

Northern Territory Climate Change Risk Assessment 2024: Technical Report

Department of Environment, Parks and Water Security – Office of Climate Change

June 2024

Senior Policy Officer, Climate Change

[Name Redacted]

Office of Climate Change

Department of Environment, Parks and Water Security (DEPWS)

7 June 2024

Re: RFQ 230232 – Northern Territory Climate Change Risk Assessment

Thank you for the opportunity to provide our services for the Northern Territory Climate Change Risk Assessment (NT CCRA), as per your notice of acceptance dated 6 June 2023.

In the process of conducting the NT CCRA, a series of cross-Government climate change risk assessment workshops were conducted to:

- Identify and assess the Territory's vulnerability to climate change, with particular focus on domains which influence liveability (social, economic, natural and built systems);
- Identify and prioritise actions that can be taken by government to reduce future vulnerability to climate change or to harness economic opportunities; and
- Inform the development of the *Northern Territory Adaptation Action Plan*.

We are pleased to present you with the Technical Report for the First Pass NT CCRA herein. The Technical Report highlights key methodological components of the risk assessment, and provides detailed findings on risks, opportunities, and gaps in each domain. This includes qualitative and where possible quantitative descriptions of impacts, exposure, vulnerability, interacting risks, confidence, and adaptation urgency. This Report provides the evidence base for the assessment findings. We are deeply appreciative of the many stakeholders who provided input into the analysis and who attended online and face-to-face workshops.

Yours sincerely,

[Signature Redacted]

[Name Redacted]

Partner, Deloitte Touche Tomatsu

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Table of Content

Executive summary	4
Introduction	9
Risk assessment approach	12
Climate change in the Northern Territory	24
Climate change risks in the Northern Territory	35
<i>Safe and stable built environment</i>	37
<i>Safe and stable natural environment</i>	49
<i>Economic sustainability</i>	56
<i>Community health and wellbeing</i>	73
<i>Resource security</i>	86
<i>Natural disaster readiness</i>	93
Climate change opportunities for the Northern Territory	101
Recommendations	103
Conclusion	109
Appendices	111

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A photograph taken from the driver's perspective inside a car. The car's interior, including the dashboard and rearview mirror, is visible in the foreground, slightly out of focus. Through the windshield, a winding asphalt road leads towards a large, reddish-brown rock formation (Uluru) under a sunset sky. The text "Executive summary" is overlaid in white on the left side of the image.

Executive summary

Executive summary

Context

The Department of Environment, Parks and Water Security (DEPWS) has engaged Deloitte to undertake the Territory's First Climate Change Risk Assessment (NT CCRA).

The objective of the Northern Territory Climate Change Risk Assessment (NT CCRA) was to identify and prioritise the climate change risks which have the potential to impact the future liveability of the Territory. In the process of conducting the NT CCRA, a series of collaborative cross-Government climate change risk assessment workshops were conducted to:

- Identify and assess the Territory's vulnerability to climate change, with particular focus on liveability measures which influence liveability (social, economic, natural and built, disaster resilience and resource security systems);
- Identify and prioritise actions that can be taken by government to reduce future vulnerability to climate change or to harness economic opportunities; and
- Inform the development of an adaptation action plan for the Northern Territory.

The findings of NT CCRA is set out in this Technical Report.

Key findings

The NT CCRA identified and assessed 49 climate risk which have been grouped by six liveability measures: Safe and stable natural environment, safe and stable built environment, community health and wellbeing, resource security, natural disaster readiness, and economic sustainability.

The risk assessment process identified that 46 of the 49 risk statements require more action within the next five years to manage these risks. Table 1 presents the definition of different types of actions (e.g., more action is needed to manage a given risk), and level of urgency (e.g., Tier 1 risks are most urgent to action) and distribution of risks across each of the urgency tiers.

Refer to the next page lists the name of risks that require urgent action (Tier 1 risks).

Table 1: High-level summary of NT CCRA results, illustrating the type of actions required,, tier of urgency and their definition and distribution of risks across different tiers.

Type of action	Tier of urgency	Definition of urgency tier	Number of risk statements
More action needed	Tier 1	High level of consequence is expected in the mid-term (2050). New, stronger or different government policies or implementation activities, over and above those already planned, are needed in the next five years to reduce longer term climate change risks.	16
	Tier 2	Medium to high level of consequence is expected in the mid-term (2050). Some degree of adaptation efforts are underway; however, more adaptation efforts are required at a Territory-level including (new study/research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.	30
Sustain current action	Tier 3	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. This includes any existing plans to increase or change the current level of activity.	3
Watching brief	Tier 4	The evidence in these areas should be kept under review, with long-term monitoring of risk levels and adaptation activity so that further action can be taken if necessary.	No risks identified

Executive summary

We identified 16 risks for the Northern Territory which require stronger or different government policies or implementation activities, over and above those already planned, are needed in the next five years to reduce longer term climate change risks. Each of these risks is explored in more detail throughout this Technical Report (see [Chapter 4](#)).

Tier 1 Adaptation Urgency Risks for the Northern Territory		
Liveability measures	Risk categories	
 Safe and Stable Built Environment	Risks to communications and ICT Risks to transport and logistics Risks to waste collection and storage	
 Safe and Stable Natural Environment	Risks to biosecurity (invasive species)	
 Community Health and Wellbeing	Risks to Northern Territory communities (including rural communities) Risks to cultural heritage, including Aboriginal cultural heritage Risks to skills and education	
 Resource Security	Risks to water resources and associated infrastructure	
 Natural Disaster Readiness	Risks to emergency services and management Risks to flood and coastal defences	
 Economic Sustainability	Risks to banking, finance and insurance institutions, and fiscal and financial systems Risks to mining Risks to manufacturing	Risks to small and medium enterprises Risks to the financial position of NT businesses due to premature write-downs of fossil fuel assets Risks to NT's economic growth due to slow, ineffective or no action

Executive summary

Overarching recommendations

To manage priority climate change risks in the Northern Territory, we have made several recommendations for the NT Government that should be considered within the next five years. Here we present only the broad recommendations. Please refer to [Chapter 6](#) for more specific recommendations.

Table 2: Overarching recommendations for managing future climate risks in NT

Overarching recommendations	Description	Key actions
Review and update Climate Change Risk Assessment every five years	The NT CCRA should be revisited and reassessed every five years due to the dynamic nature of climate change. This will ensure that the latest data, trends, and projections are incorporated, providing a more accurate understanding of current and future risks for the NT. Importantly it will enable the NT to build on any actions that have been implemented and reprioritise or identify additional actions.	- Keep abreast of global and Australian climate change trends. - Develop a robust monitoring process and review the risks and adaptation actions every five years. - Consider new scientific research and data sources. - Compare progress against previous assessments.
Design and implement a cohesive monitoring and evaluation program	Monitoring and evaluation helps to guarantee the enduring success of climate adaptation initiatives, plans and actions. They play an important role in the following three aspects of adaptation:¹ - Monitoring the effectiveness of activities conducted during the development of an adaptation strategy (e.g., involvement of stakeholders). - Assessing whether the intended outputs and outcomes from adaptation efforts have been achieved. - Evaluating against current trends and other climate change initiatives supports leading practice.	Develop and implement a monitoring and evaluation plan/program to support the implementation of the NT CCRA and subsequent adaptation actions and recommendations. These actions could include: - Indicators will be selected to measure success and progress of climate risk management over time. - Actions should be designed to have clear and measurable objectives. - Based on progress measurement data, the effectiveness of actions can be measured and used to inform any updates to the current approach. - The program should be revised and reviewed every five years.
Conduct more detailed and granular climate change risk assessments	More detailed assessments at either the liveability measure or risk statement level, is crucial for understanding impacts and vulnerabilities that are crucial to be addressed. Moreover, such assessments help identify vulnerable populations and areas disproportionately affected by climate hazards allowing for more tailored and tangible outcomes from the risk assessment process. Tailoring adaptation strategies to address these nuanced risks is facilitated by more detailed risk assessments, ensuring that adaptation actions and strategies meet the unique needs of each community.	- Conduct a more detailed second pass risk assessment focusing on emergency management, identifying the key complex risks associated with an emergency climate event in the Territory to inform future funding and investment in resilience building activities. - Conduct a more detailed second pass risk assessment focusing on liveability measures relevant to remote regions and communities in the Territory. As part of this assessment the Territory could identify the most vulnerable remote communities to climate risks. - Incorporate climate change scenarios and risk information inland land-use and urban planning processes. By proactively considering these factors, future housing, industrial developments, and infrastructure projects can be strategically located to avoid high-risk areas. This approach will reduce the likelihood of emergency management interventions and recovery operations, fostering more resilient and sustainable community growth. - Incorporate heat mitigation measures in land-use planning, precinct and building designs. These measures will enhance the Territory's ability to cope with rising temperatures, ensuring more sustainable and resilient development.
Increase cross-government collaboration	Establish a coordinated, multi-agency response to implementing climate adaptation measures across all levels of government. This unified approach will streamline budget planning, minimise resource duplication, enable broad stakeholder engagement and ensure buy-in from key stakeholders.	Identify opportunities across all levels of government to enhance the coordination of resources targeting climate adaptation. This enhanced collaboration should focus on creating cohesive and efficient strategies for climate adaptation, ring that resources are optimally allocated, and initiatives and policy action are complementary.

Report structure

Structure of this Report

The report is structured as follows:

Table 3: Report structure

Chapter		Report purpose
Chapter 1	Introduction	This chapter presents the overview of the background and objectives of the NT CCRA, and how the report is structured.
Chapter 2	Risk assessment approach	This chapter presents the summary of the NT CCRA approach.
Chapter 3	Climate change in the Northern Territory	This chapter presents the climate change projections for the NT which underpinned the risk assessment.
Chapter 4	Climate change risks in the Northern Territory	This chapter presents the climate change risks that have been identified and assessed as part of this risk assessment. Included in this chapter are the final results and detailed risk profiles for the most urgent risks.
Chapter 5	Climate change opportunities for the Northern Territory	This chapter presents high level summary of the key opportunities relating to climate change in NT.
Chapter 6	Recommendations	This chapter presents high-level, near-term recommendations made to the NT Government with regards to the Tier 1 risks.
Conclusion		Final remarks regarding the Technical Report.
Appendices		Refer to here for assessment criteria, detailed risk assessment methodology, and references.

Introduction

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Context and objectives

Background

The Northern Territory Government recognises the importance of limiting climate change impacts through the reduction in greenhouse gas emissions and implementing adaptation projects. The *Northern Territory Climate Change Response: Towards 2050* establishes four policy objectives, including net zero emissions by 2050 and a resilient Territory. Separately, the NT Government is pursuing actions to progressively reduce greenhouse gas emissions and achieve the long-term objective of net zero emissions by 2050.

Despite ambitious emission reduction targets, climate change is impacting and will continue to impact the NT into the future. *A Resilient Territory - a Framework to build the Northern Territory's resilience to climate change* (the Framework) provides the strategic foundation to build the NT's resilience to the risks and associated impacts of the changing climate through adaptation.

Consistent with the goals and objectives of the Framework Deloitte was engaged to lead the NT Government through a process of climate change risk assessment and adaptation planning to examine and prepare for climate related risks that may impact the future liveability of the NT. The climate change risk assessment will build on the Northern Territory's (NT) existing body of work. This includes the *Climate Change in the Territory – State of the science and climate change impacts* report by the Earth Systems and Climate Change Hub of the National Environmental Science Programme (NESP) that examines the climate projections for the NT and its impact on economic sectors and the environment.

Objectives of the Northern Territory First-Pass Climate Change Risk Assessment

The objective of the Northern Territory First-Pass Climate Change Risk Assessment (NT CCRA) is to deliver a climate risk assessment report that identifies and prioritises the climate change risks which have the potential to impact the future liveability of the Territory.

The key questions which guided the NT CCRA process were:

- What are the key climate risks that have the potential to impact the measures which determine the future liveability of the Territory?
- What are the key climate risks to future water security in the Territory, the types of risks, and which locations are at the highest risk?
- How can the Government prepare for future climate change related natural disasters?
- How can Government address and reduce climate risks and associated impacts?
- What governance frameworks are required to monitor, implement and review climate change risk treatment options where Government is the risk owner?

In the process of conducting the NT CCRA, a series of cross-Government climate change risk assessment workshops were conducted to:

- Identify and assess the Territory's vulnerability to climate change, with particular focus on domains which influence liveability (social, economic, natural and built systems);
- Identify and prioritise actions that can be taken by government to reduce future vulnerability to climate change or to harness economic opportunities; and
- Inform the development of the *Northern Territory Adaptation Action Plan*.

Report purpose

Purpose of this Report

Two reports have been prepared to communicate the findings of the NT CCRA, as outlined in Table 4.

This is the Technical Report.

Table 4: Report purpose

Report	Report purpose
Technical Report (this report)	The Technical Report highlights key methodological components of the risk assessment, and provides detailed findings on risks, opportunities, and gaps in each domain. This includes qualitative and where possible quantitative descriptions of impacts, exposure, vulnerability, interacting risks, confidence, and adaptation urgency. This Report provides the evidence base for the assessment findings.
Summary report	The high-level summary is targeted at the broader audience of stakeholders which includes policy makers. It provides a high-level summary of risk assessment findings, with a focus on the most significant risks

Risk assessment approach

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Climate risk framework and approach | High-level overview

This chapter presents a high-level overview of the risk assessment approach for the NT CCRA. The completion of the NT CCRA was supported by a combination of research methods, including extensive literature review, stakeholder engagement and climate change data analysis. The sections in this Chapter present key components of the risk framework used in the NT CCRA.

The NT CCRA first pass risk assessment approach was based on the Scan Cycle, described below. This is based on national and international best practice of climate change risk management e.g., ISO14091:2021, the National Climate Risk Assessment of Australia (NCRA), New Zealand Climate Change Risk Assessment (NZCCRA), Climate Compass; CoastAdapt.

The Scan Cycle is a complete risk management process which includes assessment of climate change risks and development, and implementation of adaptation plans and a periodic review.

As a first-pass risk assessment, the scope of the NT CCRA is limited the first four steps of this framework, as described on the right: *Scope, Envision, Identify* and *Prioritise*.

The Scan Cycle Process:

1. **Scope:** What needs to be included in the risk assessment (assets/operation, timeframe, hazards etc.) and what criteria and process to be followed.

2. **Envision:** Qualitative and quantitative physical and transition climate scenarios assessment out to 2100

3. **Identify:** climate change risks and opportunities

4. **Prioritise:** Prioritise adaptation responses to risks/opportunities
5. **Implement:** Develop a roadmap and implementation plan for next steps.

6. **Evaluate:** Learn from the first pass assessment to recommend further directions and processes.

High-level overview of the NT CCRA risk assessment process

1. Scope

- a) What should be included in the climate change risk assessment for the NT?
- Process:
Adopt best practice approach and tailor through scoping workshop with stakeholders.
- Output:
 - Key parameters to be considered in the risk assessment (liveability measures, systems, time horizon, climate change scenarios, type of hazards and risk to be covered etc.)

2. Envision

- a. How could the NT be impacted by a changing climate?
- Process:
 - Literature review; and
 - Identification of preliminary risks for NT across all liveability measures.
- Output:
 - Preliminary list of impact statements

3. Identify

- a. What is the current and future level of physical and transition risk/ opportunity?
- Process:
 - Literature review;
 - Risk workshop; and
 - Scenario analysis.
- Output:
 - Refined list of priority risks;
 - List of opportunities;
 - Risk rating (including consequence); and
 - Confidence ratings.

4. Prioritise

- a. How is the risk/opportunity being currently managed?
- b. Is risk treatment urgent? Are there benefits from further action in the next five years, over and above what is already planned?
- Process:
 - Online survey to identify ongoing or planned adaptation in NT; and
 - Adaptation priority workshop.
- Output:
 - Short list of priority risks for the Northern Territory Government.

Key concepts and terminology used in NT CCRA

During the Scoping Stage, stakeholder consultation was held to test and confirm what should be included in the climate change risk assessment for NT (Scoping Workshop; refer to the Appendix more information on the NT CCRA stakeholder engagement process).

In undertaking the Identify and Prioritise Stages of the Scan Cycle, the NT CCRA incorporates key aspects of the IPCC risk framework that combines ‘hazard’, ‘vulnerability’, ‘exposure’, and ‘response’, as described and defined below.

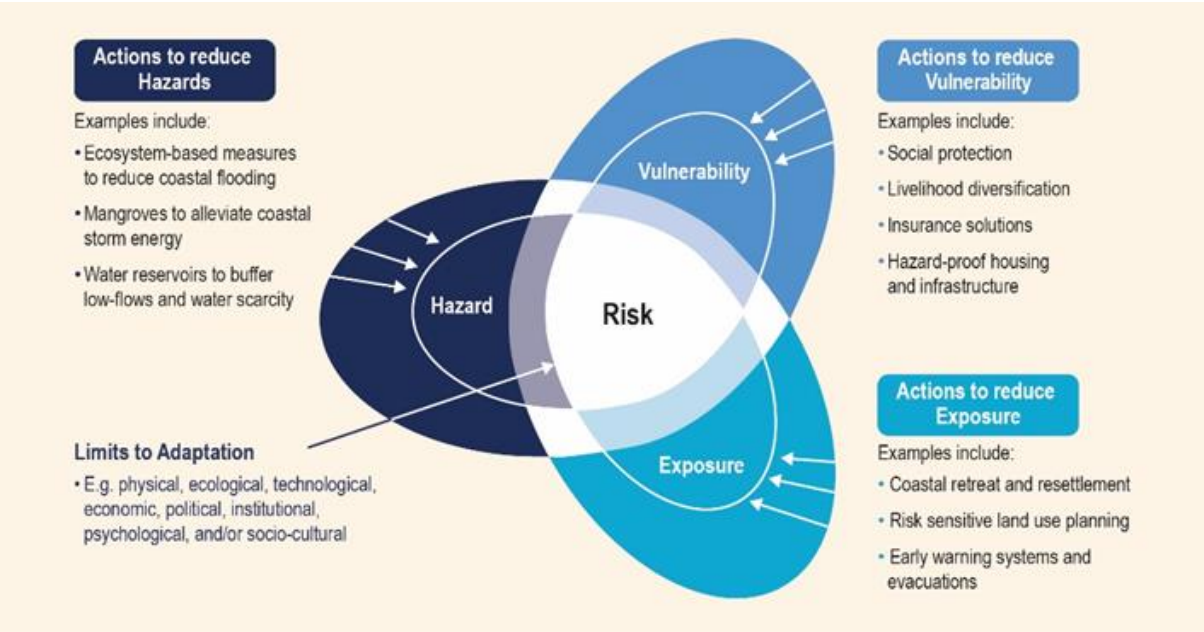


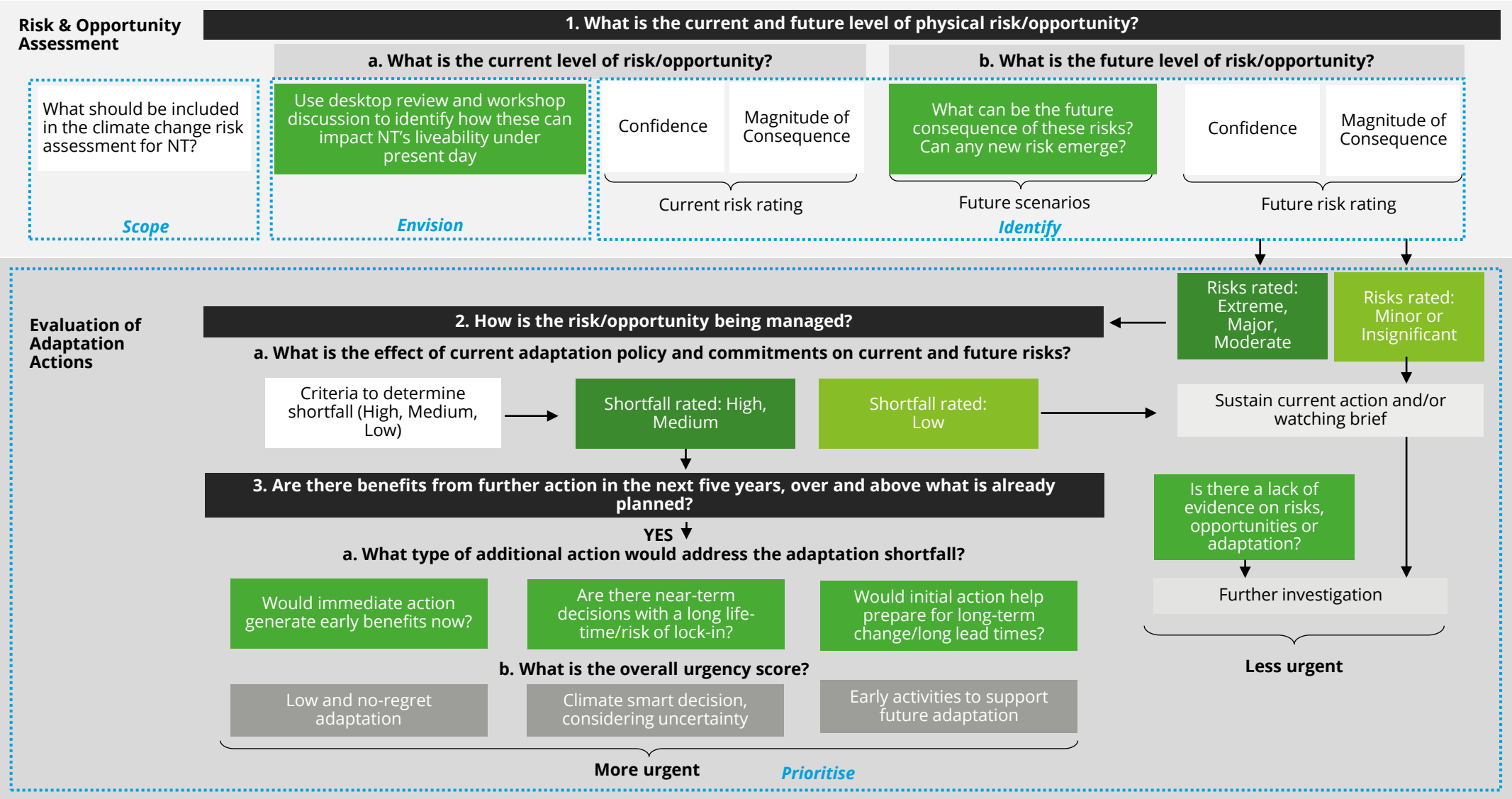
Figure 1: Risk framework presented in IPCC AR6 and adopted by NT CCRA. Three propellers show three key components of risk (e.g., hazard, exposure and vulnerability) and arrows show response across each component. (Source: IPCC AR6)

Table 5: Definitions and examples of different components of the NT CCRA framework

Component	Definition	Physical risk example	Transition risk example
Hazard/Driver	Hazard (for physical risks): The current and/or future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements. Driver (for transition risk): The current and/or future technology or socioeconomic factors/changes that may have an effect on vulnerable and exposed elements.	Bushfire	Renewable energy policy
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.	Assets situated within bushfire prone areas	Electricity consumers impacted by prices
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.	Buildings in a low socio-economic, bushfire prone area may be older, and their construction does not comply with bushfire resilience standards.	Impact to low socio-economic electricity consumers where energy bills are a high proportion of total income.
Response	The ability of institutions to react following a natural hazard.	Zoning regulations, building standards, support for low-income housing upgrades.	Development of new policies and investment to assist electricity consumers.

