks, and what level of those risks, are acceptable, and for developing appropriate adaptation and mitigation actions. Ireland's first National Climate Change Risk Assessment (NCCRA) is currently being developed to enhance understanding of climate risks and opportunities in Ireland. This assessment is underpinned by the NCCRA methodology (EPA, 2024b) which has been developed based on international best practice approaches to CCRA and informed by the International Organization for Standardization (ISO) 14091:2021 'Adaptation to climate change'[1] standard.

Under the National Adaptation Framework 2024, 14 sectors are required to prepare Sectoral Adaptation Plans (SAPs). Climate change risk assessments are a key part of SAPs as they support sectors to identify and prioritise their exposure to climate risks. To ensure consistency across national and sectoral planning, a Technical Guidance for Sectoral Risk Assessments has been developed to assist sectors in implementing climate change risk assessments that are consistent with the NCCRA Methodology (EPA, 2024b).

The Technical Guidance for Sectoral Risk Assessments introduces the ISO 14091 standard (Section 2), summarises the NCCRA methodological approach and its outputs (Section 3), outlines how this guidance should be used (Section 4), and provides technical recommendations for the relevant steps of ISO 14091 (Section 5).

[1] ISO 14091:2021 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment.

2 The ISO 14091 Standard

ISO 14091:2021 ‘Adaptation to Climate Change’ is an international standard that provides guidelines for assessing the risks related to the potential impacts of climate change. It outlines how to understand vulnerability and develop and implement a robust climate change risk assessment. This standard can be used for assessing both present and future climate change risks. The standard refers to organisations[2], however in the context of this technical guidance note, an organisation is considered equivalent to a sector. The standard includes the following stages:

Introduction to Climate Change Risk: This stage involves understanding the specific context in which an organisation (sector) operates, including its objectives, stakeholders, legal and regulatory requirements, and other relevant factors. It also involves clearly defining what the organisation (sector) hopes to achieve through the risk assessment process.

Preparing a Climate Change Risk Assessment: This stage involves development of a dedicated team to decide on the scope, methods, and timeframe for the risk assessment, and to collect necessary data.

Implementing the Risk Assessment: This involves identification of potential climate change impacts, development of impact chains, and identification of indicators to measure risks, thereby providing a comprehensive view of the risks and evaluating the organisation’s (sector's) adaptability.

Reporting the Results: This stage involves analysis of the results, consideration of sector interconnections, review by an independent party, and communication of the findings to stakeholders.

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[2] ISO 14091 defines organisation as person or group of people that has its own functions with responsibilities, authorities, and relationships to achieve its objectives. The concept of organisation includes, but is not limited to, sole-trader, company, corporation, firm, enterprise, authority, partnership, charity or institution, or part or combination thereof, whether incorporated or not, public or private.

This Technical Guidance for Sectoral Risk Assessments provides guidance on the areas of ISO 14091 related to climate change risk assessment only, specifically for the sections ‘Preparing a Climate Change Risk Assessment’ and ‘Implementing a Climate Change Risk Assessment’.

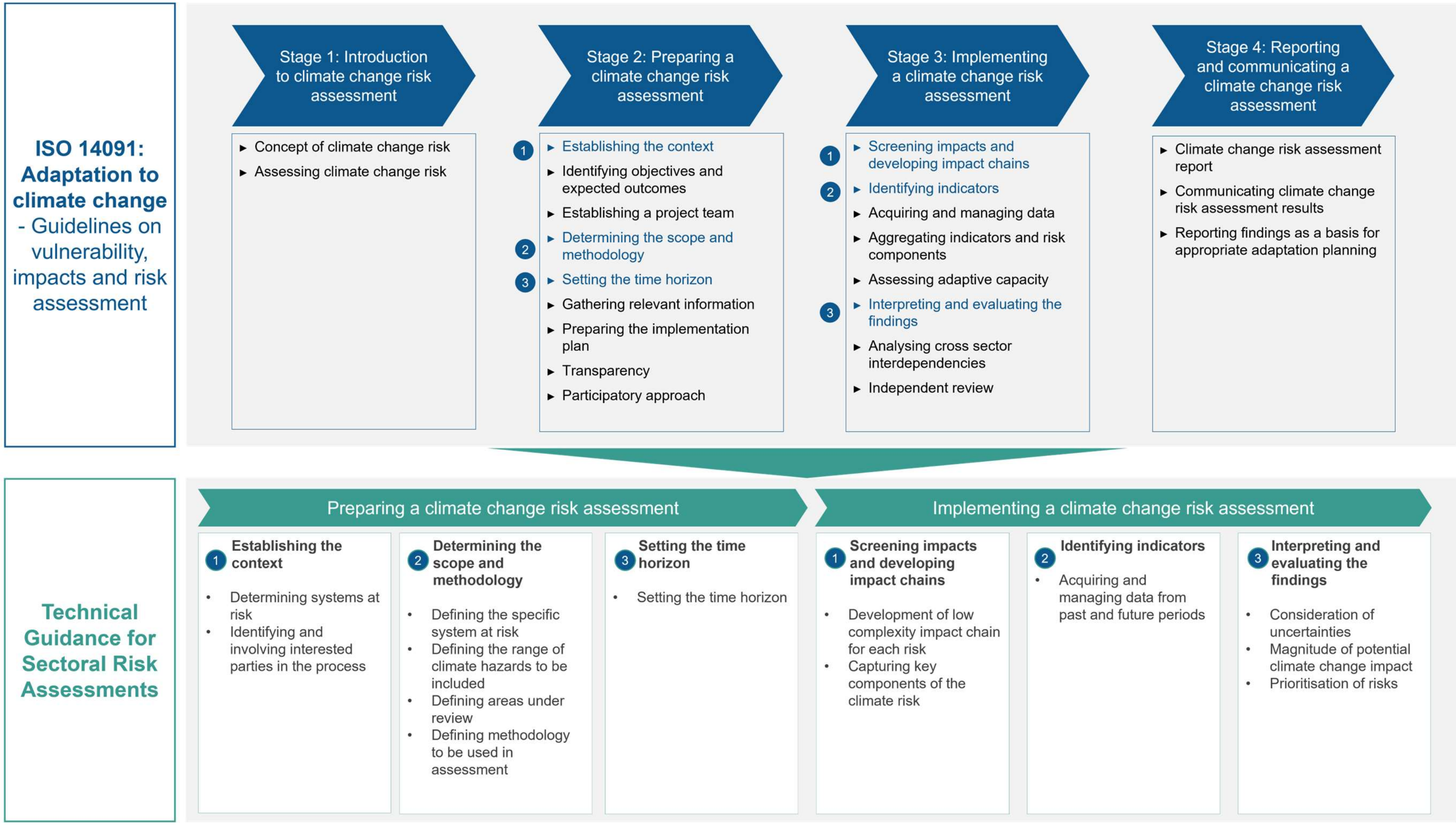

Figure 2.1: An overview of the ISO 14091 standard with the relevant stages and steps indicated for which recommendations are provided through the Technical Guidance for Sectoral Risk Assessments.