Risk assessment process overview

A detailed overview of the risk assessment process is presented below. It illustrates the process that was followed to identify and assess risk and opportunities, how these are currently being managed and benefits and urgency for further adaptation action. This process follows leading practice in multi-sectoral risk assessments at the Territory/State and national scale, with key aspects tailored to the NT.



Stakeholder participation in the risk assessment process

Throughout the risk assessment process, aspects of the NT CCRA methodology, risk statements and their ratings were tested with workshop participants. The process followed is described below, indicating how three stakeholder workshops were used to develop and hone the risk statements and their ratings.

The risk statements were developed building upon the literature review and Scoping Workshop

The literature review included review of reports, research papers, climate metrics and available data to gain an understanding of historical climate events, assets and populations at risk and existing adaptation actions in the Territory. Risk assessment parameters were selected and presented including liveability measures and subsystems within these, timeframes and climate scenarios and criteria for consequence ratings. These were presented and discussed during the Scoping Workshop and participants provided additional data and information to support the risk assessment.

The Scoping Workshop aimed to:

- Discuss the scope of the climate change risk assessment.
- Discuss the risk assessment process and agreement on key risk assessment parameters (timeframe, consequence criteria, etc.).

What are risk statements?

During the Scoping Workshop, it was agreed upon that the risk assessment will develop a series of **'risk statements'** that align to the six liveability measures which were further analysed using climate change information. These risk statements are used in the risk assessment to describe the impacts of climate change to different sectors and aspects of the environment or community. For example, risks to water resources and associated infrastructure.

The draft risk statements were reviewed and initially rated in the Risk Workshop

The risk statements were first rated by the Deloitte team using findings from the literature review and agreed magnitude of consequence criteria, and then reviewed by workshop participants during the Risk Workshop. The agreed magnitude of consequence criteria (see [Appendix A](#)) were used by workshop participants when reviewing and refining the preliminary risk ratings. The updated consequence ratings made during the workshops were reviewed and the risk statements were prioritised based on workshop outputs. Any discrepancies between multiple stakeholder opinions were made using professional judgement.

The Risk Workshop aimed to:

- Review and discuss preliminary climate change risks identified for the Territory.
- Discuss the consequences of each risk statement.
- Prioritise key climate change risks for each risk statement.

Risk ratings and adaptation priorities were confirmed in the Adaptation Priority Workshop

Current adaptation actions identified in the literature review were collated and adaptation shortfall scores and overall urgency ratings were applied and by combining the workshop participant agreed consequence ratings, adaptation shortfall and confidence in the data. Shortfall and overall urgency scores were tested with workshop participants and suggestions were combined into final risk ratings. These were used to frame the Tier 1 risk profiles presented in this Report.

The Adaptation Priority Workshop aimed to:

- Identify and verify adaptation actions being delivered to deliver statewide impact in the Territory.
- Analyse adaptation actions to understand how climate change risks are currently being managed.
- Identify priority risks and the corresponding adaptation actions for the Territory.
- Gain agreement on adaptation urgency and priorities.

The risk statements and ratings are utilised in this Technical Report. All Tier 1 risks have a risk profile written delving into a description of the exposure of the risk in the Territory, specific vulnerabilities, adaptation actions and confidence in data quality. Refer to [Chapter 4](#) for more information.

Key parameters for NT CCRA

The NT CCRA process was based on a series of parameters and climate change scenarios. These parameters are aligned with best practice and were recommended to and agreed upon by DEPWS and workshop participants through Scoping workshop. Table 6 below summarises the key parameters for the NT CCRA. These parameters are discussed in further detail throughout this Chapter.

Table 6: Key parameters for the Northern Territory Climate Change Risk Assessment are collated in the table below.

Risk assessment parameters	Adopted features		
Liveability measures <i>See page 19 for more information</i>	The six liveability measures include: • Safe and stable natural environment • Community health and wellbeing • Resource security • Natural disaster readiness • Economic sustainability, and • Safe and stable built environment.		
Risk and opportunity types	• Physical risks and opportunities, and • High-level transition risks and opportunities.		
Timeframes and climate scenarios <i>See Chapter 3</i>	<i>Risk type</i>	<i>Timeframes</i>	<i>Scenarios</i>
		Present day	Historic (1995-2014)
	Physical risks	2050 2090	For both timeframes, a High greenhouse gas emissions scenario: SSP3–7.0 and a Low greenhouse emissions scenario: SSP2–4.5
Climate hazards <i>See Chapter 3</i>	• Extreme heat • Extreme rain and flood • Bushfire • Drought	• Sea Level Rise • Frost • Soil moisture, and • Cyclone.	
Transition risk drivers <i>See Appendix B</i>	• Policy and legal • Technology • Market • Reputation		
Scale	• Territory-wide		

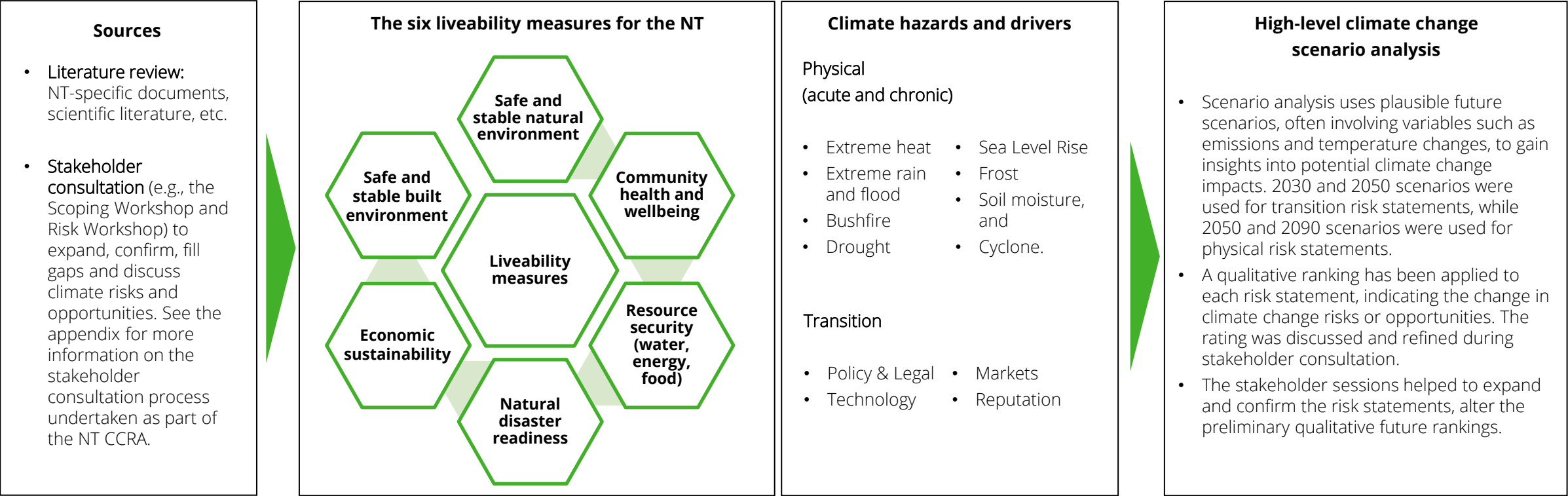
Developing climate change risk statements for NT CCRA

During the Scoping Workshop, it was agreed upon that the risk assessment will focus on six liveability measures: safe and stable natural environment, community health and wellbeing, resource security, natural disaster readiness, economic sustainability and safe and stable built environment. Based on that, **a series of ‘risk statements’ were developed for each of these six categories which were further analysed using climate change information** (e.g., what may a future change in climate mean for a given risk statement). Further descriptions of liveability measures are presented on the following page.

Climate change risk statements are a combination of the hazard/driver, exposure, vulnerabilities and impacts. The risk statements were identified through an extensive literature review process. The risk statements were also reviewed by NT CCRA workshop participants to validate and ensure their relevance to Territory. Based on discussions at the Scoping Workshop, 49 climate change risk statements were identified for NT CCRA and further refined in collaboration with workshop participants in the Risk Workshop. Outlined below is the process which was adopted for the NT CCRA to identify and assess the risk statements.

Refer to [Chapter 4](#) for more detailed information on the risk statements.

Categorisation of the NT CCRA risk and opportunity statements



Liveability measures

Liveability is a key consideration for people across all life stages in choosing where to settle. Initiatives to enhance liveability are central to the NT Government’s economic and social agenda. This includes promoting and enhancing work-life balance and promoting the Territory’s liveability to attract and retain young professional women, young families, late career workers and migrants.

Table 7 provides the definitions for each of the six liveability measures, and the systems at risk. Systems at risk are the things of value to NT. They can be highly subjective and values-based, resulting in some spanning across several liveability measures depending on worldview.

The risk and opportunity statements identified and assessed as part of the NT CCRA are aligned to each of these liveability measures. Refer to [Chapter 4](#) and [Chapter 5](#) for more information.

Table 7: NT liveability measures

Liveability measures		Systems at risk	
	Safe and stable natural environment Natural systems are functional and resilient in the face of climate change through adaptation action that protects the environment, sustainably manages different uses and maintains ecosystems and biodiversity	- Ecosystem services - Biodiversity - Marine, coasts, and offshore islands - Land - Atmosphere (including air quality)	- Inland water (surface and ground) - Natural heritage - Aboriginal connection to land and sea - Biosecurity (including invasive species)
	Community health and wellbeing Society, government, communities, families and individuals of the NT have the capacity and resources to adapt to and avoid the worst impacts of climate change and to maintain health, wellbeing, prosperity and cultural livelihoods.	- Physical and mental health and wellbeing - Employment and financial wellbeing - Culture and cultural heritage - Housing - Indigenous culture, values and principles	- Skills, education, and training - Social cohesion - Social welfare services - Sports and recreation - Public sector
	Resource security (including water, energy and food security) Water security is having an acceptable quantity and quality of water for people, economic opportunities, cultural and environmental needs, now and in the future. The key elements of water security are water supply, quality and demand. Energy security is about ensuring sufficient, affordable and sustainable energy resources to meet Territorian energy needs, today and in the future. Food security relates to the economic and physical access to culturally appropriate, safe and sufficient healthy food and the ability to safely store and utilise it.	- Water resources - Water infrastructure (including stormwater and wastewater)	- Energy infrastructure - Food and grocery assets
	Natural disaster readiness Arrangements to ensure that, should an emergency occur, all the resources and services that are needed to cope with the effects can be efficiently mobilised and deployed.	- Emergency services and management - Flood and coastal defences	Access to services and information during disasters
	Economic sustainability Climate risks to the NT’s economy, businesses, industries and workers are managed ensuring a climate-resilient future, including the creation of new jobs and industries generated by a low carbon economy, an investment in clean technologies and infrastructure projects.	- Agriculture - Forestry - Fisheries and aquaculture - Banking, finance and insurance - Charities and not-for-profits - Construction - Healthcare and social assistance - Manufacturing	- Mining - Government sector - Tourism - Small to medium enterprises - Trade sector - Local economy - Workforce - Supply chains
	Safe and stable built environment The NT’s built environment, utilities and physical infrastructure are developed and maintained to prevent, withstand and recover from the impact of climate change.	- Appropriate buildings and structures - Cities, towns and remote locations - Communications and ICT - Infrastructure planning	- Education infrastructure - Healthcare and medical assets - Transport infrastructure - Waste collection and storage

Risk assessment criteria

A set of risk assessment criteria were presented and discussed in the Scoping Workshop. They include magnitude of consequence, confidence, urgency and adaptation shortfall criteria. The criteria provide a clear, structured and standardised process for assessing risks, ensuring consistency and enabling comparison.

The criteria are described below. Please refer to [Appendix A](#) for each criterion in full. Please also see the following page for a step-by-step description of how the risk assessment criteria was applied by the NT CCRA to assess the identified risks, and identify which are the most urgent, from an adaptation perspective.

Magnitude of Consequence	Adaptation Shortfall	Confidence	Adaptation Urgency
Magnitude of consequence is the outcome of an event that may result from a hazard. The magnitude of consequence score indicates the potential magnitude of impact from the risk - different descriptors are provided to capture the potential magnitude across the different areas of DEPWS. Most risk assessments seek to assign an overall magnitude using a combination of likelihood and impact. However, climate risk assessments consider a broader set of risks which include longer-term trends as well as probabilistic events over a much longer-time frame than most event-based risk assessments. Given this, likelihood scoring is not appropriate. This is consistent with the approach taken in the UKCCRA and NZCCRA. The magnitude of consequence criteria used for the NT CCRA is based on the Department's Enterprise Risk Framework. During the Scoping Workshop, the criteria was presented to NT stakeholders for their valued input and agreement. See here for the criteria.	The objective of adaptation shortfall is to assess whether risks are being adequately managed by existing and planned adaptation actions in the future, in light of the changing climate. There is unlikely to be an existing, standardised approach to identifying adaptation action or many evaluations of their impacts. As such, this part of this assessment focussed on creating an inventory and baseline of current adaptation actions for future assessments and monitoring and evaluation. In assessing the urgency of action, the NT CCRA utilised criteria to assess whether risks are being managed. See here for the criteria.	The objective of the confidence criteria is to support the evaluation of risks by rating confidence in the robustness of, or agreement about, the supporting evidence. It refers to the degree of confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively. The NT CCRA uses a confidence rating approach similar to how the IPCC evaluate its findings. Here, for each risk, the assessment considers the quality of the evidence, along with the level of agreement between studies and experts. See here for the criteria.	The objective of the urgency criteria is to evaluate where adaptation action is most urgently required in the short-term for risks that may not otherwise be managed to an acceptable level. The urgency score indicates the degree to which action is needed to reduce a risk or realise an opportunity from climate change. It identifies where the need for adaptation is likely to be most urgent in the next five years. See here for the criteria.

Process to determine the most urgent climate risks for the Northern Territory

Outlined below is the process that was used by the NT CCRA to determine which of the identified risks may require urgent action in the next five years to ensure that the risks are adequately managed. The risks which requires more action are referred to as 'Tier 1 Adaptation Urgency' and 'Tier 2 Adaptation Urgency'. The process described below illustrates how these risks have been identified, using the criteria set out in [Appendix A](#). Refer to [Chapter 4](#) for more detailed information on the risks assessed.

1 Input the consequence scores for each risk statement agreed upon with workshop participants

Consequence score (2050)	Insignificant	Minor	Moderate	Major	Extreme
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2 Identify adaptation activities through desktop review and online survey

Description of adaptation action	Status-committed, ongoing or implemented	Who owns the adaptation action?	Risks addressed	Type of action (category)	Does this address any risk statements?
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3 Assess how each risk is managed, e.g., is there any adaptation shortfall

Adaptation shortfall score	Low shortfall	Medium shortfall	High shortfall
----------------------------	---------------	------------------	----------------

4 Assess confidence in the shortfall assessment e.g., quality of information used to make the assessment

Confidence score	High	Medium	Low
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5 Combine all the preceding scores to determine urgency of action score and tier (1-4)

Adaptation urgency score		
MORE ACTION NEEDED	Tier 1	High level of consequence is expected in the mid-term (2050). New, stronger or different government policies or implementation activities- over and above those already planned are needed in the next five years to reduce longer term climate change risks.
	Tier 2	Medium to high level of consequence is expected in the mid-term (2050). Some degree of adaptation efforts are underway; however, more adaptation efforts are required at a Territory-level including (new study/research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.
SUSTAIN CURRENT ACTION	Tier 3	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. This includes any existing plans to increase or change the current level of activity.
WATCHING BRIEF	Tier 4	The evidence in these areas should be kept under review, with long-term monitoring of risk levels and adaptation activity so that further action can be taken if necessary.

Complex risk | Context

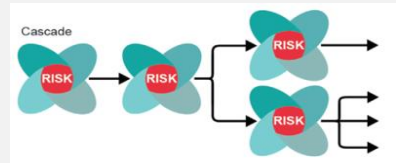
What is complex risk?

Complex risk is a key consideration when assessing risks and opportunities related to climate change in the Northern Territory. Complex risks result from multiple climate hazards occurring concurrently, and from multiple risks interacting, compounding overall risk and resulting in risks transmitting through interconnected systems and across regions, including the flow on impacts to the Territory from more frequent hazards occurring interstate. For example, freight transport delays due to road closures in neighbouring states.¹

Intersecting and cascading climate-related risks increase impacts and risks to the community health and livelihoods, ecosystems, infrastructure, and economic performance at all levels. Intersecting risks can also generate new sources of vulnerability to climate hazards, and compound the overall risk.¹ It is therefore critical that complex risk is incorporated and considered by climate change risk assessments to ensure that the nuanced risk interactions are better understood, to ensure that the most appropriate adaptation actions are identified and prioritised to address the risks.

Cascading Risk

One event or trend triggering others; interactions can be one way (e.g., domino or contagion effects) but can also have feedbacks. Cascading risk is often associated with the vulnerability component of risk, such as critical infrastructure. The diagram below provides an overview of the flow of cascading risk.



Example

An extreme rainfall event overwhelms water storage and catchments, leading to an overflow of water. This overflow continues to escalate, causing significant flooding in the area. The flood waters spread, blocking major roads, disrupting public transport, and isolating community members. Critical infrastructure is also affected as it becomes inundated and malfunctions, resulting in disruptions in service and access.

Compounding Risk

Risks that arise from the unilateral and/or bilateral interaction of hazards, which can be characterised by single extreme event or multiple coincident or sequential events that interact with exposed systems or sectors. The diagram below provides an overview of the flow of compounding risk.



Example

A flood event caused by extreme rainfall fall on river catchments that were still saturated from an earlier wet season. The event was started by extreme rainfall from a low-pressure trough. Additionally, onshore winds resulted in elevated sea levels along parts of the coastline. This hinders the drainage of the flood waters into the ocean, exacerbating the impact of the rainfall. Emergency management agencies are stretched and fatigued from back-to-back events which is also compounding the flood risk.

Aggregate Risk

Aggregation occurs when risks with unrelated causes – including those not directly related to the climate – occur simultaneously. The diagram below provides an overview of the flow of aggregate risk.



Example

A region is impacted by an earthquake and a drought at the same time.

¹ Avanti (2022), Major Rail and Road Flooding Causes Freight Delays.

Complex risk | How has complex risk been considered by the NT CCRA

How complex risk has been considered by the NT CCRA

To better understand the interconnectivity and complexity of risks in the context of the NT, a series of activities were undertaken. These activities were designed to be primarily introductory and educational illustrating the complexity of risks and the interrelationships between them. The complex risk-related activities included:

- Participants were asked to discuss how different climate risks within NT can cascade across sectors. Through this discussion, participants developed preliminary complex risk diagrams to identify the interconnections between the NT CCRA risk statements. Participants were asked to consider the risks that occur because of a climate event, such as flood or drought, factoring in how these risks might compound, cascade and aggregate from one to another. The complex risk maps below were developed by workshop participants (Figure 2).
- The cascading nature of risks were investigated and described at a high-level for the risk statements identified as the most critical and urgent to be addressed. These descriptions provided additional understanding of the significance of these risks and the necessity for them to be addressed. The narrative descriptions includes reference to the specific risk statements which are affected (e.g., C2, E3).

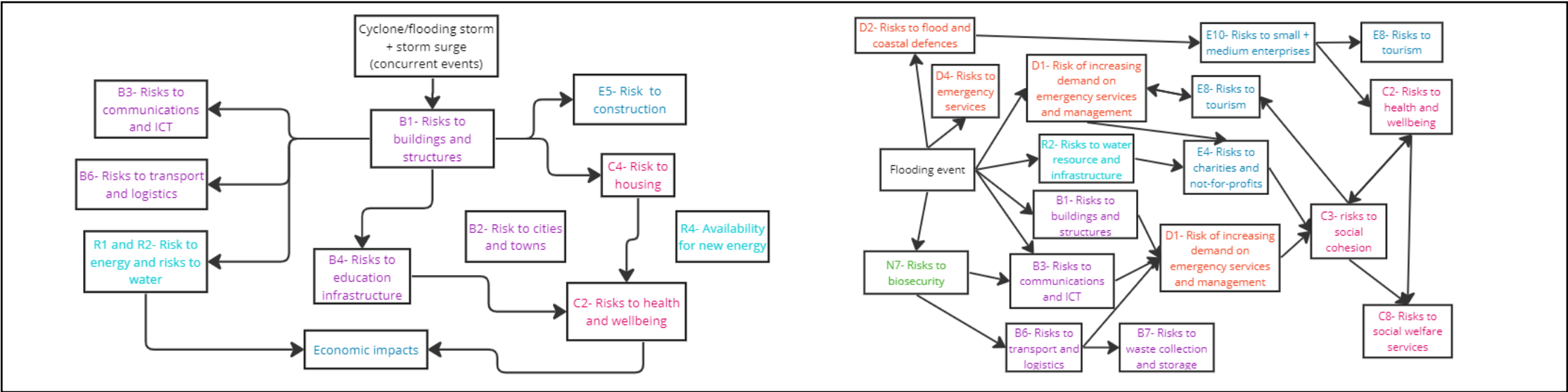


Figure 2: Extracts from the Risk Workshop activities, developed by workshop participants. These complex risk maps illustrate the interrelationships and interactions between different risk statements being assessed as part of the NT CCRA. For more detailed descriptions of the risks, Refer to Chapter 4.



Climate change in the Northern Territory

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Introduction to climate change

Overview

To inform the Identify phase of the risk assessment, future climate change projections of NT were collated and used based on a number of climate change scenarios. This Chapter describes the key concepts relating to climate change scenarios and projections, and how they were used in the climate risk assessment process.

What is climate change?

Climate change ‘is a long-term change in global or regional climate patterns and conditions caused by increased levels of greenhouse gases in the atmosphere, which in turn, result in more heat being trapped in the Earth’s atmosphere.’

According to the Intergovernmental Panel on Climate Change’s (IPCC) Synthesis Report for the Sixth Assessment Report, ‘Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020.’

This is resulting in changes in climate extremes across the globe and is predicted to worsen. On average, Australia has warmed by 1.47 ± 0.24°C since national records began in 1910, with most warming occurring since 1950. Every decade since 1950 has been warmer than the previous.

Climate change is causing increased frequency, severity and longer-lasting heatwaves, floods, droughts, and contributing to sea-level rise and an increased risk of bushfires. Rural, regional and remote communities are particularly exposed as the climate continues to change and decline in Australia. Additionally, climate change compounds the chronic difficulties and inequities that already face many of these vulnerable communities.

The Northern Territory’s climate is changing

The Northern Territory’s unique environment, diverse communities and economy are vulnerable to the changing climate. The Territory has experienced a 1.5°C increase in average temperatures since 1910, and greater frequencies of hot days and fewer frost days will be expected in the southern part of the Territory. The natural rainfall variability and extreme rainfall events are predicted to increase. Additionally, the Territory will spend more time in harsher and more frequent drought and fire weather. Refer to the diagram on the right for an overview of high-level climate projections for the Territory.

These changes in climate will have significant impact to key industry sectors such as agribusiness and has potentially devastating flow on socio-economic implications. For example, a recent study found that one third of doctors in the Northern Territory are already, or a likely, to consider leaving due to climate change. This would leave a large gap in the Territory’s health care system.

Refer to pages 28-34 for more detailed climate change projections for the NT.