3 The NCCRA

Ireland's first NCCRA aims to enhance understanding of climate risks and opportunities in Ireland by:

- Identifying priority actions to make Ireland more resilient to the impacts of climate change.
- Supporting the prioritisation of adaptation-related investments (e.g., infrastructure, operations, people) and improve the robustness of policy development in climate-sensitive sectors.
- Providing a consistent evidence base to inform on the development and implementation of the National Adaptation Framework.
- Providing a national reference for conducting and updating sectoral, local, and other Ireland-specific risk assessments.

To implement the NCCRA, a methodology was developed that aligns with international best practice, such as the European Climate Risk Assessment (EUCRA), and the ISO 14091 standard. The methodology employs standard climate and socio-economic projections to inform assessments based on defined scenarios and timeframes. It utilises a semi-quantitative approach to comprehend the temporal and spatial variation in climate risks. The methodology also identifies and assesses risks within and across sectors, including cascading, transboundary, and cross-cutting risks. Risks are prioritised based on standardised definitions of consequence and decision urgency, ensuring that risks within and outside existing Irish adaptation sectors are identified and assessed.

Sections 6 and 7 of the Climate Act establish the requirement for the preparation of Sectoral Adaptation Plans (SAPs) for 14 sectors of the Irish economy and society. Each Plan identifies the key risks faced across the sector and the approach being taken to address these risks and build climate resilience for the future.

Both, The NCCRA and sectoral climate change risk assessments undertaken in the development of statutory Sectoral Adaptation Plans, aim to identify and assess the risks associated with climate change; however, they differ in their scope and focus. The NCCRA provides a national scale assessment of how Ireland may be affected by climate change and identifies the most significant risks and opportunities for the country as a whole, whereas a sectoral climate risk assessment focuses on specific sectors of the economy and society. Both assessments are essential for effective climate change adaptation and mitigation in Ireland. However, due to the more targeted scope and focus, sectoral climate risk assessments can:

- provide a more detailed and specific analysis of climate risks within individual sectors. This can assist sectors in identifying specific vulnerabilities and adaptation measures, which may not be captured in a national-level assessment.
- provide a solid basis for decision-making so that sectors can prepare an adaptation process in a targeted and planned manner. This can lead to a more efficient use of resources and more successful implementation of actions.
- provide a higher degree of stakeholder engagement within the sector. This can lead to a better understanding of practical challenges and opportunities arising from a climate change risk assessment and enable greater ownership and commitment to climate action within the sector.

4 Using the Technical Guidance for Sectoral Risk Assessments

The NCCRA Methodology is based on assessment of climate risks as the national scale. Given that sectors will need to assess climate risks to individual sectors, this Technical Guidance for Sectoral Risk Assessments has been developed to aid in the preparation and implementation of climate risk assessments at the sectoral level. It's important to note that this Technical Guidance for Sectoral Risk

Assessments do not supersede the need for consulting ISO 14091 when planning a climate risk assessment.

The NCCRA is due for completion in February 2025. To ensure the inclusion of any methodological advancements, the Technical Guidance for Sectoral Risk Assessments will be updated periodically throughout the NCCRA process.

In support of the National Adaptation Framework (2024) and SAP development, sectoral adaptation planning guidance is to be issued which should be the primary reference document used by sectors in development of Sectoral Adaptation Plans. The Sectoral Adaptation Planning Guidance aligns with and is informed by the NCCRA Methodology and ISO 14091 approaches.

5 Technical Recommendations

This section will provide the technical recommendations for implementing the ISO 14091 standard in line with the NCCRA Methodology (EPA, 2024b). Each section will outline the contents of the ISO 14091 standard section, followed by recommendations to align a climate change risk assessment with the NCCRA Methodology.

5.1 Preparing a climate change risk assessment

The ‘Preparing a climate change risk assessment’ stage within ISO 14091 involves several steps. First, a dedicated team should be formed to carry out the risk assessment. The organisation (sector) then needs to establish the context of the risk assessment and determine the scope and the methods that will be used. The organisation (sector) should determine the time horizon for the risk assessment and collect data and information that will be used. The organisation (sector) should then develop a detailed plan outlining how the risk assessment will be carried out.

The NCCRA Methodology (EPA, 2024b) contains information that is pertinent to ‘Establishing the context’, ‘Determining the scope and methodology’, and ‘Setting the time horizon’ of the ISO 14091 approach. The following sections with outline the relevant information from the NCCRA Methodology for the pertinent ISO 14091 step.

5.1.1 Establishing the context

ISO 14091 Summary

Each risk assessment has a unique context that shapes its scope, goals, and anticipated deliverables. To define the context of the risk assessment, the ISO 14091 outlines a number of factors that an organisation (sector) should consider in preparation of its climate change risk assessment. This process involves determining the sectoral systems at risk, identifying which climate hazards can potentially affect the system at risk, and identifying existing or planned processes (e.g., supply chain) related to the risk assessment. Determining the organisation's (sector's) knowledge of climate change, identifying and involving interested parties, and establishing the availability of resources for the assessment (e.g., financial, human, and technical resources and information/data) should be also considered. In addition, an organisation (sector) should consider external developments (e.g., demographic changes) and obligations (regulatory and non-regulatory).

Recommendations

- **Determining the system(s) at risk:** The NCCRA adopts a systems-based approach to support the identification and assessment of risks and cross-cutting risks. Systems are a group of interacting or interrelated elements that provide nationally important functions (DCCEEW, 2023). Each system, e.g., Energy, is comprised of sub-systems, e.g., Energy Transportation and Distribution Grid, which are comprised of elements at risk, e.g., Electricity Network (Figure 5.1). 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. To align with the NCCRA Methodology (EPA, 2024b), it is recommended that sectors use the systems and sub-systems approach (and classification of systems and subsystems contained within the NCCRA where relevant) to broadly determine the sectorally relevant systems, sub-systems, and elements (Section 2.1.2 of the NCCRA Methodology).

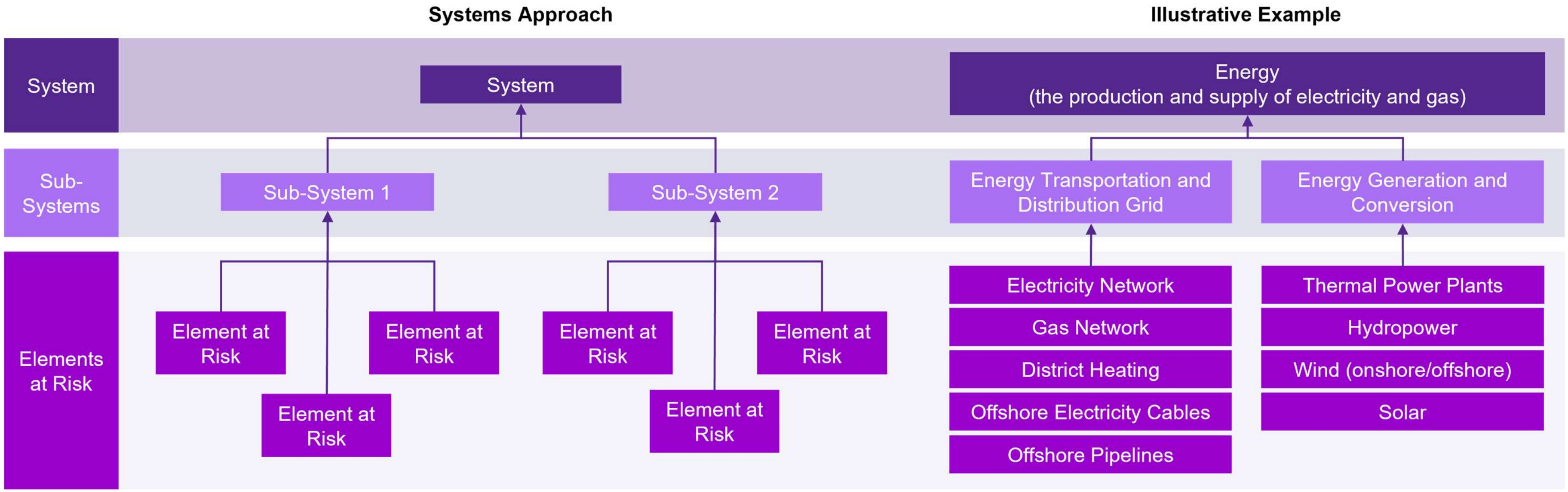

Figure 5.1: The relationship between systems, sub-systems, and elements at risk and an example from the Energy system. Source: NCCRA Methodology - Figure 2.4. (EPA, 2024b)

- **Identifying and involving interested parties in the process:** Stakeholder engagement is a critical element of the NCCRA to build an appropriate evidence base to inform the identification and assessment of risks. Based on existing information and a review of literature, key stakeholders to be engaged across the NCCRA process have been identified through a comprehensive stakeholder mapping process (Section 3 of the NCCRA Methodology). This mapping exercise sought to provide a logical and verifiable approach to the structure of the engagement processes and support cross-sectoral engagement on cross-cutting issues, e.g., coastal areas. An initial identification of wider stakeholders is shown in the appendix of the NCCRA Methodology. To align with the NCCRA Methodology (EPA, 2024b), it is recommended that sectors consider the approach to stakeholder mapping and categories of stakeholders identified within the NCCRA Methodology as possible consultees within a sectoral climate change risk assessment.

5.1.2 Determining the scope and methodology

ISO 14091 Summary

The project team, in collaboration with relevant stakeholders, must determine the scope of the risk assessment and the methodology to be used. ISO 14091 states that this process involves identifying the specific system at risk, determining the level of detail needed for the assessment to be fit-for-purpose, and identifying the population groups involved (e.g., rural communities). The project team must also consider the range of climate hazards to be included (e.g., flooding) and their nature (e.g., extreme in the mean and variability). The areas under review and whether it is a single spatial unit, or a comparison of areas, must also be defined. The spatial and temporal resolution of the assessment, which can be influenced by the availability of data, must be decided. The project team must also choose the methodology to be used in the assessment (e.g., quantitative, qualitative, or a mixed approach) and consider the resources (e.g., financial, human) available for the risk assessment.

Recommendations

- **Defining the specific system at risk:** As discussed in 5.1.1, the NCCRA adopts a systems-based approach to support the identification and assessment of cross-cutting risks at a national level. Each system is comprised of sub-systems, which are comprised of elements at risk. To align with the NCCRA Methodology (EPA, 2024b), it is recommended that sectors use the systems and sub-systems approach (and classification of systems and subsystems contained within the NCCRA where relevant) to broadly determine the sectorally relevant systems, sub-systems, and elements (Section 2.1.2 of the NCCRA Methodology). The existing evidence base such as the Irish Climate Change Assessment (EPA, 2024a), National Risk Assessment (Department of Defence, 2024), EPA (2020), EU CRA, IPCC AR6 should be reviewed to inform the possible systems impacted by climate change.
- **Defining the range of climate hazards to be included:** ISO 14091 defines hazard as ‘potential source of harm’. The NCCRA definition of hazard includes further specificity and defines hazard as 'the potential occurrence of a natural or human-induced physical event or trend or physical impact 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’. The climate hazards that will be considered within Stage 1 and Stage 2 of NCCRA have been identified (see Appendix A) based on current and potential hazard occurrence in Ireland. To align with the NCCRA Methodology (EPA, 2024b), it is recommended that at a minimum, sectoral climate change risk assessments consider the risks posed by the climate hazards identified within the NCCRA Methodology. If a climate hazard threshold exists, e.g., days above >25°C, days with >30 mm precipitation, this should be used to define the climate hazard. The National Framework for Climate Services can be contacted to assess if relevant hazard thresholds are available.

- **Defining the areas under review:** The NCCRA is a national scale assessment, however, the impacts of climate change will vary spatially across the country. The NCCRA therefore reports climate projections, climate hazards and risks and opportunities across eight sub-national regions. These regions are based on the NUTS (Nomenclature of Territorial Units for Statistics) classification, a geocode standard for the European Union (EU). Where information is available, risks are identified at the NUTS 3 (Figure 5.2 and Table 5.1) or county level. The NCCRA Methodology also describes the marine environment regions that are to be used (Figure 5.3).

  Reflecting the requirement for more detailed and sector relevant climate risk assessments, it is recommended that sectors report climate risks at sectorally appropriate spatial units (e.g., community-level, water bodies/river catchments, HSE Health Regions).