High-level climate change projections for the Northern Territory	
Average Temperatures Over the past 100 years, average temperatures have already risen by around 1°C and are expected to continue to rise a further 2.7°C to 4.9°C by 2100.	Heatwaves Hot spells and the number of days over 35°C are expected to be experienced for around 33% of the year by 2100.
Bushfire intensity Fire intensity is expected to increase in the northern half of the Territory, while fire frequency is not expected to change.	Sea level rise Sea levels could rise by 65cm to 87cm above 2005 levels by 2100. This could lead to larger king tides and storm surges.
Drought Droughts are expected to continue, particularly in the southern region of the Territory.	Variable rainfall There is uncertainty in the total projected rainfall for the northern region, but intensity of extreme rainfall is expected to increase.
Evapotranspiration Evapotranspiration (a combination of evaporation and plant transpiration from the Earth’s land and ocean surface to the atmosphere) is expected to increase in all seasons. And is expected to be exacerbated by higher temperatures.	Intensity of extreme weather events The frequency of tropical cyclones is expected to remain constant or decrease, but they are expected to be more intense. Higher storm surges are expected to impact the northern coast.

Source: Northern Territory Government (2019), 10 Year Infrastructure Plan 2019-2028

Climate change scenarios | Introduction to the concept

Introduction to climate change scenarios

Climate emission scenarios illustrate what the future might look like under differing degrees of climate change and provide a structured way of making strategic choices. They are not predictions about what will happen, but rather hypotheses about what could happen in the short to long term.

In its Sixth Assessment Report (2021), the IPCC advanced the existing climate change scenario approaches by merging the transition *Shared Socio-economic Pathways (SSPs)* and physical climate *Representative Concentration Pathways (RCPs)*. This merge provides a more holistic approach towards anticipating, mitigating, adapting, and responding to projected climate changes.

The SSPs are climate change scenarios of projected socio-economic global changes up to 2100. The SSPs provide 5 narratives (SSP1-SSP5) for how socio-economic factors may change, leading to different climate futures. These socio-economic factors include population, economic growth, education, urbanisation, land use and land cover change, and the rate of technological development.

Figure 3 on the right (based on Hausfather et al 2020) illustrates the multiple possible scenario pathways to explore the possible changes in future energy use, greenhouse gas emissions and temperature. It suggests that SSP3-7.0 is the high end of the spectrum (which is the average of models with no climate policy) and SSP2-4.5 is the mid-range scenario which is aligned with a modest climate mitigation policy across governments.

Refer to the following page for more information on SSPs.

Scenario analysis for the NT CCRA

The uncertainty about the possible future makes it best practice to include a range of scenarios for physical and transition risks to cover a range of possibilities for the future. To ensure the NT CCRA is informed by the most up to date climate information, two SSPs are used (see Table 8 below):

Table 8: Agreed upon climate change scenarios used for the NT CCRA

Timeframes	Scenarios
Present day	Historic (1995-2014)
2030	For both timeframes:
2050	- High greenhouse gas emissions scenario: SSP3-7.0 - Moderate greenhouse emissions scenario: SSP2-4.5

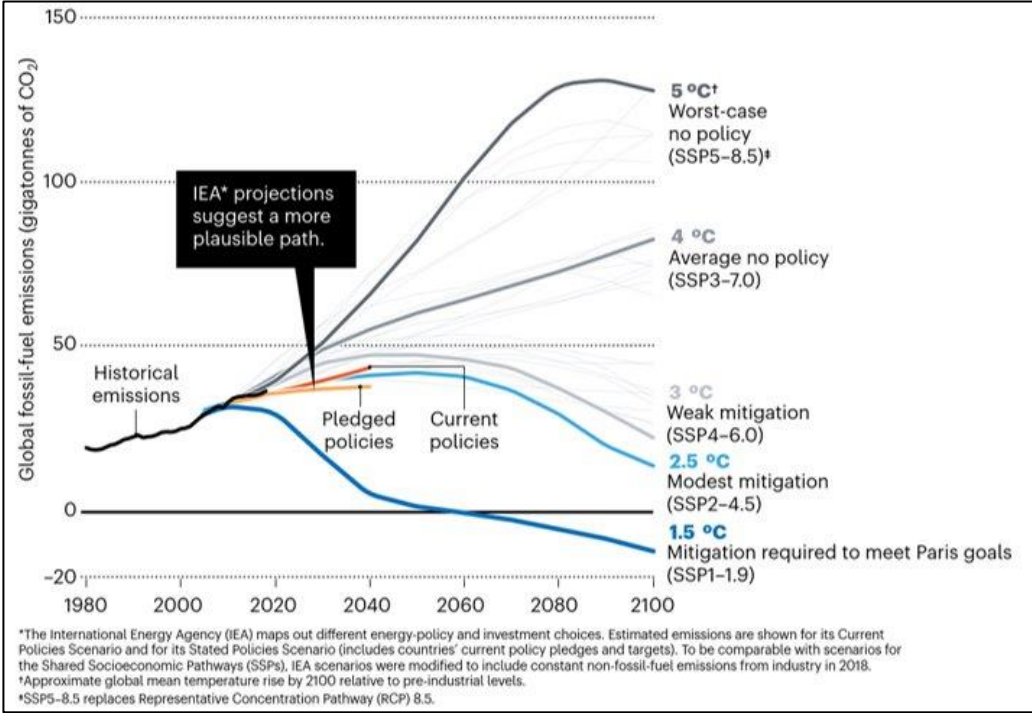


Figure 3: The International Energy Agency (IEA) maps out deferent energy-policy and investment choices. Estimated emissions are shown for its Current Policies Scenario and for its Stated Policies Scenario (includes countries' current policy pledges and targets). To be comparable with scenarios for the Shared Socioeconomic Pathways (SSPs), IEA scenarios were modified to include constant non-fossil-fuel emissions from industry in 2018. Source: Hausfather et al 2020.

Shared Socio-economic Pathways (SSPs)

Table 9 presents two SSPs that are used to inform the NT CCRA: SSP3-7.0 (high emissions scenario) and SSP 2-4.5 (moderate emissions scenario).

Table 9: Detailed descriptions of the SSPs

Scenario ambition	Modelled scenarios	Overview	Key assumptions of the scenario	Why this this scenario was used
Limited Climate Action High (4°C) Emission Scenario	SSP3-7.0	Average-case of how global emissions would evolve if governments and markets make no changes to their existing policies and investments in low carbon.	- Socio-economic narrative: assumes low population growth but with high migration, strongly reduced inequality with high Gross Domestic Product (GDP) growth per capita and high material consumption. - Emission reduction policies are limited to the current policies, and global coordination on tackling climate change is lacking. - Continued use of fossil fuels, and energy intensive activities and lifestyles. - Momentum in clean energy is insufficient to offset the effects of an expanding global economy and growing population. - Effects of climate change require significant investments in adaptation measures to protect assets, infrastructure and communities.	- Most regional physical model data available. - Provides higher end of the risk spectrum for physical risks, however, the world may experience worse impacts due to ice sheet and tipping points not modelled (IPCC AR6).
Current Targets & Pledges Moderate (2.5°C) Emission Scenario	SSP2-4.5	Emissions are curbed based on existing policies and announced commitments, including Nationally Determined Contributions, but fall short of meeting the Paris Agreement targets.	- Socio-economic narrative: assumes moderate population growth with medium migration, moderately inequality with uneven medium GDP growth per capita and intense material consumption. - Emissions are curbed based on existing policies and announced national commitments to reduce emissions but fall short of meeting the Paris Agreement. - Slow implementation of policies due to political, institutional and societal barriers. The transition to a low carbon economy is disorderly, uncoordinated and delayed. Transition happens faster in certain regions compared to others leading to differences in regional policies and implications on cost of doing business and global trade (e.g., carbon border tax).	- Most regional physical model data available. - Scenarios within this range are often considered to represent current emissions trajectory. - Explores the impact of late or disorderly transition to a decarbonized economy.

Scenario analysis for the NT CCRA

Table 10 shows Territory-wide average of each climate metrics in the Northern Territory. The majority of metrics are expected to increase in severity, such as annual mean temperature, days over 40°C, wettest day rainfall in mm, high bushfire days and longest dry spell duration across most scenarios. Metrics such as rainfall and frequency of extreme rain days over 20mm are variable in their expected changes over different scenarios and time horizons, while frost days is the only metric expected to decrease across all scenarios.

Table 10: Territory-wide average of future climate projections of different metrics.

Hazard Type	Hazard	Metrics	Current (1995-2014)	2050 (2040-2059)		2090 (2080-2099)	
				Low (SSP2-4.5)	High (SSP3-7.0)	Low (SSP2-4.5)	High (SSP3-7.0)
Acute Intensity and/or frequency of extreme weather events	Extreme rain and floods	Wettest day rainfall	37.0 to 46.4 mm	+1 to 13%	+2 to 15%	-1 to +15%	+4 to 21%
		Frequency of extreme rain days over 20mm	3 to 23 days	-1.9 to +3.6%	-3.1 to +6.8%	-5.8 to +6.6%	-7.1 to +12.7%
	Extreme heat	Hottest annual temperature	38.1 to 46.3°C	+0.5 to +1.7°C	+1.3 to 2.4°C	+1.2 to 2.7°C	+3.0 to 4.0°C
		Days over 35°C per year	50 to 200 days	+30 to 66 days	+34 to 75 days	+49 to 114 days	+71 to 155 days
		Days over 40°C per year	Up to 59 days	Up to +35 days	+2 to 38 days	+1 to 58 days	+9 to 91 days
	Drought	Longest dry spell duration	97 to 179 days	+1 to 8 days	-1 to +4 days	+1 to 5 days	Up to +12 days
	Frost	Frost days per year	Up to 2 days	- 1 day	-1 day	-1 day	-2 day
	Bushfire	Days where the fire weather index exceeds the 95th percentile (fwi95d)	17 to 20 days	+3 to 8 days	+3 to 7 days	+4 to 11 days	+7 to 18 days
	Storm surge	1-in-100-year extreme sea level event ²	2.2 to 4.4 m	64 to 93 year	60 to 92 year	14 to 79 year	9 to 75 year
Chronic Long term trends in the climate	Rainfall	Total annual rainfall	255 to 1641 mm	-30 to +5 mm	-30 to +5 mm	-66 to -1 mm	-84 to +20 mm
	Temperature	Annual mean temperature	21.8 to 28.6°C	+1.0 to 1.6°C	+1.5 to 2.9°C	+1.6 to 2.6°C	+3.4 to 4.3°C
	Sea Level	Relative sea level rise	-	20 to 21 cm	21 to 23 cm	48 to 51	56 to 59 cm

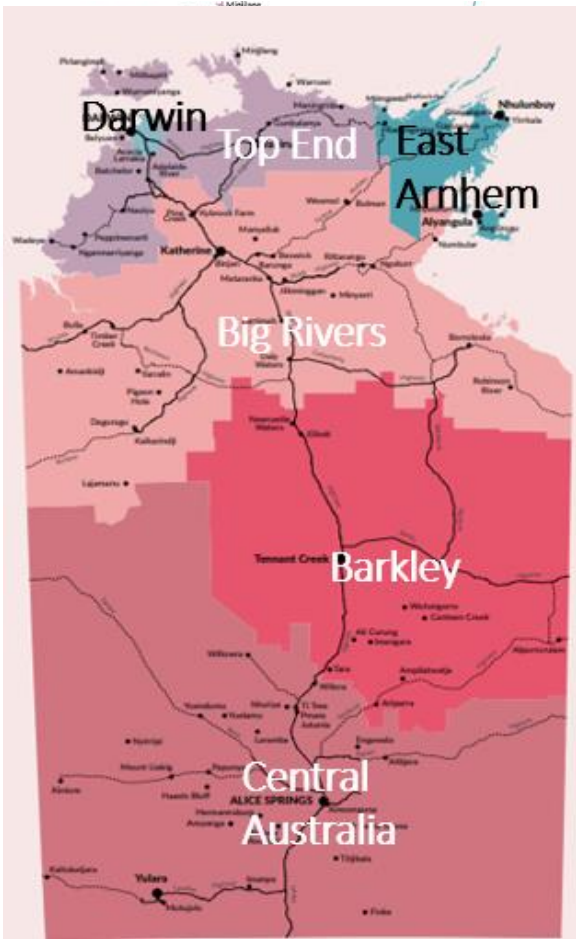
Note: ¹ An extreme sea level event is the sum of storm surge, extreme wave height and mean sea level. This metric is the future return period of the present day (1986-2014) 1-in-100yr extreme sea level event.

Climate change hotspot identification

As part of the scenario analysis, a ‘hotspot’ identification was conducted for the NT which aimed in identifying regional variability of different climate metrics across different regions of the NT. This hotspot mapping helped identifying regions in the NT which can expect more pronounced changes in future climate. This ‘hotspot’ analysis involved dividing the 19 NT LGAs (Figure 4) into six regions aligned with the economic regions in the Northern Territory (Table 11 and Figure 4).

Table 11: List of LGAs that are included under different economic regions of the NT

Barkly
Barkly
Big Rivers
Katherine Roper Gulf Victoria Daly
Central Australia
Alice Springs Central Desert MacDonnell
Darwin, Palmerston & Litchfield
Darwin Darwin Waterfront Precinct Litchfield Palmerston
East Arnhem
East Arnhem
Top End
Belyuen Coomalie Tiwi Islands Wagait West Arnhem West Daly



NT Regions

● Barkly ● Big Rivers ● Central Australia ● Darwin, Palmerston and Litchfield ● East Arnhem ● Top End

Figure 4: NT Economic Regions

Hazard categories used in hotspot identification

In order to identify hot-spots, a set of hazard categories are adopted. They range from very low to very high. Hazard categories represent to what extent a given climate metric is likely to change in future in a particular region in NT compared to other regions in the Territory.

These categories are determined based on the percentiles (see the figure on the right). For example, a ‘very low’ category of a hazard in a region suggests that future changes in that region for that hazard is likely to be relatively ‘very low’ compared to other areas in the NT.

Set out on the following pages are the detailed future climate change hotspots in the NT, under a high emissions scenario.

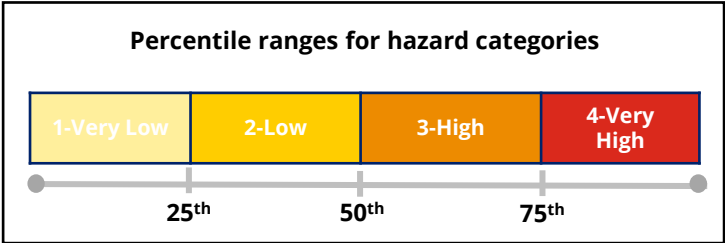


Figure 5: Percentile ranges for hazard categories

Table 12: Hazard categories and associated climate metrics

Hazard	Climate Metric	Hazard categories			
		Very Low ¹	Low ¹	High ¹	Very High ¹
Rainfall	Total annual rainfall (mm)	Close to 0 mm increase or decrease	0 to 17 mm increase or decrease	17 to 31 mm increase or decrease	Over 31 mm increase or decrease
Temperature	Annual mean temperature (°C)	Up to 1.2°C increase	1.2 to 1.7°C increase	1.7 to 2.5°C increase	Over 2.5°C increase
Sea Level	Relative sea level rise (cm)	Up to 16 cm increase	16 to 27 cm increase	27 to 41 cm increase	Over 41 cm increase
Extreme rain and floods	Wettest day rainfall (mm)	Up to 7.1% increase	7.1 to 9.3% increase	9.3 to 12.0% increase	Over 12.0% increase
	Frequency of extreme rain days over 20mm (days/year)	Over 2.2% decrease	2.2% decrease to 0.1% increase	0.1 to 2.7% increase	Over 2.7% increase
Extreme heat	Hottest annual temperature (°C)	Up to 0.9°C increase	0.9 to 1.4°C increase	1.4 to 2.1°C increase	Over 2.1°C increase
	Days over 35°C per year (days)	Up to 32 days increase	32 to 54 days increase	54 to 87 days increase	Over 87 days increase
	Days over 40°C per year (days)	Up to 6 days increase	6 to 15 days increase	15 to 32 days increase	Over 32 days increase
Drought	Longest dry spell duration (days)	Up to 1 day increase	1 to 2 days increase	2 to 3 days increase	Over 3 days increase
	Soil moisture content (%)	Under 1.4% decrease	1.4 to 3.0% decrease	3.0 to 4.0% decrease	Over 4.0% decrease
Bushfire	Extreme Fire Days (days)	Over 2.2% decrease	2.2% decrease to 0.1% increase	0.1 to 2.7% increase	Over 2.7% increase
	Extreme Fire Intensity (index)	Up to 2.2% increase	2.2 to 3.0% increase	3.0 to 4.0% increase	Over 4.0% increase
Storm Surge	1-in-100year extreme sea level event ³	Over once every 91 years	Between 73 and 91 years	Between 50 and 73 years	At least once every 50 years

Future climate change hotspots in the NT under a high emissions scenario

The below table shows the chronic hazards of rainfall, temperature and sea level and how this is predicted to impact the six NT regions identified on page 29.

Key¹

Very Low

Low

High

Very High

Table 13: Chronic hazards

Hazard	Metrics	Current ^{2,3} (1995-2014)	Year	Northern Territory ²	Barkly	Big Rivers	Central Australia	Darwin, Palmerston & Litchfield	East Arnhem	Top End
Rainfall	Total annual rainfall (mm)	607 (255 to 1641)	2050	-3 (-30 to +5)	0	-4	-2	-19	-25	-17
			2090	+1 (-84 to +20)	16	1	2	-38	-80	-32
Temperature	Annual mean temperature (°C)	26.2 (21.8 to 28.6)	2050	1.8 (+1.5 to +2.9)	1.7	1.7	1.8	2.1	2.1	2.1
			2090	(+3.4 to +4.3)	3.8	3.6	4.0	3.7	3.6	3.7
Sea Level	Relative sea level rise (cm)	N/A	2050	22 (21 to 23)	N/A	22	N/A	22	22	22
			2090	57 (56 to 59)	N/A	56	N/A	58	56	57

Note:
¹ The economic regions within the NT are coloured based on future risk levels compared to the Territory average.
² Values displayed are the average for the NT, with the range (minimum to maximum) across the LGAs within the NT.
³ Current values are not obtained from observations. They are modelled values obtained from the historic scenario of global climate models and used here to provide a baseline for future climate changes.

Future climate change hotspots in the NT under a high emissions scenario

The below table shows the acute hazards of extreme rain and floods and extreme heat and how this is predicted to impact the six NT regions identified on page 29.

Key¹

Very Low

Low

High

Very High

Table 14: Acute hazards

Hazard	Metrics	Current ^{2,3} (1995-2014)	Year	Northern Territory ²	Barkly	Big Rivers	Central Australia	Darwin, Palmerston & Litchfield	East Arnhem	Top End
Extreme rain & floods	Wettest day rainfall (mm)	41. 4 (37.0 to 46.4)	2050	7 (+2 to +15)	8	8	4	14	10	13
			2090	12 (+4 to +21)	15	15	7	21	10	19
	Frequency of extreme rain days over 20mm (days/year)	8 (3 to 23)	2050	1.8 (-3.1 to +6.8%)	1.0	3.2	1.7	-0.9	0	1.0
			2090	4.7 (-7.1 to +12.7%)	5.9	5.9	4.2	-0.7	-4.3	1.9
Extreme heat	Hottest annual temperature (°C)	44.6 (38.1 to 46.3)	2050	1.6 (+1.3 to +2.4)	1.5	1.4	1.8	1.5	1.8	1.6
			2090	3.7 (+3.0 to +4.0)	3.7	3.3	4.0	3.0	3.4	3.1
	Days over 35°C per year (days)	150 (50 to 200)	2050	41 (+34 to +75)	38	49	35	74	45	62
			2090	87 (+71 to +155)	79	101	72	155	115	138
	Days over 40°C per year (days)	40 (0 to 59)	2050	33 (+2 to +38)	38	33	35	7	4	12
			2090	77 (+9 to 91)	86	81	79	32	17	40

Note:

¹ The economic regions within the NT are coloured based on future risk levels compared to the Territory average.

² Values displayed are the average for the NT, with the range (minimum to maximum) across the LGAs within the NT.

³ Current values are not obtained from observations. They are modelled values obtained from the historic scenario of global climate models and used here to provide a baseline for future climate changes.

Future climate change hotspots in the NT under a high emissions scenario

The below table shows the acute hazards of drought, bushfire and storm surge and how this is predicted to impact the six NT regions identified on page 29.

Key¹

Very Low

Low

High

Very High

Table 15: Acute hazards

Hazard	Metrics	Current ^{2,3} (1995-2014)	Year	Northern Territory ²	Barkly	Big Rivers	Central Australia	Darwin, Palmerston & Litchfield	East Arnhem	Top End
Drought	Longest dry spell duration (days)	150 (97 to 179)	2050	2 (-1 to +4)	4	1	1	1	-1	0
			2090	7 (0 to +12)	9	4	9	4	0	3
	Soil moisture content (%)	11.3 (5.1 to 31.9 %)	2050	-1.8 (-5.3 to +2.7%)	-3.5	-2.9	0.4	-3.3	-5.3	-3.0
			2090	-6.4 (-10.6 to -2.5%)	-3.4	-6.0	-8.1	-7.0	-10.6	-6.1
Bushfire	Extreme Fire Days (days)	20 (17 to 20)	2050	5 (+3 to +7)	5	4	6	4	7	5
			2090	14 (+7 to +18)	14	13	15	11	17	14
	Extreme Fire Intensity (index)	47 (34 to 78)	2050	2.6% (1.6 to 3.2)	2.5	2.2	2.8	2.9	3.0	2.5
			2090	5.9% (4.9 to 7.0)	5.7	5.7	6.0	6.0	6.3	6.0
Storm surge	1-in-100-year extreme sea level event ⁴	3.5 (2.2 to 4.4 m)	2050	84 (60 to 92 year)	N/A	83	N/A	75	92	78
			2090	49 (9 to 75 year)	N/A	50	N/A	24	75	35

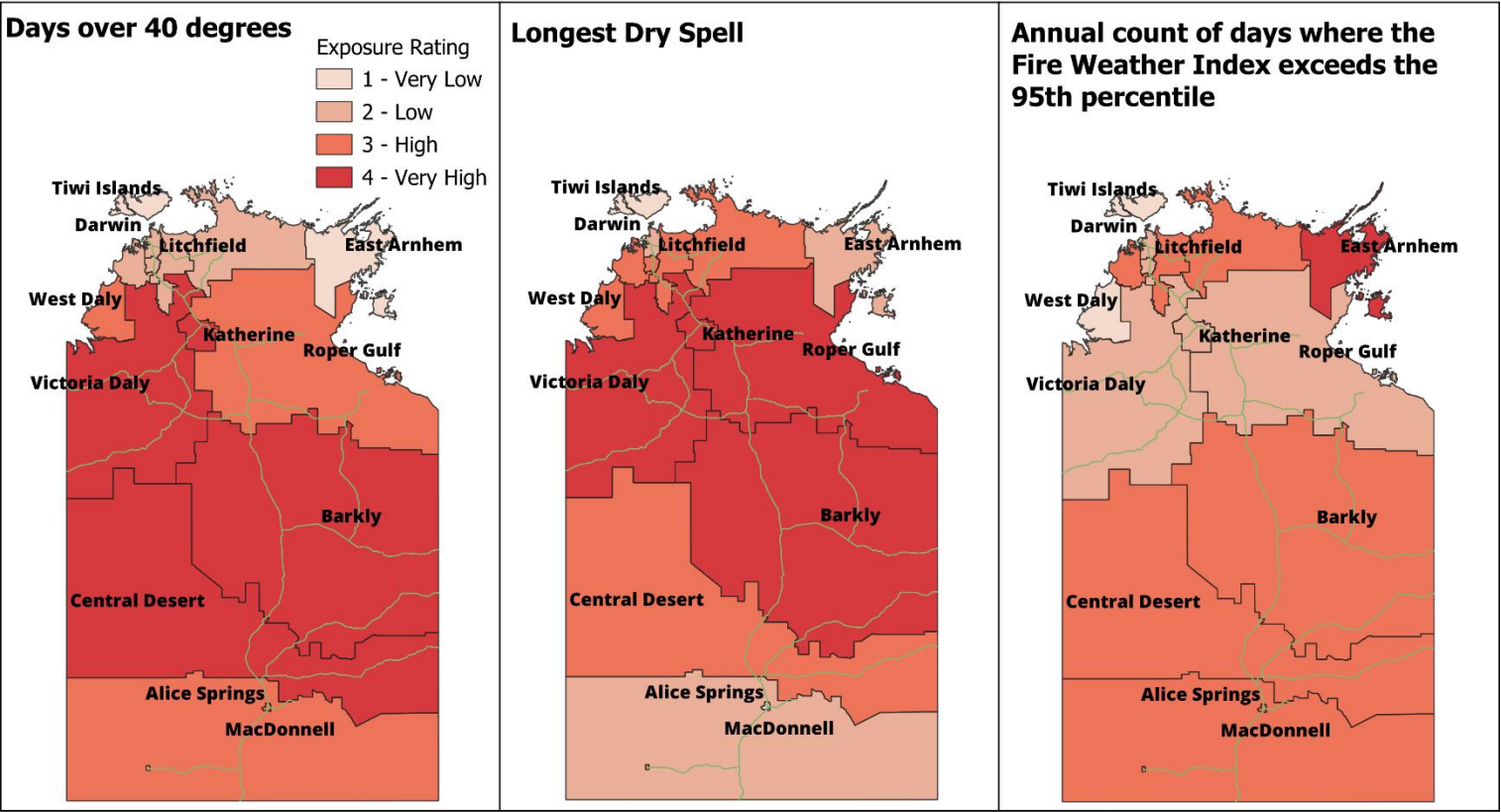
Note:
¹ The economic regions within the NT are coloured based on future risk levels compared to the Territory average.
² Values displayed are the average for the NT, with the range (minimum to maximum) across the LGAs within the NT.
³ Current values are not obtained from observations. They are modelled values obtained from the historic scenario of global climate models and used here to provide a baseline for future climate changes.
⁴ An **extreme sea level event** is the sum of storm surge, extreme wave height and mean sea level. This metric is the future return period of the present day (1986-2014) 1-in-100yr extreme sea level event.