Figure 5.2: The NUTS 3 Regions of Ireland.

NUTS 1	NUTS 2	NUTS 3	Local Authorities
Ireland	Northern and Western Region	Border	Cavan
			Donegal
			Leitrim
			Monaghan
			Sligo
		West	Galway City
			Galway
			Mayo
			Roscommon
	Southern Region	Mid-West	Clare
			Limerick City and County
			Tipperary
		South-East	Carlow
			Kilkenny
			Waterford City and County
			Wexford
		South-West	Cork
			Cork City
			Kerry
	Eastern and Midland Region	Dublin	Dublin City
			Dún Laoghaire–Rathdown
			Fingal
			South Dublin
		Mid-East	Kildare
			Louth
			Meath
			Wicklow
		Midland	Laois
			Longford
			Offaly
			Westmeath

Table 5.1: The NUTS Regions Hierarchy and the corresponding Local Authorities areas.

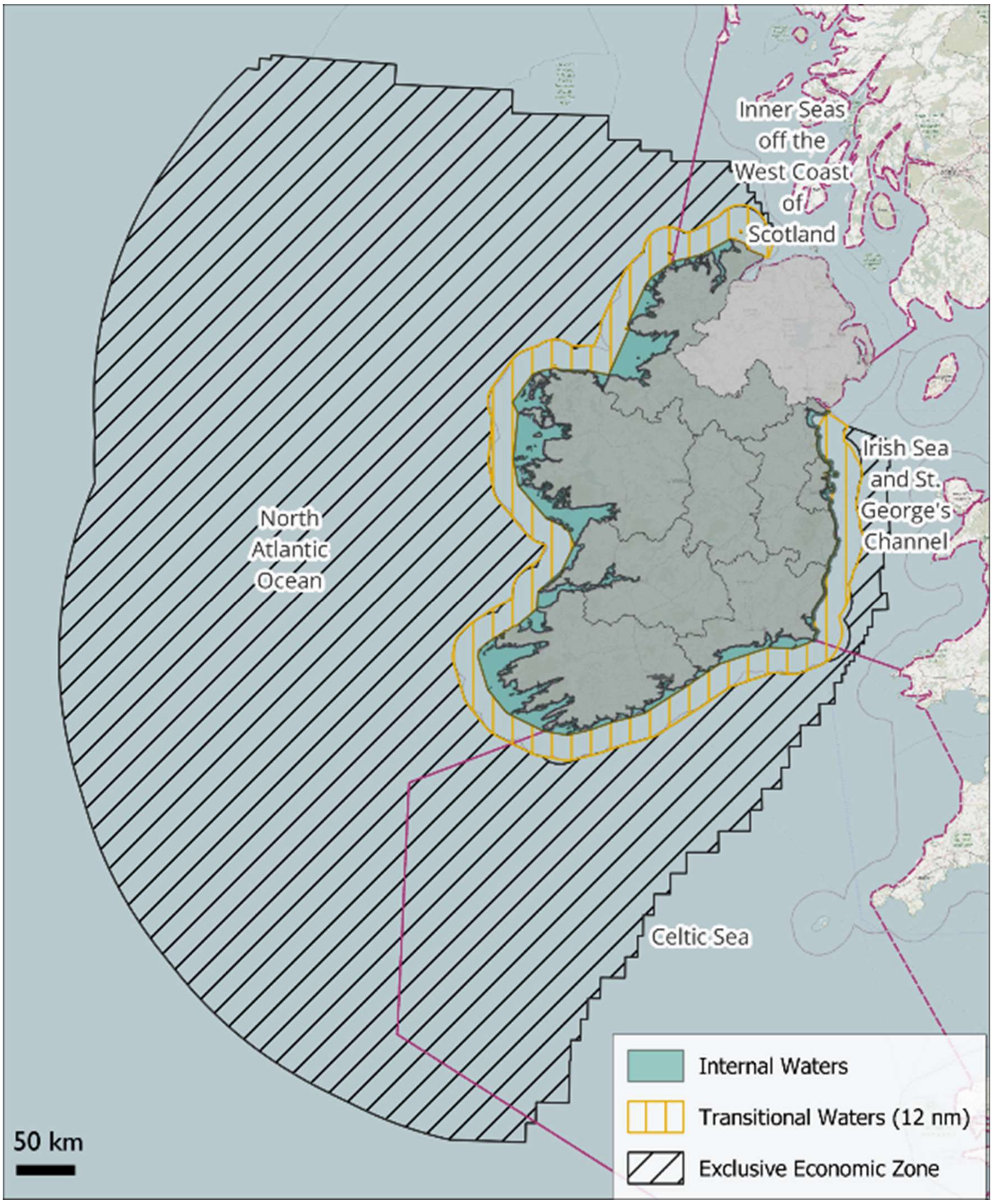

Figure 5.3: The marine environment regions of Ireland.

Defining the methodology to be used in the assessment: The NCCRA follows international best practice and uses the conceptual risk framework for climate change risks used within IPCC Sixth Assessment Report (AR6) (IPCC, 2023). In this framework, risk is a function of climate hazard, the degree to which a system is exposed to the hazard, and the vulnerability of the system at risk to the effects of the hazard. Risk is defined as the potential for adverse consequences for human or ecological systems. The NCCRA Methodology uses this framework firstly within a qualitative assessment (Stage 1 of the NCCRA) which provides a high-level understanding of climate change risks within and across individual domains and/or sectors through descriptive narratives, expert judgment, existing studies, reports, historical data, stakeholder engagement with local communities, policymakers, and practitioners.

For prioritised risks, and where possible, i.e., suitable spatial data availability, a semi-quantitative approach is used (Stage 2 of the NCCRA). Semi-quantitative climate risk assessments are built 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. To align with the NCCRA Methodology (EPA, 2024b), sectors can use a qualitative approach to climate risk identification and assessment, however, a semi-quantitative approach should be used where feasible.

5.1.3 Setting the time horizon

ISO 14091 Summary

The earlier climate-related risks are addressed, the more efficient and cost-effective their management is, whilst also assisting in the mitigation of climate change impacts. ISO 14091 states that when an organisation (sector) is setting the time horizon of their assessment, they should consider the lifetime of the system at risk, the timescales during which the effects of climate change reach critical thresholds for the system at risk and the lead time required for adaptation measure to address impacts, which may be related to the system's lifetime. The choice of time horizon may be influenced by factors such as the availability of data (incl. climate projections), uncertainties regarding long-term climate projections, and the potential for interactions between impacts to occur over different timescales.

Recommendation

Time Horizon: The NCCRA will assess the current level of risk, and for two future time periods that present the medium term, around 2050, and in the long term, around 2100 (Table 5.2). These future time horizons were selected as 2050 and 2100 align with international climate goals, allow the consideration of long-term impacts, have relevance for infrastructure planning, and are used extensively in climate projection and scenario modelling. To align with the NCCRA Methodology (EPA, 2024b), it is recommended that sectors assess climate risks using the timeframes outlined in Table 5.2.

Timeframe	Description
Present	Risks already occurring, up to 2030
Medium term	Risks that may occur around 2050
Long term	Risks that may occur around 2100

Table 5.2: Timeframes used within the National Climate Change Risk Assessment.

The Mid-Range Future Scenario (MRFS) and High-End Future Scenario (HEFS) used by the OPW for river and coastal flooding projections are determined by potential future increases in precipitation/peak flood flow and mean and sea level and a future timeframe is not directly assigned to the MRFS and HEFS. To support national and sectoral risk assessments, an approach to align these scenarios with the NCCRA timeframes is outlined in the NCCRA Methodology (EPA, 2024b).

5.2 Implementing a climate change risk assessment

The '5.2 Implementing a climate change risk assessment' stage within ISO 14091 starts with identifying potential impacts of climate change and developing impact chains. The organisation (sector) should then identify indicators that will be used to measure and monitor climate change risks. The organisation (sector) needs to collect and manage data related to the identified indicators. The organisation (sector) should combine the indicators and risk components to provide a comprehensive view of the climate change risks. The organisation (sector) needs to evaluate its ability to adapt to the potential impacts of climate change.

The NCCRA Methodology contains information that is pertinent to 'Screening impacts and developing impact chains', 'Identifying indicators', and 'Interpreting and evaluating the findings' of the ISO 14091 approach. The following sections with outline the relevant information from the NCCRA Methodology for the pertinent ISO 14091 step.

5.2.1 Screening impacts and developing impact chains

ISO 14091 Summary

To carry out a risk assessment, the project team needs to understand the cause-effect relationships. Impact chains provide the basic framework for assessing climate change risk and support the understanding, systemisation, and prioritisation of the factors that drive the level of risk and vulnerability. In addition, impact chains serve as a representation of how potential climate change risks can affect a sector (its systems, sub-systems and elements at risk) via direct and indirect impacts and can be important tools for stakeholder communication. ISO 14091 provides guidance on developing low, medium and high complexity impact chains that capture at an increasing level of detail the interaction between risk components.

Recommendation

To align with the NCCRA Methodology (EPA, 2024b), it is recommended that sectors develop low complexity impact chains for each risk. Impact chains should be developed to capture the key components of climate risk: climate impact driver, hazard, exposure/element at risk, vulnerability, sensitivity, adaptive capacity, impacts, and risk (Figure 5.4). Medium and high complexity impact chains may also be developed by sectors if feasible to support identification of risks and cross-sectoral interdependences.

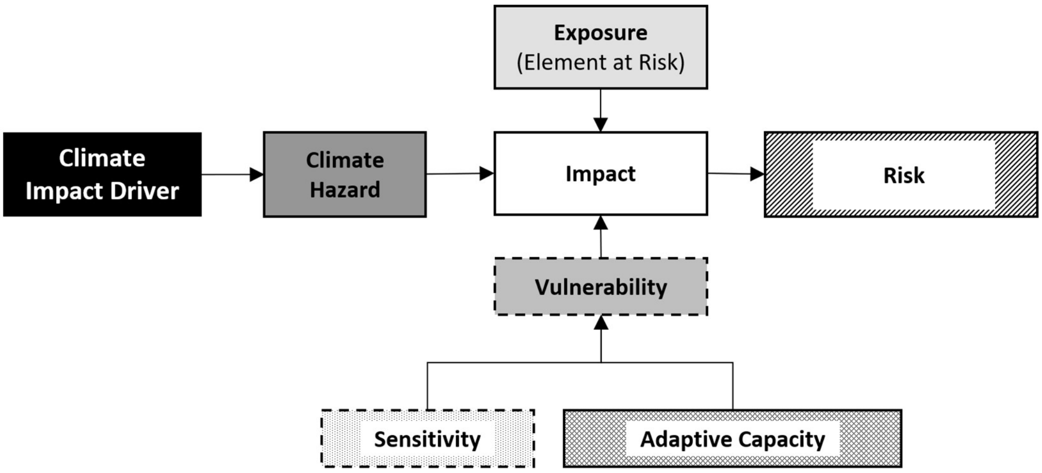

Figure 5.4: An example of a low complexity impact chain showing the interaction between the determinants of risk and the impact of the risk.

The key terms are defined as follows:

- **Climate Impact Driver (CID)** refers to physical conditions or factors in the climate system that can influence the occurrence and intensity of climate hazards. These conditions encompass means, events, and extremes, and are described by various indices such as mean sea level rise, increasing surface temperature, changes in precipitation patterns;

- **Climate Hazard** refers to 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. Examples of climate hazards include heatwaves, and river flooding;

- **Exposure** refers to 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. These can be considered as elements at risk.

- **Vulnerability** refers to the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity and adaptive capacity:

  Sensitivity describes the degree to which populations, systems, or species are affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a negative impact on population livelihoods or health, i.e., reduced income or adverse health impacts, due to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise);

  Adaptive Capacity refers to the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to impacts;

- **Impacts** refer to the consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health, and wellbeing, ecosystems, and species, economic, social, and cultural assets, services (including ecosystem services), and infrastructure;

- **Risk** refers to the potential adverse consequences for a sector.

Climate risks can emerge from the interaction and subsequent cascading of various risks, leading to risks being transmitted across interconnected systems and sectors. For instance, the failure of critical infrastructure associated with energy or water supply can trigger secondary impacts on other sectors, such as health. In line with the NCCRA Methodology (EPA, 2024b), it is advisable for sectors to identify and evaluate these cascading risks using the impact chain approach where feasible.

5.2.2 Identifying indicators

ISO 14091 Summary

According to ISO 14091, indicators should be specific, considering spatial coverage, and resolution, temporal coverage, representativeness, replicability (for subsequent repetition of risk assessments), and feasibility. The ISO 14091 states that the selection process of indicators is an iterative process and can be guided by individual experts or workshop discussions with specialists. Availability and quality of data, or resource constraints can limit the number of indicators. Hazard indicators typically consist of directly measurable or modelled climate parameters like temperature or precipitation. Exposure indicators typically include indicators on asset types and location information. Vulnerability indicators ideally use bio-physical or socioeconomic data from measurements or models, but often rely on national statistics, past observations, or expert judgement due to data limitations.