Future climate change hotspots in the NT under a high emissions scenario

From the hotspot tables on pages 31-33, these maps were developed by overlaying climate metric data with a map of the Territory and additional assets such as roads to show how different regions across the Territory are predicted to experience extreme heat, drought and bushfire risks in 2050, unique to their location.

These maps are a way of visually depicting the differences expected across the Territory to inform fit-for-purpose adaptation actions and recommendations in future.

For example, regions in the center of the Territory including Central Desert, Barkly and Victoria Daly face the highest exposure to extreme heat days over 40°C, while MacDonnell, Tiwi Islands and East Arnhem are at low exposure to drought through longest dry spells. In contrast, East Arnhem is expected to face the highest risk from bushfire, with West Daly experiencing very low exposure in 2050.



Title:

NT Climate Hazard Projections Assets - 2050

Figure:

Rev:

Deloitte endeavours to ensure that the information provided in this map is correct at the time of publication. Deloitte does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



0 250 500 km

Deloitte.

Figure 6: NT 2050 hotspot maps (source: Deloitte)



Climate change risks in the Northern Territory

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Introduction to climate change risks in the Northern Territory

Context

This chapter presents the outcomes of the first four stages of the climate risk assessment process. As part of the NT CCRA, 49 physical and transition risk statements were identified and assessed, grouped by the Territory's six liveability measures. A summary of the NT risk assessment process and associated results was presented.

Each risk or opportunity statement describes a climate risk and/or opportunity. The statements are a combination of the hazard/driver, exposure, vulnerabilities and impacts. The risk statements were identified through an extensive literature review process. The risk statements were reviewed by workshops participants to validate and ensure their relevance to the Territory, and representing the NT's unique features and challenges, now and into the future.

Within this Chapter, each liveability measure has a dedicated section which delves further into the specific risk statements that have been assessed as part of the NT CCRA:

- 1. [Safe and stable built environment](#)
- 2. [Safe and stable natural environment](#)
- 3. [Economic sustainability](#)
- 4. [Community health and wellbeing](#)
- 5. [Resource security](#), and
- 6. [Natural disaster readiness](#).

For the opportunities identified for the NT, please refer to [Chapter 5](#).

Adaptation urgency summary

Urgency criteria are used to evaluate where adaptation actions are required in the short-term to address risks that may not otherwise be managed to an acceptable level.

The adaptation review found that 46 of 49 risk statements require more action within the next five years to manage the risks associated with each statement (Tier 1 and Tier 2) (Table 16).

Detailed risk profiles were developed for the most urgent risks, referred as 'Tier 1' risk statements, based on the identified adaptation urgency. These are risks which require, stronger or different government policies or implementation activities, over and above those already planned, in the next five years to reduce longer term climate change risks. Refer to the subsequent liveability measure sections for these risk profiles.

Table 16: Adaptation urgency summary

Adaptation urgency score			Number of risk statements
More action needed	Tier 1	New, stronger or different government policies or implementation activities- over and above those already planned are needed in the next five years to reduce longer term climate change risks.	16
	Tier 2	More information is required (new study/research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.	30
Sustain current action	Tier 3	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. This includes any existing plans to increase or change the current level of activity.	3
Watching brief	Tier 4	The evidence in these areas should be kept under review, with long-term monitoring of risk levels and adaptation activity so that further action can be taken if necessary.	No risks have been identified



Safe and stable built environment

Safe and stable built environment | Introduction



The safe and stable built environment liveability measure includes the NT's built environment, utilities and physical infrastructure are developed and maintained to prevent, withstand and recover from the impact of climate change.

Under this liveability measure, there are:

- Seven physical risk statements
- One transition risk statement, and
- Two opportunity statements (refer to the *Climate change opportunities for the Northern Territory* section).

Refer to pages 39-40 for the full list of risks assessed.

Summarised in Table 17 are the risk statements which have been identified as 'Tier 1 Adaptation Urgency' and 'Tier 2 Adaptation Urgency Risks'.

The Tier 1 risks are discussed in further detail on pages 41-47.

Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 17: Summary of safe and stable built environment risk categories. Detailed risk statements are provided in following two pages.

Tier 1 Adaptation Urgency Risks	
B3	Risks to communications and ICT
B6	Risks to transport and logistics
B7	Risks to waste collection and storage
Tier 2 Adaptation Urgency Risks	
B1	Risks to buildings and structures
B2	Risks to cities and towns including those in remote and island communities
B4	Risks to education and training infrastructure
B5	Risks to healthcare and medical assets

Safe and stable built environment | Risk statements and ratings

Summarised below are the ratings assigned by workshop participants to each of the safe and stable built environment risk statements. The risk statements which have been identified as 'Tier 1 Adaptation Urgency' are discussed in further detail on pages 41-47. Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 18: Safe and stable built environment risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
B1	Physical	Risks to the buildings and structures (private and commercial property, industrial property, community/emergency shelter and cultural assets) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise causing damage and increased operational and capital expenditure. Exposure to these weather events will result in increased wear on building materials.	Major	Major	Major	Medium	Medium	Tier 2
B2	Physical	Risks to cities and towns including those in remote and island communities (cultural and commercial precincts, parks and public realm, green infrastructure) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise causing damage and increased operational and capital expenditure.	Major	Major	Extreme	Medium	Medium	Tier 2
B3	Physical	Risks to communications and ICT (telecommunications, data storage or processing facilities, space technology) due to changes in chronic temperature, precipitation, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing damage and increased capital expenditure.	Major	Major	Major	Medium	Low	Tier 1
B4	Physical	Risks to education and training infrastructure (education facilities and building including schools, TAFEs and Universities) due to changes in chronic temperature and precipitation affecting water availability, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing damage and increased operational and capital expenditure.	Minor	Moderate	Major	Medium	Medium	Tier 2

Safe and stable built environment | Risk statements and ratings

Table 18 (continued): Safe and stable built environment risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
B5	Physical	Risks to healthcare and medical assets due to increased frequency and intensity of both chronic and acute risks including extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) leading to technology/equipment failure, supply shortages (medicine, supplies, power, water), and a rise in event related emergency and health issues and increased operational and capital expenditure.	Minor	Moderate	Major	Medium	Low	Tier 2
B6	Physical	Risks to transport and logistics (aviation, ports/maritime, roads, rail, freight infrastructure, public transport and logistics) due to changes in chronic temperatures and increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise, particularly for those in remote and island communities.	Major	Extreme	Extreme	Medium	Medium	Tier 1
B7	Physical	Risks to waste collection and storage (infrastructure that supports collection, resource recovery, reprocessing and disposal) due to changes in chronic precipitation and increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise causing damage and impeding operations.	Moderate	Moderate	Major	High	Low	Tier 1

Safe and stable built environment | Tier 1 Risk Profile | B3: Risks to communications and ICT

Physical risks to communications and ICT (telecommunications, data storage or processing facilities, space technology) due to changes in chronic temperature, precipitation and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing damage and increased capital expenditure.

Table 19: Communications and ICT risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Major consequence	Major consequence	Major consequence
	Climate change is already impacting the Territory's communications and ICT infrastructure. Extreme weather events pose threats to telecommunications networks and data storage facilities. Repairing infrastructure and mitigating risks require significant investment, leading to short-to-medium term disruptions to utilities and roads.	By 2050, the consequences of climate change on communications and ICT infrastructure will likely intensify. Extreme weather events are projected to increase in frequency and intensity, which can cause extensive infrastructure damage and disruptions in communications services. The increased capital expenditure required for repairs and upgrades strains economic resources, while the widespread infrastructure damage necessitates major repairs. Significant intervention will likely be required to mitigate these risks, including relocation of vulnerable infrastructure and further investment.	By 2090, the consequences of climate change on communications and ICT infrastructure is likely to remain critical levels. Extreme weather events will increase in frequency and intensity, causing widespread disruption and damage to telecommunications networks, data storage facilities, and space technology installations. The extensive infrastructure damage will likely require major repair efforts. Reversing these effects will likely require significant intervention and investment.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	Communication and ICT infrastructure and services play a critical role in connecting NT communities and providing people with access to essential services. The NT is served by telecommunications services in major urban areas with Darwin, Katherine and Nhulunbuy receiving NBN through fiber to the premises, and Tennant Creek and most of Alice Springs receiving fiber to the node. Communities in these areas have a choice of more than one mobile phones service provider. However, access is more limited and restricted in more remote areas. Of the more than 750 Northern Territory communities and residential areas:¹ 55 have mobile phone services (predominantly provided by Telstra and Optus); 43 have fixed broadband services; and 40 are connected to the national network by optic fiber. There is limited understanding of the physical locations of all communication and data facility infrastructure in the NT. Generally, this infrastructure is concentrated around primary population centres, such as Darwin, and spread more broadly across the Territory to provide services to the more remote populations. While it may be challenging to identify specific infrastructure at risk in this risk assessment, regional climate change projections provide an understanding of the areas of the NT most likely to be impacted and exposed to heightened risks. Communications and ICT infrastructure located in at-risk areas are at risk of: • Extreme weather events, such as storms, floods and bushfires, can lead to the damage and destruction of physical infrastructure and assets. Repair and replacement costs can be significant for telecommunication providers. Communication network also have significant consequences for communities. The exposure of this key infrastructure will increase over time. For instance, by 2050, the Big Rivers region will likely experience the most significant increase in the frequency of extreme rainfall days compared to other parts of the Territory. By 2090, this high degree of exposure will likely spread also to Barkly and Central Australia. Notably, the level of exposure to such rainfall conditions will significantly reduce in East Arnhem, Darwin, Palmerston, and Litchfield. • Telecommunication services can become overloaded during emergencies as people try to contact others or seek out information. This can create large volumes of calls and internet usage, overloading the network and stopping critical calls from connecting. This extra load can exhaust the primary and backup power supplies.² • Equipment, such as servers, may overheat during periods of extreme heat, resulting in failures and service disruptions. Extreme heat can also result in the expansion and contraction of materials, such as fiber optic cables. This can lead to the damage or breakage of the cables, resulting in signal degradation or the total failure of communications and connections. • Periods of extreme heat and extreme weather events can create dangerous working conditions for on-the-ground staff who maintain and operate infrastructure. This can result in delays in maintenance and repairs of infrastructure, and the return of services to business-as-usual. • Mobile base stations, telephone exchanges, and fixed wireless towers are susceptible to interruptions in electricity supply. Communication infrastructure is often unable to sustain service during extended power outages due to insufficient back-up power supply, leading to network outages.⁶		

Safe and stable built environment | Tier 1 Risk Profile | B3: Risks to communications and ICT (cont.)

Table 19 (continued): Communications and ICT risk profile

Risk component			
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- The age, maintenance status, and remoteness of communications infrastructure increases its vulnerability to climate-related impacts. - During and after extreme weather events, telecommunications disruptions tend to disproportionately impact rural populations, including remote Aboriginal communities, farming properties, and mining, tourism and fishing operations.⁷ - The Territory's remote communities generally lack basic telecommunication infrastructure and access.³ When remote communities lose access, their ability to buy goods and services is restricted, they are unable to communicate with others and essential service providers, repair costs can be significant, and repairs can be time consuming due to the remoteness. Between July 2020 and September 2021, there have been over 100 outages in NT remote communities, over 80% lasted 5 days or less, with up to 4% lasting more than 10 days and one outage over 30 days.¹ - Ensuring reliable telecommunications in the NT is a challenge due to its size, sparse populations, and harsh weather. This presents logistical challenges in providing connectivity to the 20% of the population that live and work in remote areas. Additionally, a lack of infrastructure, such as transmission and mobile towers, in remote areas means that roughly 20% of the NT population does not have access to mobile phone services.⁴ As at 2021, roughly 6,000 Territorians in many remote communities remain without any form of telecommunications service.¹ - In 2023, the NT has recorded the lowest score of all Australian states and territories with regards to its digital inclusion (access, affordability, and digital ability). There are significant disparities in the level of access between Darwin and other parts of the Territory, with more remote areas having very limited and restricted access. The lowest scoring LGAs in the country are located in remote parts, such as Belyuen Community and East Arnhem Regional Council. This disparity reflects the vastly different demographics and geographies that exist across Australia, as well as different levels of investment in telecommunications infrastructure and opportunities for digital support and learning.⁵ It is critical to highlight that where access to telecommunications are poor, the level of disadvantage and challenges experienced by those affected communities are significantly exacerbated. - There is a considerable digital gap between Aboriginal and non-Aboriginal people in Australia, and the NT.⁴		
	The loss of access to communications and ICT infrastructure in such an area can trigger a cascade of complex risks that affect various aspects of daily life, economy, and security for the NT communities. It is important to recognise that the consequences of loss in communications in remote communities is more critical than for regional and urban areas. Some of the key complexities include: - The reliability of communications and ICT is heavily influenced by the reliability of energy infrastructure (R1). Any loss or disruption in electricity connectivity will likely result in loss of communications (e.g., internet access, etc.). - Isolating communities (C3 and C5), hindering their ability to contact emergency services in times of need (risk C2), and restrict their ability to purchase essential goods and services (E3 and E10). - Hinders emergency services' coordination efforts, delaying response times and potentially increasing the severity of the system (D1 and C2).		
Adaptation	Adaptation shortfall: Medium	Confidence: Low	Adaptation urgency rating: Tier 1
	While there are several projects and investments being made into bolstering the communications and ICT infrastructure in the NT, and improving access to services within remote communities, there is no specific policy or strategy in place which manages climate-related risks to these services and infrastructure.	There is little to no evidence of the effects of future adaptation in managing the risk and little agreement between experts, specific to the adaptation actions specific to climate-related risks related to communications and ICT infrastructure and services in the NT.	Urgent action is required to adapt communications and ICT infrastructure in the NT to mitigate climate change risks over the next five years. Stronger government policies must prioritise resilient infrastructure development, integration of climate data, community engagement, and collaboration with industry stakeholders. These measures are essential to ensure the continuity of essential services and reduce the NT's vulnerability to climate-related disruptions.

Safe and stable built environment | Tier 1 Risk Profile | B6: Risks to transport and logistics

Physical risks to transport and logistics (aviation, ports/maritime, roads, rail, freight infrastructure, public transport and logistics) due to changes in chronic temperatures and increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise, particularly for those in remote and island communities.

Table 20: Transport and logistics risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence	Moderate consequence	Major consequence
	Currently, the NT is experiencing moderate consequences to its transportation and logistics infrastructure, as a result of extreme weather events and changes in the climate. These impacts often result in short-term disruptions and damage to transport infrastructure. The damage is however recoverable through maintenance and repair work.	By 2050, climate projections indicates a likely increase in the frequency and intensity of extreme weather events in the NT. While still moderate consequences, these will likely be worsened that the current-day scenario. The climatic changes will likely result in many short-term disruptions to road infrastructure, cutting off communities and limiting their access to essential services and goods. The consequences are likely reversible, but will require sufficient intervention and investment.	By 2090, the impacts of intensified extreme weather evens will have major impacts on the NT's transport and logistics infrastructure. The consequences will likely be significant. It is likely that the disruptions to the Territory's transportation and logistics infrastructure will last longer, and will likely require major repair to recover the extensive damage. Notably, however, the consequences can likely be reversed through significant intervention.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	- The Northern Territory road network spreads across a vast area of 1.3 million square kilometers. Most notably, over 70% of the Territory's 36,000 kilometers of roads are unsealed.¹ Refer to Figure 7 (page 45) for an illustration of the types and locations of road infrastructure in the NT. - The Territory's transport routes and infrastructure are highly exposed and susceptible to extreme weather events, particularly flooding. Regional and remotes communities can be isolated for up to six months at a time due to wet season rain events as roads are closed for long periods of time.^{4,6} Increase in the frequency and intensity of extreme weather events may disrupt transport (workers and supplies) and distribution of produce to market. For example, unprecedented flooding In March 2023 resulted in the closure of the Fitzroy River bridge in the West Kimberley, resulting in freight from Perth being detoured through South Australia and the Territory to reach towns such as Kununurra, Wyndham and Halls Creek. The closure of the Victoria Highway, between the Buntine Highway intersection and Timber Creek, meant that East Kimberley could not be re-supplied with essential goods by road. During this flooding event, 200m of rail lines were also washed away.² - By 2050, it is likely that significant portions of the Territory's road infrastructure will be highly exposed to extreme heat, bushfires, and drought. Roads located in and around Darwin will be particularly exposed to extreme rain days, which is conducive to flooding. - The following critical highways in the NT are exposed, and will continue to be exposed and at risk to climatic changes and extreme weather events: - The Stuart Highway, a vital north-south route connecting Darwin to the southern regions, is particularly exposed. - The Victoria Highway, linking Katherine to Kununurra, is exposed to flooding and extreme rainfall damages. The highway goes through remote areas and river crossings, making it prone to washouts and disruptions during intense rain events. - The Arnhem Highway, connecting Darwin to Nhulunbuy, is particularly at risk. Coastal erosion threatens sections of this highway, compromising its integrity and requiring significant investment in protective measures. - Coastal highways in the Northern Territory face a distinct set of challenges due to rising sea levels and increased storm surges. The Arnhem Highway, connecting Darwin to Nhulunbuy, is particularly at risk. Coastal erosion threatens sections of this highway, compromising its integrity and requiring significant investment in protective measures.		

Safe and stable built environment | Tier 1 Risk Profile | B6: Risks to transport and logistics (cont.)

Risk component	
Exposure <i>Continued</i>	Coastal transportation and logistical infrastructure is exposed to saltwater intrusion due to sea level rise, storm surge, and cyclones. This can result in damage and disruption to the infrastructure. It is estimated that approximately 2,000km of the Territory's road infrastructure is at risk from inundation and shoreline recession for a 1.1m sea level rise. Further, the replacement value of railways and tramways exposed to inundation and shoreline recession for a 1.1m sea level rise is \$0.1 – 0.5 billion.⁷
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- High temperatures can cause road surfaces to deteriorate rapidly, leading to increased wear and tear on the infrastructure. - The extreme heat not only accelerates pavement degradation but also affects the stability of the underlying soil, making the highway susceptible to subsidence and structural damage. - Over 70% of the Territory's 36,000 kilometers of roads are unsealed, increasing their vulnerability to wet weather.^{1,3} Intense storms and heavy rainfall amplify erosion and washouts, posing hazards to vehicles. Altered precipitation patterns increase dust levels, impairing visibility and causing respiratory issues. Freeze-thaw cycles and extreme temperatures exacerbate road surface degradation. Climate-induced vegetation changes can also compromise road stability and elevate landslide risks. - The following road networks in the NT have been identified as being highly vulnerable due to their significance to the Territory (e.g., supporting the movement of good and fuel to communities, and moving goods to and from enterprises), exposure to extreme weather events (extreme heat, cyclones, storms, flooding, and bushfires), and the impact which disruptions will have on the Territory: Arnhem Highway, Central Arnhem Highway, Buchanan Highway, Lasseter Highway, and Carpentaria Highway.⁵ - Transport networks located in remote areas are particularly vulnerable due to their geographical isolation, making it difficult to reach in a safe and timely manner to ensure the roads are regularly maintained and repaired as required. - Accessing public transport, vehicle registration and driver licensing services is more challenging for people living in remote areas in the NT. People living remotely find it harder to keep their vehicles in good shape as they do not have the same access to mechanical services as those in urban areas. People living remotely are also more likely to be driving older vehicles and driving long distances on unsealed roads.³ - The resilience of transport infrastructure in the NT is limited, for example a lack of adequate bridge and drainage infrastructure over stream crossings limits the accessibility of the road network.⁶ - Road freight costs can be 65% higher on unsealed roads than on sealed roads (as at 2022).⁶ 38% of bridge structures in the region are in poor or very poor condition (as at 2022).⁶ - Many remote communities rely on barge landings to import freight, especially during the wet season.⁸
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	The NT grapples with the intricate challenge of maintaining robust transport routes and logistics infrastructure across its expansive and remote landscape. The susceptibility of these systems to various disruptions poses a spectrum of risks, each with cascading implications, for example: - Disruptions to supply chains as essential goods and services may face delays or shortages, impacting communities and businesses (E10, E11, C2, C5). - Natural disasters or accidents may result in delayed or ineffective emergency responses due to hindered transportation (D2). - Loss of access to road infrastructure can be detrimental for the Territory's tourism industry, and businesses reliant on travelers (E8 and E10). - Remote communities and areas reliant on transport routes can experience significant isolation if key roads are impacted (C3 and C5). This isolating can be devastating to communities, as they may not be able to access healthcare and emergency services, and may struggle with food and water shortages (C2 and C8). Communities will likely be displaced and will be forced to evacuate (C2 and C3). Limited access to transportation options can exacerbate social disparities, hindering opportunities for education, employment, and healthcare.

Safe and stable built environment | Tier 1 Risk Profile | B6: Risks to transport and logistics (cont.)