Recommendations

- **Acquiring and managing data:** Risk assessments require data from both past and future periods, with the latter derived from scenarios and projections. Various methodologies, including expert judgement, measurements, censuses, surveys, and modelling, can be used to gather data as per ISO 14091. To align with the NCCRA Methodology (EPA, 2024b), the following data should be used for the relevant risk component:

  National Framework for Climate Services (NFCS): The National Framework for Climate Services (NFCS), coordinated by Met Éireann, aims to enhance Ireland's climate resilience by coordinating collaboration between climate services providers and users. It ensures access to robust climate information, promotes existing resources, and defines climate services based on user needs. These services span across various timeframes (e.g., short term warnings to climate projections that span decades and centuries), enabling climate-smart decision-making via effective climate risk assessment and adaptation planning.

All sectors should engage with the NFCS to ensure they are using and/or developing data sets that are interoperable with the NFCS to enable the robust assessment of risks, in particular cross cutting risks. Once such NFCS compatible data sets are produced, sectors should then ensure that relevant data sets are made available for other stakeholders to use e.g., future land use projections, disease prevenance, regional visitor numbers.

Climate Data: To inform future climate, the NCCRA Methodology uses the Met Éireann TRANSLATE standardised climate projections and Nolan and Flanagan (2020) climate projections. See Appendix A for suggested climate variables.

In the NCCRA, a conservative approach is taken to assess risks to Ireland and assumes global emission reduction targets are not met, as a result, RCP8.5 and RCP4.5 are adopted to assess risks to Ireland. RCP8.5, a high-emissions scenario leading to the highest physical risk for Ireland, was chosen for its alignment with a conservative approach to the NCCRA and used in both Stage 1 and 2 assessments. RCP4.5, a moderate-emissions scenario more aligned with current global climate actions, will also be used in Stage 2 of the NCCRA.

Hazard Data: The NCCRA Methodology uses flood hazard information developed by the OPW through Catchment-based Flood Risk Assessment and Management (CFRAM), National Coastal Flood Hazard Mapping, OPW National Coastal Extreme Water Level Estimation, EPA water resources and Eflow data, and the GSI's groundwater flooding data.

For changes within the ocean environment, information on Changes in Sea Temperature and Changes in Ocean Chemistry is derived from IPCC AR6.

Exposure Data: To provide information on the spatial location of assets that are potentially exposed, the NCCRA Methodology uses the Tailte Éireann

Prime 2 dataset. Sector specific data will also exist that can be used to inform exposure and should be included if feasible.

Vulnerability Data: To inform future changes in population and demographics, the NCCRA Methodology uses data from the CSO on modelled future population and labour force for the period 2017 to 2051 at the national level and for six scenarios. Sector specific data will also exist that can be used to inform vulnerability and should be included if feasible.

For socioeconomic vulnerability factors relevant to a sector where appropriate projections are not available, sectors may conduct a qualitative evaluation, utilising reports, academic literature, and stakeholder engagement, to understand current socioeconomic vulnerability factors, their spatial distribution (if relevant) and how these may evolve into the future.

5.2.3 Interpreting and evaluating the findings

ISO 14091 Summary

The evaluation and interpretation of results aim to comprehend the risks identified and contribute to the risk assessment's objectives. According to ISO 14091, consideration of uncertainties is important when evaluating results. In addition, climate change impacts should be prioritised to identify where the need for adaptation is the highest. This prioritisation, which includes consideration of possible adaptation actions and responsibilities, should be carried out by decision-makers (or by the project team in conjunction with them). ISO 14091 notes that the magnitude of a potential climate change impact is not the same as its significance. For example, in some cases, small changes can be of great significance, such as minor disturbances of traffic flows in a specific area. Whilst in other cases even large climate change impacts can be easily managed. If thresholds are defined, then the magnitude of change can indicate its significance. ISO 14091 also notes that when the objective of the assessment is to compare impacts or risks across different areas of activity, such as sectors or regions, an integrated evaluation should be carried out.

Recommendations

- **Consideration of uncertainties:** Uncertainties are an inherent part of all projections of climate change and its impacts. They will never be fully eliminated but adaptation measures will be required, nonetheless. To account for this uncertainty, the NCCRA Methodology adopts a precautionary approach where necessary. To align with the NCCRA Methodology (EPA, 2024b) when assigning levels of confidence, it is recommended that sectors use the confidence criteria used in the IPCC AR5 (IPCC, 2014) and AR6 (IPCC, 2023) based on Mastrandrea et al. (2011).

Agreement →			
	High Agreement Limited Evidence (Medium)	**High Agreement Medium Evidence (High)**	**High Agreement Robust Evidence (Very High)**
	Medium Agreement Limited Evidence (Low)	Medium Agreement Medium Evidence (Medium)	Medium Agreement Robust Evidence (High)
	Low Agreement Limited Evidence (Very Low)	Low Agreement Medium Evidence (Low)	Low Agreement Robust Evidence (Medium)
	Evidence (type, amount, quality, consistency) →		

Table 5.3: Confidence criteria that will be applied to each risk with confidence classification in parentheses, based on Mastrandrea et al. (2011)

As shown in Table 5.3, the criteria use the level of robustness of evidence and the level agreement between available information to assess overall confidence. This will be applied qualitatively with a confidence level given for the hazard and consequence of each risk and considering the confidence across the three-time horizons. The qualifiers used to express a level of confidence will be Very low, Low, Medium, High, and Very High. Information such as academic literature, reports, climate projections, and data, can be used to inform levels of confidence.

To support the operationalisation of the criteria in Table 5.3, elements of the GRADE-CERQual approach (Lewin et al. 2018) used by Berrang-Ford et al. (2021) can be used to inform the allocation of confidence (Table 5.4).