Table 20 (continued): Transport and logistics risk profile

	Adaptation shortfall: Medium	Confidence: Medium	Adaptation urgency rating: Tier 1
Adaptation	There are some commitments in place, such as the <i>Arnhem Highway Adelaide River floodplain upgrade</i> and funding received as part of the <i>National Highway Network Flood Resilience Assessment project</i>. Notably, the NT Government has made it clear that it is committed to upgrading and sealing roads. Despite this, there is not yet any clear policies or strategies implemented in the NT that specifically focuses on climate-related risks and opportunities for the Territory's transportation and logistics infrastructure.	There is some evidence of the effectiveness of the adaptation measures implemented and planned in the NT to manage the risks to transportation and logistics infrastructure.	Due to the vulnerable nature of the NT's transport and logistics infrastructure, urgent action is needed to address the physical risks facing the transport and logistics sector due to climate change. This includes enhancing infrastructure resilience, incorporating adaptive planning, improving emergency response preparedness, engaging communities, and investing in technology and innovation. These measures are crucial to ensuring the continued accessibility and reliability of essential services, particularly for remote and island communities, over the next five years.

The below Figure provides an example of exposure of highways in the NT to extreme rain days (left) and days over 40°(right) by 2050 under a high emissions scenario (SSP3-7.0). Note, this is not showing flood potential, rather showing roads that are located in areas where high degree of future extreme rainfall change is projected (red colour).

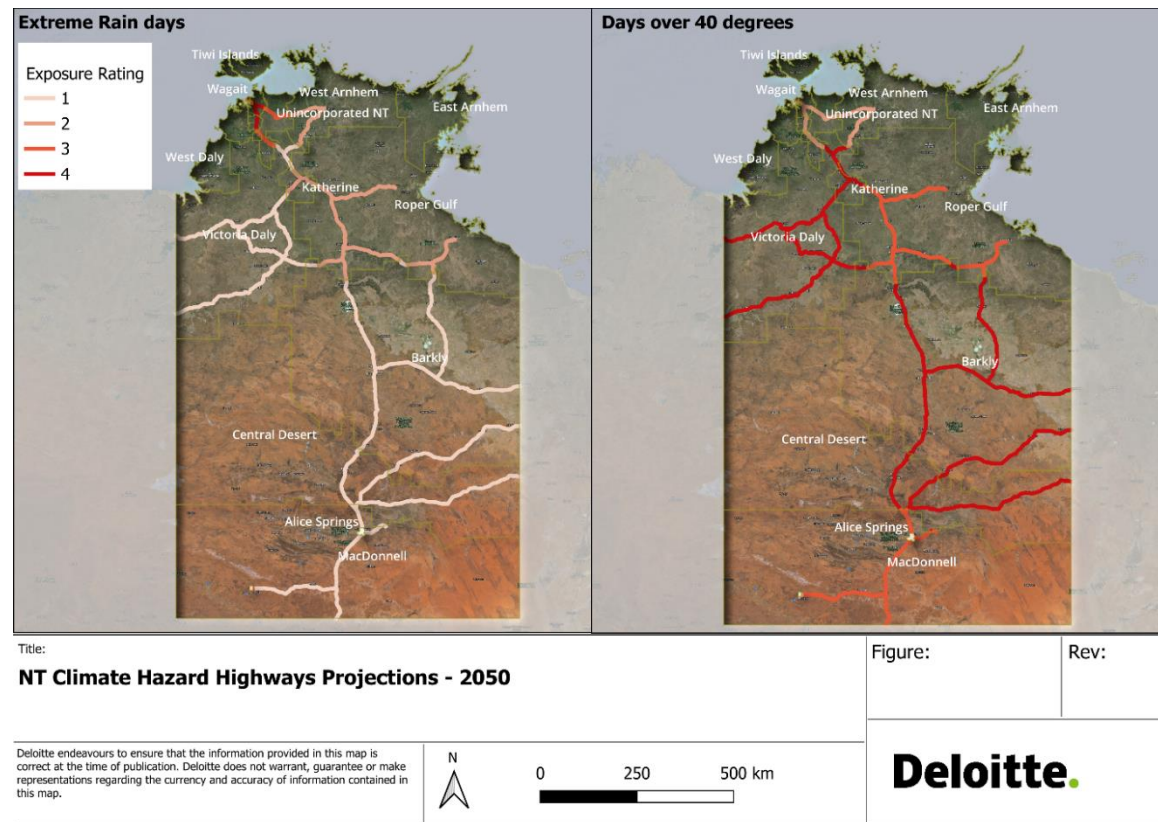


Figure 7: NT climate hazard projections for highways by 2050

Safe and stable built environment | Tier 1 Risk Profile | B7: Risks to waste collection and storage

Physical risks to waste collection and storage (infrastructure that supports collection, resource recovery, reprocessing and disposal) due to changes in chronic precipitation and increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise causing damage and impeding operations.

Table 21: Waste collection and storage risk profile

	Current	2050	2090
Consequence	Moderate consequence	Moderate consequence	Major consequence
Level of change or impact, is this sustained, or irreversible?	In the NT, climate change is moderately affecting waste collection and storage infrastructure. Changes in precipitation and occasional extreme weather events disrupt operations, requiring NT agencies' attention. With maintenance and minor repairs, the impacts are reversible, but short-term disruptions are common.	By 2050, the consequences of climate change on waste collection and storage infrastructure in the NT will remain moderate, but will likely to be more intense than the present-day consequences. While infrastructure service disruptions will likely persist, they will require more extensive interventions and management strategies to address.	By 2090, the consequences of climate change on waste collection and storage infrastructure is likely to become major. Repairing the damage requires major interventions and significant investment. While the consequences will likely be major, they may be reversed with substantial intervention, including comprehensive repair and adaptation measures.
Exposure	Residents in major regional centers typically have better access to hazardous waste facilities and specialized operators for waste management compared to remote communities. This access helps minimise the risk of hazardous waste ending up in landfills. These services are available in Darwin, Palmerston, Alice Springs, Katherine, Tennant Creek, and Nhulunbuy. Remote communities with low population density however do not have the same access to waste collection and management services and infrastructure, and are more reliant on techniques such as landfill burials and burnings. ¹ Waste generated in the NT is largely comprised of: construction and demolition waste (32%); commercial and industrial waste (30%); and municipal solid waste (38%). ²		
What is impacted and where (i.e., ecosystem, industry, community, etc.)?	Storms, cyclones, floods, and bushfires are highly destructive in nature, and can create significant volumes of waste that needs to be removed and processed. These conditions put significant pressure on the Territory's waste collection and management services and infrastructure to meet the increased service demand. Summarised below are the impacts of extreme weather events on waste creation and subsequent management in the NT:		
	- Significant waste generation from damage and debris, putting pressures on the every-day waste collection and storage services. Additionally, areas may become inaccessible due to road closures, impacting on the ability of kerbside waste contractors to perform their regular community collections. - Closure of waste storage and processing infrastructure due to infrastructure damage, and high repair costs to return the infrastructure and services to business-as-usual functionality. - Extreme weather events can create dangerous and hazardous conditions for both the community and waste management workers. This can impact on the removal and management of waste in a timely and safe manner.		
Vulnerability	- Remote communities in the NT are poorly serviced and some are isolated from the rest of the Territory for months during wet seasons. Additionally, the transportation of waste from some locations can incur long travel distances on poor-quality roads and higher costs.¹ It is therefore like that the waste collection and management systems and infrastructure in these areas may be more prone to being overwhelmed during extreme weather events, and recovery efforts may experience delays. - There may be limited capacity and capability during extreme events to meet the response and recovery demands. - Waste management and processing facilities may not have the necessary capacity or capability to process the influx of waste and debris created by these extreme weather events. - The key problem wastes common across the NT include liquid wastes, asbestos, medical waste, batteries, paints and solvents.¹ NT communities and waste services will experience significant challenges which there is a spike of such waste types. - There is no common and standardised design requirements and standards for landfills in the NT.¹ Poorly designed and managed landfills in remote areas create large volumes of leachate, often containing heavy metals and other toxic chemicals, which can leak into groundwater, local creeks and rivers.²		
How susceptible is the system to the driver, level of resilience, can it adapt?			

Safe and stable built environment | Tier 1 Risk Profile | B7: Risks to waste collection and storage (cont.)

Table 21 (continued): Waste collection and storage risk profile

Risk component			
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	The management of waste collection and storage infrastructure in the NT faces escalating risks attributed to shifting precipitation patterns, exacerbated by the amplified frequency and intensity of extreme weather events, including storms, cyclones, heavy rainfall, extreme heat, floods, bushfires, and storm surges, compounded by ongoing sea-level rise. These hazards pose substantial threats to facilities supporting waste collection, resource recovery, reprocessing, and disposal, leading to physical damage, operational impediments, environmental contamination, public health concerns, and increased financial burdens on waste management systems. Some of the specific cascading complex risks include: - Health and wellbeing risks to people can occur when waste products are not able to be disposed of safely, leading to leached metals and chemicals entering waterways and soil creating negative health impacts (C2). - Environmental impacts to biodiversity including changes in flora and fauna distribution and animal health can occur if waste including heavy metals and chemicals contaminate soil and waterways (N1, N2, and N5).		
Adaptation	Adaptation shortfall: High	Confidence: Low	Adaptation urgency rating: Tier 1
	Significant investments have recently been made for the development of new waste management infrastructure in the NT. However, there are no policies, strategies or plans currently in place in the NT to manage climate-related risks to the Territory's waste collection and storage infrastructure.	As no policies, strategies or plans are currently in place to ensure the infrastructure can adapt to the changing climate, confidence is rated as low.	Urgent adaptive actions within the next five years is needed to safeguard waste collection and storage infrastructure. New, robust government policies and implementation strategies, exceeding current plans, are imperative to mitigate long-term climate risks and ensure the resilience of waste management operations in the NT.

Safe and stable built environment | Tier 2 risk statements

Listed below are the four Tier 2 Adaptation Urgency risk statements for Safe and Stable Built Environment. For each of these risk statements, more information is required (for example, through a new study or additional research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.

Table 22: Safe and stable built environment Tier 2 risk statements

Risk statement		
B1	Physical	Risks to the buildings and structures (private and commercial property, industrial property, community/emergency shelter and cultural assets) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise causing damage and increased operational and capital expenditure. Exposure to these weather events will result in increased wear on building materials.
B2	Physical	Risks to cities and towns including those in remote and island communities (cultural and commercial precincts, parks and public realm, green infrastructure) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise causing damage and increased operational and capital expenditure.
B4	Physical	Risks to education and training infrastructure (education facilities and building including schools, TAFEs and Universities) due to changes in chronic temperature and precipitation affecting water availability, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing damage and increased operational and capital expenditure.
B5	Physical	Risks to healthcare and medical assets due to increased frequency and intensity of both chronic and acute risks including extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) leading to technology/equipment failure, supply shortages (medicine, supplies, power, water), and a rise in event related emergency and health issues and increased operational and capital expenditure.



Safe and stable natural environment

Safe and stable natural environment | Introduction



The safe and stable natural environment liveability measure includes the natural systems are functional and resilient in the face of climate change through adaptation action that protects the environment, sustainably manages different uses and maintains ecosystems and biodiversity.

Under this liveability measure, there are:

- Eight physical risk statements
- Two transition risk statements, and
- Three opportunity statements (refer to the *Climate change opportunities for the Northern Territory* section).

Refer to pages 51-52 for the full list of risks assessed.

Summarised in Table 23 are the risk statements which have been identified as 'Tier 1 Adaptation Urgency' and 'Tier 2 Adaptation Urgency Risks'.

The Tier 1 risks are discussed in further detail on pages 53-54.

Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 23: Summary of safe and stable natural environment risk categories. For detailed risk statements, please refer to the next two pages

Tier 1 Adaptation Urgency Risks	
N7	Risks to biosecurity (invasive species)
Tier 2 Adaptation Urgency Risks	
N1	Risks to marine ecosystems and species
N2	Risks to inland water ecosystems and species
N3	Risks to biodiversity
N4	Risks to coasts and offshore islands
N5	Risks to land
N6	Risks to natural heritage/cultural features
N8	Risks to atmosphere

Safe and stable natural environment | Risk statements and ratings

Summarised below are the ratings assigned to each of the safe and stable natural environment risk statements. The risk statements which have been identified as ‘Tier 1 Adaptation Urgency’ are discussed in further detail on pages 53-54. Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 24: Safe and stable natural environment risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
N1	Physical	Risks to marine ecosystems and species (coral reefs, mangroves, seagrass, sand/mud flats and nurseries) due to changes in chronic temperature, ocean temperature and acidification impacting species composition and ecosystem productivity due to oceanic mixing, nutrient availability and growing conditions.	Moderate	Major	Major	Medium	High	Tier 2
N2	Physical	Risks to inland water ecosystems and species (lakes, riverine and springs) due to changes in chronic rainfall and temperature, drought conditions and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires) affecting water availability, soil erosion and sediment transport impacting habitats/species.	Moderate	Major	Major	Medium	High	Tier 2
N3	Physical	Risks to biodiversity due to changes in chronic rainfall and temperature, drought and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires) threatening the variety of living organisms and their ecological complexes such as ecological succession across all sources (terrestrial, marine and aquatic).	Moderate	Major	Extreme	Medium	High	Tier 2
N4	Physical	Risks to coasts and offshore islands: risks to estuaries, offshore islands, gulfs, reefs, coastal flora and fauna nurseries, and habitats due to ongoing sea level rise and extreme weather events (storm surge) including increased tidal ranges. Water security on remote islands is at risk.	Moderate	Major	Extreme	Medium	Medium	Tier 2
N5	Physical	Risks to land e.g., soil, vegetation, deserts, agricultural land, landforms and habitats due to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) fragmenting/damaging habitats and causing potential species loss, with additional risks to Aboriginal land ownership/custodianship.	Moderate	Major	Extreme	Medium	High	Tier 2

Safe and stable natural environment | Risk statements and ratings (cont.)

Table 24 (continued): Safe and stable natural environment risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
N6	Physical	Risks to natural heritage/cultural features e.g., natural features, ecosystems, landscapes and biological diversity due to changes in chronic rainfall and temperature, drought and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires).	Minor	Moderate	Major	Medium	High	Tier 2
N7	Physical	Risks to biosecurity (invasive species) due to chronic temperature, precipitation changes and fire, enhancing the spread, survival and establishment of invasive species (animal and plant pests and diseases, food borne illnesses, zoonosis and the misuse of rural chemicals). e.g. Gamba grass.	Moderate	Major	Major	Medium	Low	Tier 1
N8	Physical	Risks to atmosphere (air quality) due to an increases in extreme weather events (bushfire smoke) and related fire management actions and favourable meteorological conditions for extreme air pollution such as high ozone (i.e., heat waves, temperature inversions and atmospheric stagnation).	Moderate	Major	Extreme	Medium	High	Tier 2
N9	Transition	Risks to the environment (plants, animals, soils, landscape features, water sources) from unprepared landfill and waste management systems to handle waste generated from renewables .	Insignificant	Moderate	Major	Low	High	Tier 3
N10	Transition	Risks to natural environment (including biodiversity, air quality) from new energy infrastructure which may lead to additional damage to habitats and ecosystems, disruptions to migration paths, decline in species and biodiversity.	Minor	Moderate	Moderate	Low	High	Tier 3

Safe and stable natural environment | Tier 1 Risk Profile | N7: Risks to biosecurity (invasive species)

Physical risks to biosecurity (invasive species) due to chronic temperature, precipitation changes and fire, enhancing the spread, survival and establishment of invasive species (animal and plant pests and diseases, food borne illnesses, zoonosis and the misuse of rural chemicals). e.g. Gamba grass

Table 25: Biosecurity (invasive species) risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence	Major consequence	Major consequence
	Invasive flora, fauna and diseases are currently significantly impacting parts of the territory in localised areas particularly in the northern tropical regions. There are Territory-wide implications for primary industries, tourism and national parks management and require NT agencies to respond to the spread and control it.	There will likely be widespread alteration of ecosystems from expanding spread of flora, fauna and diseases, with major impacts at the Territory scale leading to significant ecosystem instability and/or species declines. Consequences of climate change have implications for primary industries, tourism and national parks can be managed to minimise impacts but require NT agencies to respond quickly.	By 2090, ecosystems will likely be altered, from changes in distribution of invasive flora, fauna and diseases. Territory scale impact such as ecosystem instability and native species decline is expected. Management of impacts require NT agencies to respond quickly to prevent further increase in human health issues and damage from invasive species in future.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	- Invasive plants are typically more adaptable to changing climate conditions such as increasing rainfall intensity conditions than many natives. - Invasive plants can act as pioneering species post bushfire resulting in higher competition with native species and wider spread, impacting local biodiversity, primary industries production, availability of traditional indigenous foods and overall ecosystem health.¹ - Gamba grass is a declared weed across NT and weed of national significance, primarily infesting areas north of Katherine, such as Kakadu National Park and can create larger fuel loads, resulting in higher risk of bushfires in the NT as the climate dries in areas of the Territory over time.² - Invasive animals such as camels, horses, cane toads, fox, cat, pig, rabbit, buffalo, however their distribution will likely decrease as rainfall decreases across the Territory.³ - Viruses and diseases, particularly those spread through mosquitos such as Barmah Forest virus are expected to become more prevalent during extreme rainfall periods across the territory. - Melioidosis is a bacterial disease that is exacerbated during heavy rainfall periods⁴ of which are expected to increase significantly across Big Rivers region in 2050 and additionally, in Barkly and Central Australia regions by 2090.		
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- Different invasive species will be more or less vulnerable depending on where they are growing, for example species that are best suited to drier climates will likely be more vulnerable to extreme rainfall. Plant species with deeper roots may be best suited to increased storm events, while shallow rooted plants- both native and invasive are more vulnerable. - Native plant and animal species that have slower reproductive rates are move vulnerable to competition with invasive species as temperatures increase. - Invasive plants which are suited to waterlogged and wet environments will be more vulnerable to decreases in rainfall across the Territory. - Plants and animals that require a regular water for survival such as aquatic plants or animals or diseases that thrive with soil moisture may be out competed with invasive species more suited to extreme heat conditions.		

Safe and stable natural environment | Tier 1 Risk Profile | N7: Risks to biosecurity (invasive species) (cont.)

Table 25 (continued): Biosecurity (invasive species) risk profile

Risk component			
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	The Northern Territory faces escalating physical risks to biosecurity due to changing temperature, precipitation patterns, and increased fire incidence, which enhance the spread and establishment of invasive species like Gamba grass. The complex/cascading risks associated with biosecurity includes: • Invasive species, such as Gamba grass, can fuel the intensity and frequency of wildfires, exacerbating fire risk in affected areas and leading to widespread ecological degradation and habitat loss. • Invasive species able to rapidly adapt to changing climate conditions and weather patterns can outcompete native species, resulting in a reduction in ecological biodiversity (N1, N2, and N3). • Invasive plants can encroach on agriculture crops and invasive animals can damage crops and become pest species reducing production yields leading to economic losses (E1, E10, and E11). • Health and wellbeing concerns are linked to the increase in mosquito borne diseases and higher risk of invasive disease spread (C2).		
	Adaptation shortfall: Medium There are some existing territory biosecurity plans, weed management and invasive species fact sheets available, however, these do not specifically consider the impacts of climate change over time.	Confidence: Low There is little data available specific for the NT that addresses how climate change will impact invasive species spread and disease prevalence.	Adaptation urgency rating: Tier 1 Additional resourcing and prioritisation of financial considerations e.g. new/ expanded biosecurity programs due to climate conditions is required. Additional policies are required over the next five years to implement a co-ordinated approach to invasive species management to effectively manage climate change risks.

Safe and stable natural environment | Tier 2 risk statements

Listed below are the seven Tier 2 Adaptation Urgency risk statements for Safe and Stable Natural Environment. For each of these risk statements, more information is required (for example, through a new study or additional research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.

Table 26: Safe and stable natural environment Tier 2 risk statements

Risk statement		
N1	Physical	Risks to marine ecosystems and species (coral reefs, mangroves, seagrass, sand/mud flats and nurseries) due to changes in chronic temperature, ocean temperature and acidification impacting species composition and ecosystem productivity due to oceanic mixing, nutrient availability and growing conditions.
N2	Physical	Risks to inland water ecosystems and species (lakes, riverine and springs) due to changes in chronic rainfall and temperature, drought conditions and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires) affecting water availability, soil erosion and sediment transport impacting habitats/species.
N3	Physical	Risks to biodiversity due to changes in chronic rainfall and temperature, drought and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires) threatening the variety of living organisms and their ecological complexes such as ecological succession across all sources (terrestrial, marine and aquatic).
N4	Physical	Risks to coasts and offshore islands: risks to estuaries, offshore islands, gulfs, reefs, coastal flora and fauna nurseries, and habitats due to ongoing sea level rise and extreme weather events (storm surge) including increased tidal ranges. Water security on remote islands is at risk.
N5	Physical	Risks to land e.g., soil, vegetation, deserts, agricultural land, landforms and habitats due to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) fragmenting/damaging habitats and causing potential species loss, with additional risks to Aboriginal land ownership/custodianship.
N6	Physical	Risks to natural heritage/cultural features e.g., natural features, ecosystems, landscapes and biological diversity due to changes in chronic rainfall and temperature, drought and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires).
N8	Physical	Risks to atmosphere (air quality) due to an increases in extreme weather events (bushfire smoke) and related fire management actions and favourable meteorological conditions for extreme air pollution such as high ozone (i.e., heat waves, temperature inversions and atmospheric stagnation).



Economic sustainability

Economic sustainability | Introduction



The economic sustainability liveability measures includes the climate risks to the NT's economy, businesses, industries and workers are managed ensuring a climate-resilient future, including the creation of new jobs and industries generated by a low carbon economy, an investment in clean technologies and infrastructure projects.

Under this liveability measure, there are:

- Eight physical risk statements
- Three transition risk statements, and
- Two opportunity statements (refer to the *Climate change opportunities for the Northern Territory* section).

Refer to pages 58-60 for the full list of risks assessed.

Summarised in Table 27 are the risk statements which have been identified as 'Tier 1 Adaptation Urgency' and 'Tier 2 Adaptation Urgency Risks'.

The Tier 1 risks are discussed in further detail on pages 61-71.

Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 27: Summary of economic sustainability risk statements

Tier 1 Adaptation Urgency Risks	
E3	Risks to banking, finance and insurance institutions, and fiscal and financial systems
E7	Risks to mining
E9	Risks to manufacturing
E10	Risks to small and medium enterprises
E13	Risks to financial position of NT businesses due to premature write-downs of fossil fuel assets
E14	Risks to NT's economic growth due to slow, ineffective or no action
Tier 2 Adaptation Urgency Risks	
E1	Risks to agriculture and forestry
E2	Risks to fishing and aquaculture
E4	Risks to charities and not-for-profits
E5	Risks to construction
E6	Risks to healthcare and emergency services
E8	Risks to tourism

Economic sustainability | Risk statements and ratings

Summarised below are the ratings assigned to each of the economic sustainability risk statements. The risk statements which have been identified as 'Tier 1 Adaptation Urgency' are discussed in further detail on pages 61-71. Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 28: Economic sustainability risk statements and ratings

	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
E1	Physical	Risks to agriculture and forestry due to changes in chronic rainfall and temperature, drought conditions, invasive species, saltwater intrusion, water availability and evaporation impacting growing season length and conditions and increasing impact/damage due increases in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and associated land clearing for additional operations.	Moderate	Major	Extreme	Medium	Medium	Tier 2
E2	Physical	Risks to fishing and aquaculture (both land-based and marine) resources and associated infrastructure due to changes in chronic temperature, ocean temperature and acidification impacting the spatial distribution of fish stocks, along with growing conditions/productivity/health of aquaculture sites.	Moderate	Moderate	Major	Medium	Medium	Tier 2
E3	Physical	Risks to banking, finance and insurance institutions, and fiscal and financial systems due to the impact of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) on certain assets (claims) and income streams (write-downs and losses). This can also lead to unaffordability of insurance and wide-reaching impacts to consumers including financial hardship.	Moderate	Moderate	Major	High	Low	Tier 1
E4	Physical	Risks to charities and not-for-profits (providing social assistance to communities and individuals) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing a rise in event related demand for social assistance.	Minor	Minor	Moderate	Medium	Medium	Tier 2

Economic sustainability | Risk statements and ratings (cont.)