	Agreement	Robustness
High	No or very minor concerns about the extent to which the underlying literature is consistent with the key statement; This could be assessed by number cut-offs but also requires judgement. For example, if a supermajority of sources agrees to the answer (e.g., >70% of sources agree is High, 20% medium, and 10% low).	No or very minor concerns about the extent to which the underlying literature is consistent with the key statement; You feel certain that there is good quality evidence upon which to base the conclusions drawn; Numerous sources provide an answer to the question; They address the issue directly (not inferred by coders), and have no methodological concerns (e.g., they have large sample sizes or detailed case sources)
Medium	Minor to moderate concerns about the extent to which the underlying literature is consistent with the key statement; This could be assessed by number cut-offs but also requires judgement. For example, if a majority of sources agree to the answer (e.g., 50% of sources agree is High, 40% medium, 10% low); This could also include the case where the answers are split between two close answers (e.g., 45% High, 45% Medium, 10% low)	Minor to moderate concerns about the extent to which the underlying literature is consistent with the key statement; You feel reasonably sure there is good evidence upon which to base the conclusions drawn; Multiple sources provide an answer to the question; At least some of them address the issue directly; there are only a few sources with methodological concerns or the concerns are minor
Low	Moderate to serious concerns about the extent to which the underlying literature is consistent with the key statement; This could be assessed by number cut-offs but also requires judgement. For example, if sources are evenly split between the categories with no clear pattern (e.g., 33% High, 33% medium, 33% low); Or categories are split bimodally (e.g., 45% High, 10% medium, 45% low);	Moderate to serious concerns about the extent to which the underlying literature is consistent with the key statement; You are not entirely certain that the evidence upon which conclusions are based is solid; Only a few sources address this topic; They may not address the topic directly, or they may have methodological concerns (either concerns are frequent or severe or both).

Table 5.4: Criteria that can be used inform allocation of confidence, based on Berrang-Ford et al. (2021).

If sufficient quantitative/probabilistic information exists for a hazard, then a statistical likelihood will be provided by the NCCRA. Table 5.5 defines the likelihood language and the corresponding statistical level.

Likelihood Language	Statistical Level
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33-66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

Table 5.5: Likelihood scale from Mastrandrea et al. (2011).

- **Magnitude of a potential climate change impact:** When assessing and prioritising climate risks, an assessment of consequence of each risk is required. Table 5.6 shows the magnitude of consequence criteria to be employed as part of the NCCRA. The categories of consequence are based on the EUCRA (2024).

  To align with the NCCRA Methodology (EPA, 2024b), sectors should assess the level of consequence for each identified risk according to the criteria outlined in Table 5.6, with the level of consequence for a risk based on the level of impact a risk may have on the sector.

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

Table 5.6: Magnitude of consequence criteria adapted from the EU CRA (2024) and amended for application at the sectoral level.

- **Prioritisation of risks:** Stage 3 of the NCCRA is a qualitative assessment of the current and planned adaptation responses and the short-term (within the next five years) decision urgency required to manage each of the key risks to an acceptable level.

  To align with the NCCRA Methodology (EPA, 2024b), a sector should use decision urgency categories 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 (Figure 5.5) with a Decision Urgency profile developed for each risk.

Urgency Criteria

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.

Figure 5.5: The criteria to assign urgency to each risk (Committee on Climate Change, 2022).

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Glossary

Key Term	Definition
Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2023: Annex 1).
Adaptive Capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (adapted from MA, 2005) (IPCC, 2022: Annex II).
Assets	'Things of value' that may be exposed or vulnerable to a hazard or risk. Physical, environmental, cultural, financial or economic element that has tangible, intrinsic or spiritual value.
Baseline	A time period of interest, or a period over which some relevant statistics are calculated (IPCC, 2022, Annex II).

Key Term	Definition
Cascading effects (of climate change)	Cascading impacts from extreme weather/climate events occur when an extreme hazard generates a sequence of secondary events in natural and human systems that result in physical, natural, social or economic disruption, whereby the resulting impact is significantly larger than the initial impact. Cascading impacts are complex and multi-dimensional and are associated more with the magnitude of vulnerability than with that of the hazard (IPCC, 2023: Annex 1).
Climate	Climate in a narrow sense is usually defined as the average weather, or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization (WMO). The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2023: Annex 1).

Key Term	Definition
Climate Change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/ or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2023: Annex 1).
Climate Projections	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of the cryosphere, the lithosphere and the biosphere and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations and anthropogenic forcings such as the changing composition of the atmosphere and land-use change (IPCC, 2018: Annex I). In Ireland, the latest standardised bias corrected climate projections are Met Éireann TRANSLATE projections.

Key Term	Definition
Climate Scenario	A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as the observed current climate (IPCC, 2014: WG2)
Co-benefits	A positive effect that a policy or measure aimed at one objective has on another objective, thereby increasing the total benefit to society or the environment. Co-benefits are also referred to as ancillary benefits (IPCC, 2022: Annex II).
Community	A community may be a geographical location (community of place), a community of similar interest (community of practice) or a community of affiliation or identity (such as industry).
Confidence	The robustness of a finding based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models,

Key Term	Definition
	expert judgement) and on the degree of agreement across multiple lines of evidence. In this report, confidence is expressed qualitatively (Mastrandrea et al., 2010).
Consequence	The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services) and infrastructure (IPCC, 2022, Annex II).
Driver	Any natural or human-induced factor that directly or indirectly causes a change in a system (adapted from MA, 2005) (IPCC, 2022: Annex II).
Emissions (Anthropogenic)	Emissions of greenhouse gases (GHGs), precursors of GHGs and aerosols caused by human activities. These activities include the burning of fossil fuels, deforestation, land use and land-use changes (LULUC), livestock production, fertilisation, waste management and industrial processes (IPCC, 2023: Annex 1).

Key Term	Definition
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 (IPCC, 2023: Annex 1).
Extreme weather event	The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as ‘climate extremes (IPCC, 2023: Annex 1).
Frequency	The number or rate of occurrences of climate hazards, usually over a particular period (NZ CCRA Framework, 2019).
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 (IPCC, 2023: Annex 1).

Key Term	Definition
Heatwave	A period of abnormally hot weather, often defined with reference to a relative temperature threshold, lasting from two days to months. Heatwaves and warm spells have various and, in some cases, overlapping definitions (IPCC, 2023: Annex 1).
Impacts (consequences, outcomes)	The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial (IPCC, 2023: Annex 1).
Impact chain	Impact chains are conceptual models describing climate impact as cause-effect relationships within a socio-ecological system.
Likelihood	The chance of a specific outcome occurring, where this might be estimated probabilistically. Likelihood is expressed in this report using a standard terminology (Mastrandrea et al., 2010).