Table 28 (continued): Economic sustainability risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
E5	Physical	Risks to construction industry and associated supply chain due to an increase in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) that lead to delays, damaged assets and increased costs, including increased work, health and safety costs.	Moderate	Major	Extreme	Medium	Medium	Tier 2
E6	Physical	Risks to healthcare and emergency services due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and chronic weather changes causing a rise in event related emergency and health issues, including biting insects and vectors.	Moderate	Major	Extreme	Medium	High	Tier 2
E7	Physical	Risks to mining (mining activities and commodities within the Northern Territory) due to an increase in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) that impact operations.	Moderate	Major	Extreme	High	Low	Tier 1
E8	Physical	Risks to tourism (tourism businesses and services, visitor destinations and attractions) due to ongoing sea level rise, changes in chronic rainfall and temperature, and increases in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge).	Minor	Major	Extreme	Low	High	Tier 2

Economic sustainability | Risk statements and ratings (cont.)

Table 28 (continued): Economic sustainability risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
E9	Physical	Risks to manufacturing (e.g., machinery and equipment, textile, wood, fabricated metal, etc.) to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) affecting assets, resources, site access and supply/distribution networks.	Minor	Moderate	Major	High	Low	Tier 1
E10	Physical	Risks to small and medium enterprises due to increased costs/share of cash flow (for preparation, damage and clean-up) from extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge)	Major	Major	Extreme	High	Low	Tier 1
E11	Physical	Risks to export and trade sector (international trade, wholesale and retail trade) due to increased frequency intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) leading to disruptions/delays.	Minor	Major	Major	Medium	Medium	Tier 2
E12	Transition	Risks to operating costs of NT businesses from transitioning to low carbon economy due to carbon tax, increased supply chain costs, benchmarking requirements, lower productivity from operating new technologies, and new activities to adapt to the shift of consumer preference to low emission products.	Moderate	Moderate	Major	Medium	High	Tier 2
E13	Transition	Risks to financial position of NT businesses due to premature write-downs of fossil fuel assets (stranded assets), increased capital expenditure and investment on new technologies, and limited access to capital if perceived as laggards in climate action.	Moderate	Major	Extreme	High	Low	Tier 1
E14	Transition	Risks to NT's economic growth due to slow, ineffective or no action on emissions reduction.	Major	Major	Major	Medium	Low	Tier 1

Safe and stable natural environment | Tier 1 Risk Profile | E3: Risks to banking, finance and insurance institutions, and fiscal and financial systems

Physical risks to banking, finance and insurance institutions, and fiscal and financial systems due to the impact of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) on certain assets (claims) and income streams (write-downs and losses). This can also lead to unaffordability of insurance and wide-reaching impacts to consumers including financial hardship.

Table 29: Banking, finance and insurance institutions risk profile

Risk component	Current	2050	2090
	Moderate consequence	Moderate consequence	Major consequence
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Presently, the risks of climatic changes to the Territory's banking, finance, insurance institutions and financial systems are moderate. The impacts are significant at a Territory-wide scale, as the industries suffer significant disruptions and medium-term reductions in profits. The consequences are notably reversible through appropriate interventions.	By 2050, the consequences of the changing climate will continue to have moderate consequences for the NT. The impacts are significant at a Territory-wide scale, as the industries suffer significant disruptions and medium-term reductions in profits. The consequences are notably reversible through appropriate interventions.	By 2090, the financial and insurance systems in the NT will likely be significantly impacted by more frequent and intense extreme weather events. It is likely that significant structural adjustments within the banking and insurance industries may be required to respond to the challenges posed by climate change. The NT Government is likely to also play a role in responding to the consequences.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	- Climate change can significantly affect the prices of assets if it reduces future cash flows and makes them more volatile. Climate risks affect the value of assets used as security for loans and thereby the potential losses that lenders face if borrowers can't meet their repayments. Climate change can also affect the ability of households and businesses to meet their repayments because of the impact it can have on their incomes.¹ - Increased frequency and intensity of rainfall, floods, bushfires, storms, and cyclones can lead to greater property damage and subsequent insurance claims, increasing the cost of insurance to being unaffordable for many residents and businesses. It is projected that by 2030, 2.5% of properties (equivalent to 2,783 properties) in the NT will be uninsurable due their exposure to extreme climatic events and conditions. The Lingiari and Solomon electoral divisions are at high risk: 4.5% and 1% of properties respectively have been identified as being at risk.² - Banks are exposed to potential credit losses from extreme climate events and climatic changes.⁶ Banks and lenders with client assets in at-risk locations will also likely face changes in insurance premiums due to intensified flood and bushfire conditions and potentially decreased property values, reducing banks appetite to lend money to buyers in higher risk areas. - Climate change is driving up insurance premiums, leading to many individuals having to scale back their coverage or opt out of insurance altogether. Even for those who can afford coverage, inconsistent and unclear policy terms often result in unsuccessful claims. Additionally, escalating rebuilding costs leave many inadequately insured. The repercussions of being uninsured or underinsured extend beyond finances to profound implications on individuals and communities, resulting in hardships and impacts on their health and wellbeing.³ - Insurance for homes and businesses may become unavailable in highly exposed areas, and banks may decrease the number of loans they offer to the NT communities. - In a worst-case scenario, insurers and banks could withdraw from highly-exposed communities in response to extreme weather events.⁷		
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- Properties and assets in low-lying areas and near rivers are more vulnerable to flooding, while such assets located in areas with high non-permeable surfaces are at a greater risk of flash flooding from high surface run-off during extreme rainfall. Both events result in asset damage and the need for insurance payouts and loans to repair damage. - Insurance unaffordability is widespread across the community but particularly in disaster-prone regions where premiums have rapidly escalated. It disproportionately impacts people on lower incomes who tend to occupy a greater proportion of housing in more disaster-prone areas.³ Climate change will not have an equal impact on home insurance premiums across households. For example, under a high emissions scenario, premium affordability is projected to deteriorate 20% for vulnerable households.⁴ - Households that are already struggling to pay home insurance premiums will also suffer most from the impacts of climate change on home insurance premiums.⁵		

Safe and stable natural environment | Tier 1 Risk Profile | E3: Risks to banking, finance and insurance institutions, and fiscal and financial systems (cont.)

Table 29 (continued): Banking, finance and insurance institutions risk profile

Risk component			
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	Extreme weather events, including storms, floods, and bushfires, pose significant physical risks to banking, finance, and insurance institutions in the NT. Some of the key complex and cascading risks include: - The flow-on effects from impacts on these institutions will have significant consequences for NT communities and businesses. For example, increases in insurance rates will mean that businesses and communities may no longer be able to afford insurance to protect them from extreme conditions (C4, E10, and B1). - The unavailability or high cost of insurance coverage can impose financial hardships on consumers, especially those in disaster-prone regions, who may struggle to recover from losses without adequate protection. - The cumulative impact of asset devaluation, income stream disruptions, and affordability challenges can contribute to systemic risks within the banking, finance, and insurance sectors, potentially destabilising fiscal and financial systems at large.		
	Adaptation	Adaptation shortfall: High	Confidence: Low
	There are no Territory-wide or industry-specific policy, strategy or plan currently in place to reduce the risks of climate change to the banking, finance and insurance institutions and systems that offer services to the NT.	As a result of the high shortfall, there is little to no evidence available regarding the effects of future adaptation in managing this risk for the NT.	Adaptation urgency rating: Tier 1 New, stronger or different government policies or implementation activities are required, over and above those already planned are needed in the next five years, to reduce longer-term climate change risks to E3.

Economic Sustainability | Tier 1 Risk Profile | E7: Risks to Mining

Physical risks to mining (mining activities and commodities within the Northern Territory) due to an increase in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) that impact operations.

Table 30: Mining risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence There is currently a moderate decline in mining production and activity and/or loss of asset value >0.04% of gross product produced. Significant mining disruptions from climate change including floods shutting down transport routes resulting in profit reductions over the next year.	Major consequence There is expected to be a decline in mining production and economic activity and/or loss of asset value >0.4% of gross product produced. Significant changes to management climate change impacts will be required by the mining sector to respond and recover from disruption impacts.	Extreme consequence There is expected to be a decline in mining production and economic activity and/or loss of asset value >4% of gross product. Failure of the mining sector may occur if actions are not taken to mitigate climate impacts to production.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	• More frequent and intense natural disasters can damage mine sites while longer droughts and frequency of floods altering the water supply can disrupt mining operations, especially in remote areas. • In 2023 the mining industry in the Territory was worth \$8.2 billion, primarily producing manganese, gold, iron ore and bauxite.¹ • Water use and decreased access to water for mining operations is a major concern for mines as drought and increasing aridity become more severe in parts of the Territory. The Barkly region including Tennant Creek are expected to experience 4 more days of drought each dry spell in 2050 and 9 more days in 2090 increasing risks to water available for mining operations. • Extreme rain and floods is a major concern to mine sites as contaminated water or tailings infrastructure could be damaged and result in land and both surface and groundwater contamination threats. This can impact local Aboriginal communities and towns causing human health problems³ and agricultural soil contamination concerns⁴. • Mine rehabilitation activities including revegetation, erosion management, contaminated land and water monitoring and weed management can be impacted by increased climate impacts including extreme heat, drought, bushfire and extreme rain and floods, impacting the success of rehabilitation works⁵. For example, rehabilitation works at Ranger mine are expected to continue until 2026, with ongoing monitoring to ensure full revegetation and bushland recovery has occurred which could be hindered as more frequent bushfires are expected to occur in East Arnhem by 7 days in 2050 and 17 days in 2090. • Access to mining sites for staff working at the location and transporting mined product to ports for export overseas can be impacted by increased extreme rain and flooding and storms which can close roads for days or weeks at a time.⁶ • Mined product shipments can be impacted by storm damage resulting in port closure. For example, ex-Tropical cycle Megan damaged a South32 ship full of manganese, preventing it from leaving the Groote Eylandt Wharf for days, delaying the mineral supply chain earlier this year.⁷		
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	• Mining is particularly vulnerable to climate risks such as extreme heat, storms and floods, which can delay goods transport due to road and rail damages and reduce worker efficiency. • Mine sites with larger amounts of dry vegetation and dead materials such as leaves, or bark are at greater risk of bushfire starting and spreading on a mine site. • Remote mines are at greater risk of increasing drought as there are less opportunities to access piped water from key rivers such as the Roper River, McArthur River and Alligator Rivers.		

Economic Sustainability | Tier 1 Risk Profile | E7: Risks to Mining (cont.)

Table 30 (continued): Mining risk profile

Risk component			
Complexity	Extreme weather events pose significant physical risks to mining operations and commodities in the NT, amplifying the cascading nature of impacts between mining activities and other environmental and socio-economic factors. Some of the key cascading complex risks include:		
	• Extreme weather events can halt or delay mining activities, leading to production losses, operational disruptions, and increased costs for mining companies. • Mining activities can result in land and water pollution, contaminating soil, groundwater, and inland water systems, posing risks to human health and environmental sustainability (N2, N3, N5, N6, N8, and C2). • Climate-induced damage to transportation and logistics infrastructure (B6) can cause significant delays and disruptions in the export of mining commodities, impacting trade relationships and economic stability (E11). • Mining towns and communities reliant on mining activities may face adverse social and economic impacts if operations cease due to extreme weather impacts, leading to job losses, population displacement, and community isolation and loss of connection (C1, C3, C5 and C7).		
Adaptation	Adaptation shortfall: High	Confidence: Low	Adaptation urgency rating: Tier 1
	Upcoming Environment Protection reforms have been developed that require mine operators to follow a new risk-based licensing system and increased compliance and enforcement powers under the Environmental Protection Act. This will come into effect in July 2024. These changes do not specifically address climate change but aim to increase some environmental protection from mining operations in the Territory.	Given the lack of supporting policies, programs and legislation related to climate change impacts to mining, the confidence in available information is low.	New, stronger or different government policies such as incorporation of climate change risks into the Mining Act or Environmental Protection Act or implementation of other land and water contamination monitoring programs across the Territory are required. Resources over and above those already planned are needed in the next five years, to reduce longer-term climate change risks to mining.

Economic Sustainability | Tier 1 Risk Profile | E9: Risks to manufacturing

Physical risks to manufacturing (e.g., machinery and equipment, textile, wood, fabricated metal, etc.) to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) affecting assets, resources, site access and supply/distribution networks.

Table 31: Manufacturing risk profile

Risk component	Current	2050	2090
	Minor consequence	Moderate consequence	Major consequence
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Currently there is a minor decline of economic activity associated with manufacturing and/or loss of asset value of less than 0.004% of gross product produced. The manufacturing industry faces disruptions from climate change resulting in short-term (< 1 year) profit reductions.	There is expected to be a decline of economic activity associated with manufacturing and/or loss of asset value >0.04% of gross product produced. The manufacturing industry faces disruptions from climate change events that result in profit reductions with an impact of greater than 1 year.	There is expected to be a decline of economic activity associated with manufacturing and/or loss of asset value >0.4% of gross product produced. This can result in significant structural adjustment by manufacturing companies to respond and recover from climate related damages and operations impacts.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	- In 2023 the manufacturing industry in the Territory was worth \$1 billion, which included fabricated metal products, helium, transport equipment and repairs. The industry employed 3,722 people in 2023.¹ - The majority of manufacturing operations in the Territory are located just east of Darwin in locations including Berrimah, Winnellie, East Arm and Pinelands. Companies include Airducter, Nilsen, Darwin bakery and ADBRI Cement are all located in these areas and are the largest manufacturing businesses by sales revenue.² - Extreme climate events can damage manufacturing sites including equipment, product and raw materials leading to loss of profit. - Extreme rain, floods, storms and bushfires can prevent workers from accessing manufacturing sites due to road closures preventing manufacturing operations from running or posing safety concerns to worker if they are unable to vacate the site in extreme weather. This can lead to delays in transport, export and wider supply chain delays impacting business operations. - Extreme heat can impact worker productivity, health and wellbeing, especially if working in hot environments such as outdoors or in factories with limited airflow.³ This can have major impacts on human health as the number of days over 40°C are expected to increase by 7 in 2050 and 32 in 2090 in the Darwin, Palmerston, Litchfield region where manufacturing sites are located.		
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- Manufacturing sites near coastal and low topographic regions including close proximity to rivers are at greater risk of flooding from extreme weather, preventing daily operations and work from being completed. - Manufacturing sites located in remote locations not the Tarcoola- Darwin trainline or national highways such as the A1, 1, 87 and 66 are more vulnerable to materials and production transport delays due to extreme weather conditions and ageing transport infrastructure.		

Economic Sustainability | Tier 1 Risk Profile | E9: Risks to manufacturing (cont.)

Table 31 (continued): Manufacturing risk profile

Risk component			
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	Extreme weather events pose cascading risks to and from manufacturing in the Northern Territory, impacting assets, resources, and supply chains, with flow-on effects on construction, banking, finance, and environmental and human health:		
	• The combination of asset damage, resource scarcity, supply chain disruptions, and production downtime can lead to financial losses for manufacturing companies, suppliers, and stakeholders, affecting local economies and employment opportunities (C1). • Disruptions to transportation and logistics networks (B6) can affect the supply and distribution of raw materials, components, and finished goods, leading to delays and increased costs (E10 and E11). • Manufacturing facilities may experience downtime or reduced productivity during extreme weather events due to power outages (R1), equipment damage, or workforce absenteeism (C1), resulting in financial losses and missed opportunities (E10 and E11). • Extreme weather events affecting manufacturing operations can lead to financial losses for banking, finance, and insurance institutions due to asset devaluation, business interruption claims, and increased insurance premiums, impacting fiscal and financial systems (E3). • Extreme heat events in manufacturing facilities can pose health and safety risks to workers, including heat stress, dehydration, and heat-related illnesses, impacting worker productivity and wellbeing (C1 and C2).		
Adaptation	Adaptation shortfall: High	Confidence: Low	Adaptation urgency rating: Tier 1
	There are no Territory-wide policy, strategy or plan currently in place to reduce the risks of climate change to the manufacturing industry.	Given the lack of supporting policies, programs and legislation related to climate change impacts to manufacturing, the confidence in available information is low.	New, stronger or different government policies such as incorporation of climate change risks into the manufacturing policies or implementation of management programs are required. Resources over and above those already planned are needed in the next five years, to reduce longer-term climate change risks to manufacturing.

Economic Sustainability | Tier 1 Risk Profile | E10: Risks to small and medium businesses

Physical risks to small and medium enterprises (SMEs) due to increased costs/share of cash flow (for preparation, damage and clean-up) from extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge).

Table 32: Small and medium businesses risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Major consequence	Major consequence	Extreme consequence
	There is expected to be a decline of economic activity associated with small and medium businesses and/or loss of asset value >0.4% of gross product produced. This can result in significant structural adjustment required by small businesses to respond and recover from climate related damages and operations impacts.	There is expected to be a decline of economic activity associated with small and medium businesses and/or loss of asset value >0.4% of gross product produced. This can result in significant structural adjustment required by small businesses to respond and recover from climate related damages and operations impacts.	There is expected to be a decline in small and medium businesses economic activity and/or loss of asset value >4% of gross product. Failure of these businesses across a variety of sectors may occur if actions are not taken to mitigate climate impacts to production.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	• In June 2023 there were over 16,000 actively trading businesses in the Territory.¹ • As climate change impacts worsen, the financial pressure on small and medium businesses in the Territory is likely to increase, resulting in higher businesses failure due to unexpected costs from damages and rising insurance premiums. • The ACCC found that insurance premiums including those for small businesses in Northern Australia are much higher than the Australian average. The Northern Territory has the second highest small business building and contents insurance premiums in Australia, placing a higher financial cost and risk to business owners in the Territory.² These additional costs may reduce the number of businesses operating in future as the upfront capital costs to establish a business may be too high to justify the benefits. • Damages and operations disruptions from extreme weather such as extreme heat and extreme rain and floods are likely to become more frequent, further impacting the economic value in operating as a small or medium business in the Territory. The costs of building damages and disruption to operations may drive business owners out of the market and discourage new businesses from operating. • The Northern Territory Government have previously implemented hardship packages for businesses during the COVID-19 pandemic to support in paying utility bills, payroll tax and business operating costs to reduce the current burden on small business owners.³ • This impacting local and remote communities who may rely on small businesses in tourism including hospitality, retail and ecotourism activities for income for the community's survival.		
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	• Small and medium businesses operating in remote communities are more vulnerable to impacts from climate change including delays in operations from staff or patrons being unable to reach the shop due or reduction in the ability to run tourism services due to unsafe weather conditions including bushfires risk, storms and flooding. • Small businesses reliant on travellers and tourism for regular sales/income are more vulnerable to major events that prevent tourists from travelling such as COVID-19 pandemic which could become more frequent due to climate change.		

Economic Sustainability | Tier 1 Risk Profile | E10: Risks to small and medium businesses (cont.)

Table 32 (continued): Small and medium businesses risk profile

Risk component			
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	Extreme weather events escalate costs for small and medium enterprises (SMEs) in the Northern Territory, affecting cash flow and preparedness efforts, with ripple effects across tourism, urban centers, and financial systems:		
	- Impacts on transportation and logistics networks and infrastructure (B6) can be devastating for SMEs, particularly located in remote areas. These businesses may not be able to restock supplies, suffer financial loss due to restricted customer access, and loss in financial and employment wellbeing (C1 and C5). - SMEs in remote areas, crucial for tourism, suffer disruptions, affecting revenue streams and local economies heavily reliant on tourism (E8). - Urban centers and remote communities rely heavily on SMEs for essential goods and services; disruptions in SME operations due to extreme weather events can lead to supply shortages, service interruptions, and economic instability (C1, C2, C3, and C5). - Financial institutions face increased claims and liabilities from SMEs, impacting fiscal and financial systems and potentially raising insurance premiums (E3).		
Adaptation	Adaptation shortfall: High	Confidence: Low	Adaptation urgency rating: Tier 1
	A number of business grants and funding options are available to businesses in the Territory. Some of these offer support in paying electricity bills, upskilling workers or disaster assist to transport goods during storms or floods. Also, funding is available to incentive business development in valuable industries such as plastic recycling and circular economy entrepreneurship to support the number of businesses starting up and continuing in a growing industry for the future.	While funding and grants exist, there is no information to understand if these payments are creating possible outcomes for these businesses or incentivising new small and medium businesses to develop.	While some funding existing, additional government policies and support for small and medium business is required to prevent insurance premiums from becoming unaffordable across the Territory. Incorporation of climate change risks into the small business policies or support programs are required. Resources over and above those already planned are needed in the next five years, to reduce longer-term climate change risks to these businesses which are relied upon in many remote and regional communities across the Territory.

Economic Sustainability | Tier 1 Risk Profile | E13: Risks to the financial position of NT businesses

Transition risks to the financial position of NT businesses due to premature write-downs of fossil fuel assets (stranded assets), increased capital expenditure and investment on new technologies, and limited access to capital if perceived as laggards in climate action.

Table 33: Financial position of NT businesses risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence	Major consequence	Extreme consequence
	There is currently a moderate decline in Northern Territory business and activity valued at >0.04% of gross product produced. Significant business disruptions from climate change including storms, bushfires and floods result in profit reductions over the next year.	There is expected to be a decline of economic activity associated with Northern Territory businesses and/or loss of asset value >0.4% of gross product produced. This can result in significant structural adjustment required by businesses to respond and recover from climate related damages and operations impacts.	There is expected to be a decline in Northern Territory businesses economic activity and/or loss of asset value >4% of gross product. Failure of these businesses across a variety of sectors may occur if actions are not taken to mitigate climate impacts to production.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	- Businesses in the Territory are at risk of investment loss and stranded assets as fossil fuel intensive industries are phased out due to reputational risk and regulatory requirements to reduce emissions, particularly for high emitting businesses such as oil and gas operations.¹ - Larger businesses will typically be impacted regulatory pressures for reporting such as National Greenhouse and Energy Reporting Scheme (NGER) and the Safeguard Mechanism,² while smaller businesses may not experience as great risks to their businesses financial position from climate change transition pressures. - Businesses may face regulatory or reputational pressure from consumers to invest in new products or processes that reduce emissions or impact on the environment. This may require increased capital and ongoing costs to maintain, operate or produce using new technologies. For example, CSIRO and NT Government working with companies such as INPEX, Santos, Woodside, Eni, Origin Energy and Xodus to investigate the development of a Carbon Capture Utilisation and Storage (CCUS) Hub in Middle Arm. - Banks such as Commonwealth Bank of Australia (CBA and National Bank of Australia (NAB) are offering green business loans to businesses that deliver environmental emissions reductions or sustainability improvements such as delivery of renewable energy projects, electric vehicle relates businesses, green building upgrades, sustainable water and wastewater management and circular economy-based businesses.³ Conditional loans such as these pose a risk to businesses that do not reduce emissions or improve sustainability may be limited in their ability to borrow money into the future as regulatory and reputations risks tighten. - High emitting businesses such as oil and gas, steel manufacturing and mining will face higher risks of stranded assets and increased capital expenditure on emissions reduction technologies such as Carbon Capture Utilisation and Storage (CCUS).		

Economic Sustainability | Tier 1 Risk Profile | E13: Risks to the financial position of NT businesses (cont.)

Table 33 (continued): Financial position of NT businesses risk profile

Risk component			
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- Businesses with long-lived tangible assets may be more vulnerable to premature write-downs of fossil fuel assets such as power stations, specialised building infrastructure, machinery and equipment due to market and regulatory pressures. - Businesses such as oil, gas, steel and mining may be more vulnerable compared to other sectors as emissions abatement options can be limited or more costly to implement.		
Adaptation	Adaptation shortfall: High	Confidence: Low	Adaptation urgency rating: Tier 1
	There are no Territory-wide policy, strategy or plan currently in place to reduce the risks of climate change to the Territory's financial position, particularly relating to high reliance on emissions intensive industries such as oil and gas operations which are facing greater regulatory compliance.	There is existing literature that identifies the importance of transitioning to a lower carbon economy to support financial positions, however the costs of implementing these actions and the future market are not always clear. As such the confidence in available information is considered low.	The Territory requires additional government policies such as incorporation of climate change risks into the manufacturing policies or implementation of management programs are required. Resources over and above those already planned are needed in the next five years, to reduce longer-term climate change risks to manufacturing.

Economic Sustainability | Tier 1 Risk Profile | E14: Risks to the NT economic growth

Transition risks to the NT’s economic growth due to slow, ineffective or no action on emissions reduction.

Table 34: NT economic growth risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Major consequence	Major consequence	Major consequence
	There is expected to be a decline of economic growth associated with the Northern Territory >0.4% of gross product produced by 2050. This can result in significant structural adjustment required by businesses to respond and recover from climate related damages and operations impacts.	There is expected to be a decline of economic growth associated with the Northern Territory >0.4% of gross product produced by 2050. This can result in significant structural adjustment required by businesses to respond and recover from climate related damages and operations impacts.	There is expected to be a decline of economic growth associated with the Northern Territory >0.4% of gross product produced by 2090. This can result in significant structural adjustment required by businesses to respond and recover from climate related damages and operations impacts.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	- The Northern Territory is already experiencing some uncertainty in the economic growth of the Territory. In 2022-23 the Northern Territory experience a decline in the value of good exports of 27% and net export of services of 112%.¹ Additionally, mining profits fell by 17% last year, which contributed to the Territory's 5% drop in Gross State Product (GSP) for 2022-23.² - However, in 2023 there was 18% growth in transport, postal and warehousing operations as well as 6% in construction and 12% in public capital investment, indicating the variable nature of the Territories economic position.³ - The Territory is reliant on emissions intensive industries such as oil, gas, mining and manufacturing for GSP. These emissions intensive industries will face continued pressure from consumers, government and industry to reduce emissions, however this is sometimes at odds with business operations profit. There is a risk that the Northern Territory experience decreased economic growth due to decreased investment in these major industries due to market pressures and reputational risks associated with high energy emissions industries.		
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- Businesses that do not consider the risks and opportunities of climate change and emissions reductions into their business operations are at greater risk of reduced business operations and overall contributing to lower economic growth impacted by a slower transition to a low carbon local economy. - The Territory's biggest international trading partners include Japan, China, Taiwan and South Korea.⁴ Due to transition drivers to a low carbon economy, these countries may require produced goods to align with low emissions targets to support their ambitions to reach net zero by 2050 and 2060 (China). This may make hard to abate but commonly traded products such as minerals to be more vulnerable to decreases in trade and pressure to decarbonise over time, impacting the Territory's economic growth.		
Adaptation	Adaptation shortfall: Medium	Confidence: Low	Adaptation agency rating: Tier 1
	The Northern Territory has some existing policy frameworks such as 'Towards 2050' that will enable the Territory to strategically manage climate change risk and opportunities. Additionally, a climate change impacts report has been released to the NT public and serves as a resource for all Territorians who want to understand how climate change will affect them. A climate change NT website has been developed to raise awareness and educate people. Darwin Heat Mitigation Strategy also aims to help people adapt to Darwin's future heat-related climate challenges, using heat mitigation methods to shade and cool the city, and reduce heat-related health challenges.	The policy framework and strategy mentioned are a good starting point, but don't provide details of the success of any adaptation actions to date, there confidence in available information is low.	The Territory requires additional government policies, requirements to factor climate change risks including emissions reductions into business policies or implementation of management programs are required. Resources over and above those already planned are needed in the next five years, to reduce longer-term climate change risks to economic growth.

Economic Sustainability | Tier 2 risk statements

Listed below are the eight Tier 2 Adaptation Urgency risk statements for Economic Sustainability. For each of these risk statements, more information is required (for example, through a new study or additional research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.

Table 35: Economic sustainability Tier 2 risk statements

Risk statement		
E1	Physical	Risks to agriculture and forestry due to changes in chronic rainfall and temperature, drought conditions, invasive species, saltwater intrusion, water availability and evaporation impacting growing season length and conditions and increasing impact/damage due increases in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and associated land clearing for additional operations.
E2	Physical	Risks to fishing and aquaculture (both land-based and marine) resources and associated infrastructure due to changes in chronic temperature, ocean temperature and acidification impacting the spatial distribution of fish stocks, along with growing conditions/productivity/health of aquaculture sites.
E4	Physical	Risks to charities and not-for-profits (providing social assistance to communities and individuals) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing a rise in event related demand for social assistance.
E5	Physical	Risks to construction industry and associated supply chain due to an increase in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) that lead to delays, damaged assets and increased costs, including increased work, health and safety costs.
E6	Physical	Risks to healthcare and emergency services due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and chronic weather changes causing a rise in event related emergency and health issues, including biting insects and vectors.
E8	Physical	Risks to tourism (tourism businesses and services, visitor destinations and attractions) due to ongoing sea level rise, changes in chronic rainfall and temperature, and increases in extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge).
E11	Physical	Risks to export and trade sector (international trade, wholesale and retail trade) due to increased frequency intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) leading to disruptions/delays.
E12	Transition	Risks to operating costs of NT businesses from transitioning to low carbon economy due to carbon tax, increased supply chain costs, benchmarking requirements, lower productivity from operating new technologies, and new activities to adapt to the shift of consumer preference to low emission products.



Community health and wellbeing

Community health and wellbeing | Introduction



The community health and wellbeing liveability measures includes society, government, communities, families and individuals of the NT have the capacity and resources to adapt to and avoid the worst impacts of climate change and to maintain health, wellbeing, prosperity and cultural livelihoods.

Under this liveability measure, there are:

- Nine physical risk statements
- One transition risk statement, and
- Two opportunity statements (refer to the *Climate change opportunities for the Northern Territory* section).

Refer to pages 75-76 for the full list of risks assessed.

Summarised in Table 36 are the risk statements which have been identified as 'Tier 1 Adaptation Urgency' and 'Tier 2 Adaptation Urgency Risks'.

The Tier 1 risks are discussed in further detail on pages 77-84.

Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 36: Summary of community health and wellbeing risk statements

Tier 1 Adaptation Urgency Risks	
C5	Risks to Northern Territory communities (including remote communities)
C6	Risks to cultural heritage including Aboriginal cultural heritage
C7	Risks to skills and education
Tier 2 Adaptation Urgency Risks	
C1	Risks and opportunities to employment and financial wellbeing
C2	Risks to health and wellbeing
C3	Risks to social cohesion
C4	Risks to housing
C5	Risks to Northern Territory communities
C8	Risks to social welfare services
C9	Risks to sports and recreation

Community health and wellbeing | Risk statements and ratings

Summarised below are the ratings assigned to each of the community health and wellbeing risk statements. The risk statements which have been identified as 'Tier 1 Adaptation Urgency' are discussed in further detail on pages 77-84. Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 37: Community health and wellbeing risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
C1	Physical	Risks and opportunities to employment and financial wellbeing due to changes in chronic temperature and rainfall, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires) impacting working conditions, locations and the job types available.	Moderate	Major	Extreme	Medium	High	Tier 2
C2	Physical	Risks to health and wellbeing (physical health, mental health, social wellbeing, quality of life and security) due to ongoing sea level rise, changes in chronic rainfall and temperature, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing physical and mental trauma, restricting resource access and quality, impacting identity, autonomy, wellbeing and the spread of diseases.	Moderate	Major	Extreme	Medium	High	Tier 2
C3	Physical	Risks to social cohesion (connectedness and solidarity including domestic violence and exacerbation of differences between Aboriginal and non-Aboriginal communities) due to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) that displace or isolate individuals, families and communities.	Major	Extreme	Extreme	Medium	High	Tier 2
C4	Physical	Risks to housing (crisis accommodation, social housing, private housing and housing affordability) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise displacing individuals, increasing damage costs and insurance affordability.	Moderate	Major	Extreme	Medium	High	Tier 2

Community health and wellbeing | Risk statements and ratings (cont.)

Table 37 (continued): Community health and wellbeing risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
C5	Physical	Risks to the Northern Territory communities (including remote communities) (retention of skilled workforce, liveability of regional areas, healthcare etc.) due to changes in chronic temperature and rainfall, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) affecting physical living conditions, employment prospects and housing affordability.	Moderate	Extreme	Extreme	Medium	Medium	Tier 1
C6	Physical	Risks to cultural heritage including Aboriginal cultural heritage (places of significance, culture, cultural heritage, values and principles) due to impacts from ongoing sea level rise and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge).	Major	Extreme	Extreme	Medium	Medium	Tier 1
C7	Physical	Risks to skills and education due to changes in chronic temperature and rainfall, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) affecting mental health, access to education, the availability of skilled workforce and students.	Minor	Major	Major	Medium	Low	Tier 1
C8	Physical	Risks to social welfare services due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) impacting staffing, transport, communications and access to facilities.	Moderate	Major	Extreme	Medium	Medium	Tier 2
C9	Physical	Risks to sports and recreation due to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing damage, creating unsafe conditions and transportation/logistical issues that impact availability and access to facilities (both natural and man-made).	Moderate	Major	Extreme	Medium	High	Tier 2
C10	Transition	Risk to housing access and affordability in NT due to new people moving in NT to support the growth and expansion of industries that mitigate climate change (such as hydrogen or renewable energy)	Moderate	Moderate	Major	Low	High	Tier 3

Community health and wellbeing | Tier 1 Risk Profile | C5: Risks to the Northern Territory communities (including remote communities)

Physical risks to the Northern Territory communities (including remote communities) (retention of skilled workforce, liveability of regional areas, healthcare etc.) due to changes in chronic temperature and rainfall, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) affecting physical living conditions, employment prospects and housing affordability.

Table 38: Northern Territory communities risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence	Extreme consequence	Extreme consequence
	Currently, climate change and extreme weather events have moderate consequences for the communities and their overall wellbeing. At a Territory-wide scale, NT communities are experiencing moderate challenges in social welfare and housing, with occasional interruptions in education, employment, and essential community services. Daily activities and behaviours are increasingly affected, and the sense of community connectedness is strained. Recovery efforts require significant resources.	By 2050, the consequences of climate change are expected to become extreme, severely compromising the health, safety, and wellbeing of NT communities. NT communities, particularly those most vulnerable and remotely located, may experience permanent disruptions to education, employment, and community services, leading to a breakdown in daily activities and community bonds. The community's functionality will be critically impaired. The impacts will be profound at a Territory-wide scale, necessitating urgent and extensive responses from Northern Territory agencies.	If unmitigated by 2090, the impacts of climate change will likely remain extreme, with conditions potentially worsening beyond those projected for 2050. The consequences will likely be acutely pronounced in the most vulnerable communities, such as those located in remote and isolated regions of the NT.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i> <i>Continued on the following page</i>	The Northern Territory is home to roughly 252,469 residents, spread across unique and diverse communities, each varying in size and geography.¹ The Northern Territory is the most sparsely populated jurisdiction in Australia with nearly 40% dispersed over remote and very remote areas, and up to 80% of the Aboriginal population residing in those areas.⁴ Population sizes range from as few as 34 residents in Mangarrayi to as many as 139,902 residents in Darwin (as at 2021).^{2,3} As at June 2021, there were an estimated 76,546 Aboriginal people living in the NT, representing approximately 30.8% of the NT's population.¹ These communities are, and will continue to be, exposed to climate change as conditions in the NT become hotter, drier, and extreme weather events increase in both intensity and frequency. The exposure of the communities to these changed climatic conditions will vary depending on their geographical location. This can strain the capacity of affected communities to recover and rebuild, exacerbating existing vulnerabilities. Access to rural and regional areas may also be compromised due to damaged roads, bridges, and other infrastructure, isolating these vulnerable communities, and hindering mobility and access to essential services. Discussed below are how communities in the Northern Territory is likely to be exposed to climatic changes and extreme events in the future, and how this exposure is likely to impact these communities Note that this list is not exhaustive, but rather highlights key exposures and impacts: - Climate projections for the NT indicates that on average, the Territory is likely to experience a 22cm sea level rise by 2030, which is projected to significantly increase to 57cm by 2090. This will likely pose significant challenges for NT communities located in low-lying coastal areas in Big Rivers, Darwin, Palmerston, Litchfield, East Arnhem, and the Top End. The overall liveability of some coastal communities may be adversely affected by these conditions. For example, these coastal communities may experience more frequent and long-term disruptions in their access to essential and community services, and impacted buildings and structures resulting in displacement.⁶ - The increasing frequency and intensity of extreme weather events will likely disrupt daily life and reduce the appeal of living in some areas and communities. For example, chronic heatwaves and severe storms can lead to infrastructure damage and increased living costs, making it challenging to maintain a stable and skilled workforce. The harsh climate conditions will likely deter new talent from relocating and make it difficult for current residents to stay, leading to a decline in local economic activity and community services. A recently study, for example, identified that 34% of NT doctors indicated that climate change is already, or is likely to, make them consider leaving the NT.⁹ Refer to the C7 Risk Profile (Risks to skills and education) for more information.		

Community health and wellbeing | Tier 1 Risk Profile | C5: Risks to the Northern Territory communities (including remote communities) (cont.)

Table 38 (continued): Northern Territory communities risk profile

Risk component	
Exposure (continued)	- Climate projections indicate that the NT will likely experience an increase in the severity and frequency of extreme rainfall, and flooding. This will likely have serious implications for a number of NT communities, particularly those located in remote regions of the Territory and with restricted access to road and transport infrastructure. As discussed in the B6 Risk Profile (Transport and Logistics), regional and remotes communities can be isolated for up to six months at a time due to wet season rain events as roads are closed for long periods of time. It is also likely that continued exposure and impact flooding events may impact on the liveability of some regions and communities, as those affected experience chronic displacement, and cannot afford the continued cost of recovering and rebuilding after each disastrous event. - Climate projections for the NT indicates that it is likely that all NT regions will experience an increase in the hottest annual temperatures, and more days over 35°C and 40°C. This will be most significant towards the end of the century, with the Territory to experience 87 days over 35°C and 77 days over 40°C a year. Across all timeframes, Darwin, Palmerston and Litchfield are projected to experience the most significant increases in days over 35°C (74 days by 2050, and 155 days by 2090). Across all timeframes, Barkly is projected to experience the most significant increases in days over 40°C (38 days by 2050, and 86 days by 2090). - Heatwaves and extreme heat pose a serious risk to human health and have been the cause of more deaths in Australia than bushfires, cyclones, earthquakes, floods and severe storms combined. Exposure to extreme heat can result in the heat stress, heat exhaustion, and heat stroke.¹² Extreme heat events presents a significant challenge to the mental health and wellbeing of those communities most exposed and that have limited access to heat relief. Extreme heat events and prolonged periods of increased ambient temperatures have been associated with increased anti-social behaviour, increased levels of aggression and domestic violence, and mental and behavioural disorders, such as self-harm.¹³ Additionally, rates of domestic violence and violent crimes tend to increase during heatwaves.¹⁴
Vulnerability How susceptible is the system to the driver, level of resilience, can it adapt? Continued on the following page	As highlighted throughout this Technical Report, rural and remote communities in the Northern Territory are acutely vulnerable to the impacts of climate change, and will likely become more vulnerable if climate-related risks are not adequately mitigated through government intervention. The NT's remote communities are particularly vulnerable because of their geographical remoteness and isolation, limited access to health, education and other services. Other key factors which contributes to the vulnerability of communities includes: - The physical and mental health and wellbeing of communities are contributing factors to climate vulnerability. Factors which increase susceptibility to climate change includes children and adolescence, older persons (over the age of 65 years), and persons with existing health conditions.¹⁰ - Low-income households, persons experiencing social vulnerability (e.g., social isolation) and socio-economic disadvantage are more vulnerable to climate change.¹⁰ As per the Socio-Economic Indexes for Areas (SEIFA) rankings, a number of communities in the NT are currently experiencing high levels of socio-economic disadvantage. SEIFA combines Census data such as income, education, employment, occupation, housing and family structure to summarise the socio-economic characteristics of an area. Particularly, Belyuen, West Daly, East Arnhem, and Central Desert, which are recognised as some of the most disadvantaged LGAs in Australia.¹¹ - Persons experiencing housing instability are more vulnerable.¹⁰ The NT is experiencing a housing challenge across its communities. The waiting list for public housing across urban and regional areas sits at over 3,500 applications, with wait times ranging from two to eight years.⁸

Community health and wellbeing | Tier 1 Risk Profile | C5: Risks to the Northern Territory communities (including remote communities) (cont.)

Table 38 (continued): Northern Territory communities risk profile

Risk component			
Vulnerability <i>Continued</i>	- Aboriginal people currently experience higher rates of climate-sensitive health conditions and socio-economic disadvantages, which will impact their capacity to adapt to climate change. Climate change may also adversely affect cultural practices.⁵ - Rural, remote and regional communities in Australia are especially susceptible to the impacts of climate change, due to their reliance on water-intensive primary industries, which are directly affected by shifts in the climate. Diminished health and wellbeing of rural people, especially farmers, primarily caused by drought, has been observed across Australia.¹⁵ - Coastal communities located in low-lying regions are vulnerable to ongoing sea level rise and coastal extreme weather events (e.g., storm surge and coastal flooding). For example, the coastal community of Maningrida is considered exposed and vulnerable due to their geographical location and isolation, and the implications which climate change will likely have on their ability to continue living in the region.⁶ - Remote communities are more likely to experience challenges and disadvantage due to low quality and poorly insulated housing, and energy instability.⁷ Inadequate housing conditions contributes significantly to the susceptibility of communities to consequences such as heat-related illnesses and morbidity. - People who work outdoors or in enclosed indoor spaces without adequate ventilation are more vulnerable to extreme heat.		
	Complexity <i>High-level narrative description of some cascading risks and impacts</i>		
Adaptation	Adaptation shortfall: Medium	Confidence: Medium	Adaptation urgency rating: Tier 1
	There is currently limited policies, strategies or plans in place specific to ensuring that NT communities, particularly remote communities, can adapt to climate change. While some work is being done, more targeted work will be required in the next five years to ensure that the Territory's communities are sufficiently protected and can adapt in the face of the changing climate.	There is some evidence on the effects of adaptation actions currently in place, and the benefits it provides to Northern Territory communities.	Due to climate-related challenges Northern Territory communities face, particularly those living in remote and rural areas, and their vulnerability to the risks associated with ongoing climate change, more action will be required in the next five years. New, stronger and different policies or implementation activities will be needed, over and above what is currently in place and planned.

Community health and wellbeing | Tier 1 Risk Profile | C6: Risks to cultural heritage, including Aboriginal cultural heritage

Physical risks to cultural heritage including Aboriginal cultural heritage (places of significance, culture, cultural heritage, values and principles) due to impacts from ongoing sea level rise and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge).

Table 39: Cultural heritage risk profile

Risk component	Current	2050	2090
	Major consequence	Extreme consequence	Extreme consequence
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Presently, climate change and extreme weather events have major consequences for cultural heritage and connection in the NT. The impacts this has are major at a Territory-wide scale as connectedness is significantly broken and there is widespread damage/loss of cultural assets. These impacts require immediate action from relevant agencies to respond to adverse impacts. Notably, however, the consequences can be reversed through significant intervention.	Climate projections for 2050 indicate that climatic changes and extreme weather events will likely worsen by 2050. These changes will likely have extreme impacts and will be of heightened interest to NT agencies to urgently control or respond to. The consequences of these impacts will likely be permanent and irreversible. The NT may suffer permanent loss of cultural assets, which may result in some communities ceasing to function effectively as the toll such loss will have, will be significant.	By 2090, climate projections indicate that the NT will likely experience a marked increase in the frequency and intensity of extreme weather events and climatic changes. This will likely significantly exacerbate the already extreme consequences and impacts these changes have the Territory's cultural heritage, as described for 2050.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i> <i>Continued on the following page</i>	Culture is defined as the practices and beliefs owned by a community or people or group. It provides distinct identity such as language and dialect, gestures, customs and traditions that define values and organise social interactions, religious and spiritual beliefs and rituals. This includes dress, art, food and music as forms of cultural and symbolic expression. The NT has a rich and diverse range of Aboriginal and European cultural heritage, values, and principles. ¹ Some of the Territory's key cultural heritage sites include (but are not limited to): ⁵ - Archaeological places, including artefact scatters, shell middens, earth mounds, quarries, stone arrangements, rock shelters with evidence of occupation, rock art, burial places, and places that provide evidence of early contact between Aboriginal peoples. - Two world Heritage sites at the Kakadu National Park and Uluru-Kata Tjuta National Park. - National Heritage Places such as the Hermannsburg Historic Precinct (Ntaria) and the Wave Hill Walk-Off Route (Daguragu).⁶ - Macassan heritage sites and artefacts located along the NT coastline. Current and future exposure of NT tangible and intangible cultural heritage to climate change include (but are not limited to): - The Kakadu National Park is exposed and vulnerable to rising sea levels, leading to coastal erosion and saltwater entering wetlands. The region is also experiencing more extreme temperatures and heatwaves, changing fire regimes, more intense cyclones, and increasingly intense extreme rainfall events.^{2,7} The Park is at risk of loss of biodiversity, due to bushfires, degradation and damage to rock art (bushfire, extreme rainfall, sea level rise, floods), accelerated erosion from sea level rise, and the destruction of wetland communities from intensified cyclones.⁴ - The Marthakal Indigenous Protected Area, covering remote islands and coastal mainland areas in the Northeastern Arnhem Land, has an average elevation of 1m above sea level. This makes the area significantly exposed and vulnerable to continued sea level rise, storm surge, and cyclone events.³ - Uluru-Kata Tjuta National Park is highly exposed to temperature increases, bushfires, and flooding.⁴ - Changing precipitation patterns and increased evaporation rates may lead to water scarcity in certain regions of the NT, impacting cultural practices that rely on access to water sources for rituals, ceremonies, and daily activities. - Coastal archaeological and cultural heritage sites are at risk of destruction and loss as a result of continued sea level rise.		

Community health and wellbeing | Tier 1 Risk Profile | C6: Risks to cultural heritage, including Aboriginal cultural heritage (cont.)