Key Term	Definition
Lock in	A situation in which the future development of a system, including infrastructure, technologies, investments, institutions, and behavioural norms, is determined or constrained ('locked in') by historical developments (IPCC, 2023: Annex 1).
Mitigation	A human intervention to reduce emissions or enhance the sinks of greenhouse gases (IPCC, 2023: Annex 1).
Percentile	A partition value in a population distribution that a given percentage of the data values are below or equal to. The 50th percentile corresponds to the median of the population. Percentiles are often used to estimate the extremes of a distribution. For example, the 90th (10th) percentile may be used to refer to the threshold for the upper (lower) extremes (IPCC, 2023: Annex 1).
Representative concentration pathway	Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover (Moss et al., 2008). The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing

Key Term	Definition
	characteristics. The term pathway emphasizes the fact that not only the long-term concentration levels, but also the trajectory taken over time to reach that outcome are of interest (Moss et al., 2010). RCPs were used to develop climate projections in CMIP5 (IPCC, 2023: Annex 1).
Resilience	The capacity of interconnected social, economic, and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation (IPCC, 2023: Annex 1).
Risk	The potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems (IPCC, 2023: Annex 1).
Risk assessment	The qualitative and/or quantitative scientific estimation of risks (IPCC, 2022: Annex II:).
Shock	Deviations from normal environmental patterns in the form of droughts, floods, heat waves, or other

Key Term	Definition
	extreme events that have been exacerbated by climate change
Stress	Environmental stress denotes both human and naturally induced pressure on the environment. As a subset of this, stress caused by climate change refers to negative environmental impacts caused by gradual changes in atmospheric conditions.
System	A set of things working together as parts of an interconnected network and/or a complex whole (NZ CCRA Framework, 2019).
Uncertainty	A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, incomplete understanding of critical processes, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures (e.g., a probability density function) or by qualitative statements (e.g., reflecting the judgement 2253 Glossary Annex VII AVII of a team of experts) (IPCC, 2022: Annex II).

Key Term	Definition
Value domain	A group of values, assets and systems that may be at risk from climate change-related hazards, or could benefit from them (NZ CCRA Framework, 2019)
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2023: Annex 1).
Wellbeing	A state of existence that fulfils various human needs, including material living conditions and quality of life, as well as the ability to pursue one's goals, to thrive and to feel satisfied with one's life. Ecosystem well-being refers to the ability of ecosystems to maintain their diversity and quality (IPCC, 2023: Annex 1).

Acronyms

Acronym	Definition
AR5	Fifth Assessment Report
AR6	Sixth Assessment Report
CCRA	Climate Change Risk Assessment
CFRAM	Catchment-based Flood Risk Assessment and Management
CID	Climate Impact Driver
CSO	Central Statistics Office
DCCEEW	Department of Climate Change, Energy, the Environment, and Water (Government of Australia)
EPA	Environmental Protection Agency
EU	European Union
EUCRA	European Climate Risk Assessment
GSI	Geological Survey Ireland
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
NAF	National Adaptation Framework
NCCRA	National Climate Change Risk Assessment

Acronym	Definition
NFCS	National Framework for Climate Services
NUTS	Nomenclature of Territorial Units for Statistics
NZ	New Zealand
OPW	Office of Public Works
RCPs	Representative Concentration Pathways
SAP	Sectoral Adaptation Plans
UK	United Kingdom
UKCP18	UK Climate Projections 2018

Appendix A

The list of climate hazards and data sources that will be considered within the NCCRA is currently in draft form and will be further developed throughout the NCCRA through dialogue with the NCCRA and NFCS teams, data providers and sectoral stakeholders.

Appendix A: The climate hazards and data sources that will be considered within the NCCRA.

Type	***Hazard***	***Data Sources***		***Comment***
		Primary	**Secondary**	
Hot and Cold	Changes in Air Temperature	Mean Temperature (TRANSLATE)		
	Changes in Water Temperature	Mean Temperature (TRANSLATE)		
	Heatwaves	Maximum Temperature (TRANSLATE) Nights >15°C (TRANSLATE) No. of Heatwaves (TRANSLATE)		

Type	Hazard	Data Sources		Comment
		Primary	Secondary	
	Frost/Ice	Icing Days (Nolan and Flanagan, 2020)		
	Changes in Phenology		Growing Season Length (Nolan and Flanagan, 2020)	
	Snowfall	Snowfall (Nolan and Flanagan, 2020)		
Wet and Dry	Changes in Precipitation	Mean Precipitation (TRANSLATE)		
	Extreme Precipitation	Wet days (>20 mm) (TRANSLATE) Very wet days (>30 mm) (TRANSLATE)		

Type	Hazard	Data Sources		Comment
		Primary	Secondary	
		Maximum daily precipitation (TRANSLATE)		
	Drought (Meteorological)	Mean Precipitation (TRANSLATE) RR1 (TRANSLATE)		
	Drought (Environmental)		HydroPredict (Meresa and Murphy, 2023; Meresa et al., 2022, Murphy et al., 2023)	
	Hail		Academic Literature Reports	

Type	Hazard	Data Sources		Comment
		Primary	Secondary	
	Fire Weather	TRANSLATE		Met Éireann to produce fire weather outputs via NFCS
	River Flooding	OPW CFRAM/PFRAM Water resources and Eflows (EPA to produce in coordination with NFCS)	Water resources and Eflows (EPA hydrotool with modifying coefficients based on HydroPredict	OPW Scenarios require alignment with RCPs
	Surface Water Flooding	Wet days (>20 mm) (TRANSLATE) Very wet days (>30 mm) (TRANSLATE)	GSI	GSI Surface Water Flooding data is only available for Dublin and does not include future scenarios
	Groundwater Flooding		GSI	Current, GSI Groundwater

Type	Hazard	Data Sources		Comment
		Primary	Secondary	
				Flooding data does not include future scenarios but is being updated.
Wind	Changes in wind	Average Wind Speed (Nolan and Flanagan (2020))		
	Storms		Nolan and Flanagan (2020)	
Coastal and Marine	Coastal Erosion		GSI Coastal Vulnerability Irish Coastal Protection Strategy Study (ICPSS)	Coastal erosion linked with sea level rise.

Type	Hazard	Data Sources		Comment
		Primary	Secondary	
	Coastal Flooding	OPW National Coastal Flood Hazard Mapping		
	Changes in Sea Temperature	Sea Surface Temperature (IPCC AR6)		Global dataset
	Marine Heatwaves		Marine Institute	
	Changes in Ocean Chemistry	pH at Surface (IPCC AR6)		Global dataset
	Sea Level Rise	Sea Level Projections (UKCP18) OPW National Coastal Extreme Water Level Estimation		OPW Scenarios require alignment with RCPs
Others	Air Pollution		Academic Literature Reports	

Type	Hazard	Data Sources		Comment
		Primary	Secondary	
	Lightning		Academic Literature	

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