Table 39 (continued): Cultural heritage risk profile

Risk component			
Exposure <i>(continued)</i>	- Increased temperatures and rising sea levels will likely impact on the availability of traditional food resources.⁸ Some of the anticipated impacts of climate change and more intense and frequent extreme weather events on cultural heritage (both Aboriginal and European) in the future will be: - The continued and exacerbated degradation and irreversible loss of cultural values and sites of cultural and historical significance. - Loss of access to natural resources critical to cultural practices and connection. - Continued grief, anger, trauma, and harm within Aboriginal communities due to the continued impacts and loss of cultural heritage and connection. - Interruptions to cultural practices. - Continued difficulties in accessing and caring for Country, and maintaining connections with the landscape and associated ecosystems.		
	Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>		
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	- Cultural heritage and places of significance are finite resources, and highly vulnerable to impacts as it often cannot be restored or replaced when damaged. - The environmental impacts of climate change, including bushfires, floods and other disasters, have, and will continue to, disproportionately affect Aboriginal communities' way of life. - Some communities are geographically diverse, which can make them more vulnerable as access can be limited or restricted. This includes access to resources, and access to the communities to provide disaster response and recovery support. - Many Aboriginal cultural sites are located along the NT coastline. Rising sea levels and increased storm surge and cyclone intensity can accelerate coastal erosion, threatening the integrity of these sites. - Traditional Aboriginal practices, such as fire management techniques, may also be susceptible to climate change impacts, such as altered fire regimes due to changing rainfall patterns. - Aboriginal communities in the NT rely heavily on natural resources for customary use and business.⁸		
	Some of the key cascading complex risks which are linked to cultural heritage in the NT includes: - The loss of cultural heritage can have detrimental implications for social cohesion, and the health and wellbeing of affected individuals and communities are linked to the heritage (C2 and C3). - Cultural practices and connections can be impacted in the event that natural resources and landscapes damaged or destroyed by climate change (N1, N2, N3, N4, N5, and N6).		
Adaptation	Adaptation shortfall: Medium	Confidence: Medium	Adaptation urgency rating: Tier 1
	There is currently no policy, strategy or plan in place specific to ensuring the NT's cultural heritage can adapt to climate change. While some work is being done to protect the Territory's culture, more targeted work will be required in the next five years to ensure that the Territory's cultural heritage is sufficiently protected and can adapt in the face of the changing climate.	There is some evidence on the effects of adaptation actions currently in place, and the benefits it provides in protecting cultural heritage and sites of significance.	Due to the vulnerable nature of the Territory's cultural heritage, more action will be required in the next five years. New, stronger and different policies or implementation activities will be needed, over and above what is currently in place and planned.

Community health and wellbeing | Tier 1 Risk Profile | C7: Risks to skills and education

Physical risks to skills and education due to changes in chronic temperature and rainfall, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) affecting mental health, access to education, the availability of skilled workforce and students.

Table 40: Skills and education risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Major consequence	Major consequence	Major consequence
	In the present day, the NT is experiencing disruptions to skills and education due to extreme weather events. Extreme weather events such as storms, cyclones, floods, and bushfires lead to temporary closures of schools, affecting students' ability to access to education and disrupting learning routines. Mental health issues arise among students and educators alike, further complicating the educational landscape. The availability of a skilled workforce is affected as individuals struggle to maintain consistent employment and training opportunities amidst climate-related uncertainties.	By 2050, the NT will likely face intensified challenges in skills and education as climate change progresses. Climatic changes and intensified weather events will likely significantly alter the skill requirements for various sectors, leading to a mismatch between workforce capabilities and industry demands. Extreme weather events will likely become more frequent and severe, likely causing prolonged disruptions to educational institutions and interfering with students' ability to attend classes regularly. Mental health issues among students and educators escalate, impacting learning outcomes and educational attainment. The availability of a skilled workforce may also decline as individuals face increased barriers to accessing education and training opportunities, exacerbating socio-economic inequalities.	In 2090, the NT will likely experience profound impacts on skills and education as a result of the changing climate. Chronic temperature and rainfall changes can render traditional skills obsolete, requiring communities to adapt to new livelihood practices. As extreme weather events will likely experience significant increase in intensity and frequency, educational infrastructure will be more likely to be damaged, resulting in the widespread displacement of students and teachers. Mental health issues can also become endemic within the education system, affecting students' ability to learn and educators' capacity to teach effectively. The availability of a skilled workforce in the NT may also reduce significantly as educational attainment declines due to prolonged disruptions.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	There 153 government schools spread across 1.35 million square kilometers. 71% of schools are located in remote and very remote areas, with 44% of the NT's total student population (approximately 34,000 students) attending those remote schools. Further, 44% of students in the NT speak a language other than English at home. ² The NT schooling system operates in Australia's most challenging socio-economic and geographic context. ¹ Listed below are examples of how Climate change can impact on in the NT: - Chronic changes in the Territory's temperature and rainfall patterns can impact on education infrastructure through heat stress and water damage. This can result in disruptions in regular classes and educational activities. Extreme weather events can also damage educational infrastructure, leading to disruptions in learning environments and compromising the safety and comfort of the students and staff. - Continued exposure to high temperatures results in poor health and wellbeing of students and teachers (for example, heat-related illnesses, dehydration, fatigue) and reduced concentration and productivity rates. These uncomfortable working conditions can also lead to a higher turnover of teachers, which had a negative impact on students' continuity of learning.³ - Extreme weather events (for example, floods, bushfires, storms and cyclones) can damage roads, bridges, and other transportation infrastructure, making it difficult for students to access schools and educational facilities, particularly in remote areas. - Power outages, water shortages, and communication breakdowns during extreme weather events can disrupt educational services, affecting students' ability to attend classes and access resources. - Bushfire and flood-affected communities and transport infrastructure means that students become displaced, and their access to education is disrupted. Students in these circumstances likely face a myriad of challenges with regards to their wellbeing and subsequently their academic performance. This is particularly pronounced in remote regions, where there is limited access to alternative transport infrastructure and education solutions.		

Community health and wellbeing | Tier 1 Risk Profile | C7: Risks to skills and education (cont.)

Table 40 (continued): Skills and education risk profile

Risk component	
Exposure <i>(continued)</i>	• Extreme weather events like bushfires and cyclones can disrupt local economies, leading to job losses and migration out of affected areas. This can result in a reduction in the availability of skilled workers and students in the region. With regards to exposure of the Territory's skilled workforce, there has been evidence to date of how climate change and the extreme heat is contributing to challenges in the attraction and retention of skilled workforces. For example, a recent survey shows that 34% of NT doctors indicated that climate change is already, or is likely to, make them consider leaving the NT. This loss will result in devastating consequences for the NT, its healthcare system, and communities.⁸
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	• The NT schooling system operates in Australia's most challenging socio-economic and geographic context. The NT has the highest concentration of very small schools in remote and very remote areas with a range of complex external factors contributing to the challenges of students engaging in and attending school, educational achievement, school completions and entry into employment. The Index of Community Socio-educational Advantage (ICSEA) for NT government schools, show that 71% of all NT government schools fall into the bottom decile of scores for all Australian schools, and of the 100 most disadvantaged schools nationally, 55 are from the NT.¹ • The NT is currently experiencing a growing chronic teacher shortages, and continued limited access to resources to adequately meet the needs of students. In 2018, the total number of teachers registered with the Teachers Registration Board of the Northern Territory was 5,737. • Remote and very remote schools in the NT are made of culturally diverse students, and are generally highly vulnerable and disadvantaged.⁴ • There are several schools across the NT which do not have access to cooling systems, such as air-conditioning, which increase the vulnerability of students and teachers to the effects of extreme heat.⁵ • Young children are the most at-risk and vulnerable to the effects of extreme heat and extreme weather events.^{6,7} • Coastal regions in the NT are particularly vulnerable to storm surge, flooding, and erosion due to sea level rise and extreme weather events, affecting infrastructure and communities.

Community health and wellbeing | Tier 1 Risk Profile | C7: Risks to skills and education (cont.)

Table 40 (continued): Skills and education risk profile

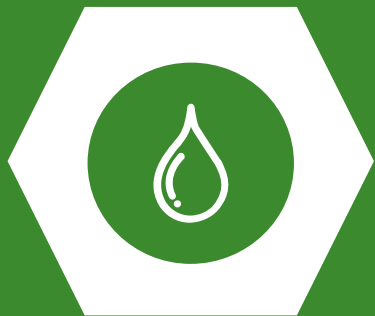
Risk component			
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	Skills and education in the NT face mounting risks stemming from changes in chronic temperature and rainfall patterns, alongside the increasing frequency and severity of extreme weather events. These risks have the following cascading effects:		
	- Exacerbated stress and anxiety levels among students, educators, and workers, negatively impacting mental health and overall wellbeing (C2 and C3). - Disruptions caused by extreme weather events, such as storms or floods, can hinder access to educational facilities and resources, leading to learning setbacks and educational inequalities, particularly in remote and vulnerable communities. - Impacted development of a skilled workforce, exacerbating skill shortages and hindering economic growth (C1 and E10). - SMEs reliant on skilled workers and graduates from local educational institutions may face challenges in recruiting and retaining talent, impacting productivity, innovation, and competitiveness (C1 and E10).		
Adaptation	Adaptation shortfall: Medium	Confidence: Low	Adaptation urgency rating: Tier 1
	The NT Government has recognised the importance of building climate resilience into workforce planning and employment conditions. There is however no clear policy or strategy in place to manage climate-related risks to skills and education in the NT.	Confidence is low as there is limited evidence available of the effects of the implemented and planned adaptation actions to manage the climate-related risks and ensure that education and skills in the NT can adequately adapt to the changing climate, now and in the future.	Without immediate and targeted interventions, the consequences of climate change will continue to exacerbate existing inequalities and threaten the Territory's long-term socio-economic development. New and stronger government policies and implementation activities are needed in the next five years to reduce longer term climate change risks.

Community health and wellbeing | Tier 2 risk statements

Listed below are the six Tier 2 Adaptation Urgency risk statements for Community Health and Wellbeing. For each of these risk statements, more information is required (for example, through a new study or additional research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.

Table 41: Community health and wellbeing Tier 2 risk statements

Risk statement		
C1	Physical	Risks and opportunities to employment and financial wellbeing due to changes in chronic temperature and rainfall, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods and bushfires) impacting working conditions, locations and the job types available.
C2	Physical	Risks to health and wellbeing (physical health, mental health, social wellbeing, quality of life and security) due to ongoing sea level rise, changes in chronic rainfall and temperature, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing physical and mental trauma, restricting resource access and quality, impacting identity, autonomy, wellbeing and the spread of diseases.
C3	Physical	Risks to social cohesion (connectedness and solidarity including domestic violence and exacerbation of differences between Aboriginal and non-Aboriginal communities) due to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) that displace or isolate individuals, families and communities.
C4	Physical	Risks to housing (crisis accommodation, social housing, private housing and housing affordability) due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) and ongoing sea level rise displacing individuals, increasing damage costs and insurance affordability.
C8	Physical	Risks to social welfare services due to increased frequency and intensity of extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) impacting staffing, transport, communications and access to facilities.
C9	Physical	Risks to sports and recreation due to extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and storm surge) causing damage, creating unsafe conditions and transportation/logistical issues that impact availability and access to facilities (both natural and man-made).



Resource security

Resource security | Introduction



The resource security liveability measures includes:

- Water security (having an acceptable quantity and quality of water for people, economic opportunities, cultural and environmental needs, now and in the future. The key elements of water security are water supply, quality and demand.
- Energy security is about ensuring sufficient, affordable and sustainable energy resources to meet Territorian energy needs, today and in the future.
- Food security relates to the economic and physical access to culturally appropriate, safe and sufficient healthy food and the ability to safely store and utilise it.

Under this liveability measure, there are:

- Two physical risk statements
- Two transition risk statements, and
- Two opportunity statements (refer to the *Climate change opportunities for the Northern Territory* section).

Refer to page 88 for the full list of risks assessed.

Summarised in Table 42 right are the risk statements which have been identified as 'Tier 1 Adaptation Urgency' and 'Tier 2 Adaptation Urgency Risks'. The Tier 1 risks are discussed in further detail on pages 89-91.

Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 42: Summary of resource security risk statements

Tier 1 Adaptation Urgency Risks	
R2	Risks to water resource and associated infrastructure
Tier 2 Adaptation Urgency Risks	
R1	Risks to energy generation, transmission, distribution as well as energy infrastructure
R3	Risks to electricity and gas system reliability and security
R4	Risk to water resources and availability

Resource security | Risk statements and ratings

Summarised below are the ratings assigned to each of the resource security risk statements. The risk statements which have been identified as 'Tier 1 Adaptation Urgency' are discussed in further detail on pages 89-91. Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 43: Resource security risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
R1	Physical	Risks to energy generation, transmission, distribution as well as energy infrastructure due to changes in chronic temperature and precipitation affecting water availability, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and winds) causing damage and increased capital and operational expenditure.	Moderate	Moderate	Major	Medium	Low	Tier 2
R2	Physical	Risks to water resource and associated infrastructure (including potable, stormwater and wastewater) (availability, storage, treatment and distribution) due to changes in chronic precipitation and increased frequency and intensity of extreme weather events (extreme rain, floods, storm damage) and ongoing sea level rise causing damage and changes (increased and decreases) to flow volumes.	Moderate	Extreme	Extreme	Medium	Medium	Tier 1
R3	Transition	Risks to electricity and gas system reliability and security from increasing renewable energy generation	Moderate	Moderate	Major	Medium	Low	Tier 2
R4	Transition	Risk to water resources and availability posed by increase in industry needs (e.g. mining and hydrogen generation) of critical elements supporting low carbon transition. Increased water allocation in these industry activities may stress the water availability for other activities (agriculture, drinking etc)	Moderate	Moderate	Moderate	Medium	High	Tier 2

Resource security | Tier 1 Risk Profile | R2: Risks to water resources and associated infrastructure

Physical risks to water resource and associated infrastructure (including potable, stormwater and wastewater) (availability, storage, treatment and distribution) due to changes in chronic precipitation and increased frequency and intensity of extreme weather events (extreme rain, floods, storm damage) and ongoing sea level rise causing damage and changes (increased and decreases) to flow volumes.

Table 44: Water resources and associated infrastructure risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence	Extreme consequence	Extreme consequence
	In the present day, moderate consequences of climate change are manifesting across the NT, requiring action from NT agencies to control and respond effectively. Short-term disruptions to services and infrastructure are widespread. Access, availability, and quality of water are experiencing noticeable changes and intermittent disruptions, challenging traditional supply systems. Moderate infrastructure damage is recoverable through maintenance and minor repair works. While the consequences are significant, they are manageable through appropriate interventions.	By 2050, the escalation of climate change is expected to bring about extreme consequences for the Territory's water resources and infrastructure. These impacts will likely result in widespread and long-term disruptions. Widespread short-to-medium term disruptions are anticipated across water resources and related utility services and infrastructure. Access to water and its availability will likely be affected, leading to shortages and challenges in meeting demand. Water quality will also undergo significant short-to-medium term changes, posing risks to public health and ecosystems. The extent of infrastructure damage will be extensive, requiring major repairs and reconstruction efforts.	Climate projections for 2090 indicate that the NT will likely experience significant increases in drought conditions, and a variable changes in annual rainfall. These climatic conditions will exacerbate the challenges the Territory's water resources and infrastructure are likely to experience in 2050. By 2090, the consequences and impacts will likely become more permanent and devastating for the Territory's communities. This is likely to be particularly pronounced in remote communities which are already experiencing significant water insecurity challenges.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	- Water resources in the NT have historically not been over allocated and are largely available to be shared. However, the NT is currently using more water than what can be captured and supplied in the long-term.³ Future climate projections coupled with projected population and industry growth, will put increased pressures on the Territory's water resources and infrastructure. Water allocated for mining and onshore gas is also expected to increase in the future.¹ - About 95% of the NT population have access to safe drinking water from a public water supply system, the rest rely on their own bores, rainwater tanks or dams. Power and Water Corporation provides safe drinking water across 18 urban centres and 72 remote communities through a reticulated network covering more than 3,000 km of water mains.¹ Indigenous Essential Services provides water from underground water sources to remote communities through 72 water supply systems with networks of over 250 bores, tanks and distribution systems.¹⁵ There are also around 35,000 water bores spread across the NT. - Some of the Territory's key water resources include (but are not limited to): 11 groundwater systems in the Darwin rural water control district,⁸ the Cambrian Limestone Aquifer,⁹ the Daly River and Basin,¹⁰ Darwin River Dam,¹¹ Katherine River, the Amadeus Basin,¹² Cabbage Gum and Kelly Well aquifers,¹³ and the Dune Plains aquifer.¹⁴ - The source of drinking water in the NT varies depending on the location. Less than 10% of the Territory's water comes from surface water. In urban areas like Darwin, Palmerston, and Katherine, most water comes from surface water sources such as the Darwin River Dam or the Katherine River.¹ The other 90% of the Territory's water supply comes from groundwater. Places like Alice Springs and Tennant Creek rely on aquifers for their water supply, ranging from local aquifers to larger regional ones, although these may not recharge frequently. Additionally, rural stock and domestic users in the NT do not need a water extraction license, ensuring access to water for households and livestock in more remote areas.¹		

Resource security | Tier 1 Risk Profile | R2: Risks to water resources and associated infrastructure (cont.)

Table 44 (continued): Water resources and associated infrastructure risk profile

Risk component	
Exposure <i>(continued)</i>	- Climate projections for the NT indicate that all areas of the Territory will likely be exposed to significant changes in its climate and the extreme weather events, which will exacerbate any existing stresses on the Territory's water resources and infrastructure. Some of the key impacts include (but are not limited to):² - Groundwater aquifers in the NT are reliant on wet season rainfall to refill. Climate projections for Darwin, Palmerston, Litchfield, East Arhem, and the Top End indicate that annual rainfall will significantly decrease in the future. This will likely put significant pressure on groundwater aquifers located in these areas, impacting future water availability. - Intense rainfall events of greater magnitude will challenge the capacity of stormwater systems, treatment plants, and sewerage networks.² - Extended periods of hot, dry weather may cause pipes to crack due to shifts in soil moisture or temperature, or due to the expansion of tree roots seeking water sources.² - Sea level rise, cyclones, storm surges, and flooding are anticipated to affect water and wastewater infrastructure, potentially leading to water contamination issues that impact both public health and the environment.² - Continued sea level rise exposes coastal water resources to saltwater intrusion and the loss of freshwater resources. For example, it has projected that a 30cm sea level rise can result in the loss of 80% of freshwater wetlands in the Kakadu National Park.¹⁶ Climate projections for the NT indicates that there will likely be a 22cm rise by 2050, which will increase to 57cm by 2090.
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- There are significant and long-standing water insecurity challenges within remote Aboriginal communities in the NT.⁴ A significant number of NT remote and Aboriginal communities are underserved by reliable drinking water supplies. For example, in 2023 the NT Government had to truck in bottled water to the remote Aboriginal community of Ali Curung due to a drinking water crisis.⁶ - Remote communities are also experiencing challenges around high treatment costs, limited capacity for repairs and regular and preventative maintenance of infrastructure, and supply chains that are impacted by distance, road conditions and limited access during wet seasons.^{5,17} Across Australia, the majority of water supply infrastructure in Aboriginal communities as built in the 1970s, and is now at the end of its life.¹⁷ - Groundwater aquifers in the southern Territory do not receive seasonal recharge from rainfall. Whilst a few communities' aquifers recharge via direct rainfall (diffuse recharge; eg Ali Curung), at least eleven communities rely on episodic recharge every decade or so, from a cyclone-related rainfall. There is a predicted decrease in the diffuse recharge in central Australia which will likely reduce the aquifer storage in already vulnerable and at-risk areas such as Ali Curung. Further, episodic recharge occurs in aquifers that supply Wutunugurra, Engawala and Laramba. The dam that supplies Yuelamu also relies on episodic rainfall which is unreliable. In at least three communities, aquifers are considered non-renewable.⁷ - The vulnerability of water infrastructure is largely driven by the age, location, construction materials, and status of maintenance and repairs of the infrastructure.¹⁷ Water sources are exposed and vulnerable to run-off contamination (for example, displaced sediment and nutrient-rich organic material) from floods, bushfires, storms, and cyclones.

Resource security | Tier 1 Risk Profile | R2: Risks to water resources and associated infrastructure (cont.)

Table 44 (continued): Water resources and associated infrastructure risk profile

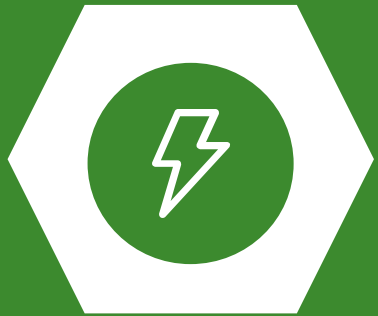
Risk component			
Complexity <i>High-level narrative description of some cascading risks and impacts</i>	Water resources and associated infrastructure in the NT face mounting risks exacerbated by the region's unique environmental dynamics. Some of the cascading complex risks include: • Damage to water infrastructure and disruptions in water supply networks have economic repercussions for NT's industries, including agriculture, mining, and tourism, affecting productivity, investment confidence, and regional development initiatives (E1, E2, E5, E7, E8, E10, and C1). • Impacted water treatment infrastructure and distribution networks, disrupting potable water supply and posing sanitation risks, especially in remote and Aboriginal communities (C5). • Reduced water flow volumes affect the health of aquatic ecosystems, biodiversity (N1, N2, N3, N6), and the sustainability of traditional Indigenous livelihoods dependent on freshwater resources (C2, C3, C5, C6).		
	Adaptation shortfall: Medium	Confidence: Medium	Adaptation urgency rating: Tier 1
Adaptation	The NT and Federal Governments recently invested in water security projects across the NT to upgrade water infrastructure in remote regions. Despite these projects and other adaptation actions, there is currently no strategy, policy or plan in place in the NT to manage climate-related risks to water resources and infrastructure, and ensuring it is able to adapt to the changing climate.	There is a degree of confidence in the effectiveness of the implemented and planned adaptation actions.	Significant policies and activities are required to ensure that the Territory's water resources remains protected in the future, and the most vulnerable communities will have access to safe drinking water in the future. Action is required in the next five years to ensure that these critical resources and infrastructure is prepared and adaptable in light of the changing climate, and increased demand and pressures as a result of population and industry growth in the NT.

Resource security | Tier 2 risk statements

Listed below are the three Tier 2 Adaptation Urgency risk statements for Resource Security. For each of these risk statements, more information is required (for example, through a new study or additional research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.

Table 45: Resource security risk Tier 2 risk statements

Risk statement		
R1	Physical	Risks to energy generation, transmission, distribution as well as energy infrastructure due to changes in chronic temperature and precipitation affecting water availability, and extreme weather events (storms, cyclones, extreme rain, extreme heat, floods, bushfires and winds) causing damage and increased capital and operational expenditure.
R3	Transition	Risks to electricity and gas system reliability and security from increasing renewable energy generation
R4	Transition	Risk to water resources and availability posed by increase in industry needs (e.g. mining and hydrogen generation) of critical elements supporting low carbon transition. Increased water allocation in these industry activities may stress the water availability for other activities (agriculture, drinking etc)



Natural disaster readiness

Natural disaster readiness | Introduction



The natural disaster readiness liveability measures includes arrangements to ensure that, should an emergency occur, all the resources and services that are needed to cope with the effects can be efficiently mobilised and deployed.

Under this liveability measure, there are:

- Four physical risk statements, and
- One transition risk statement.

Refer to page 95 for the full list of risks assessed.

Summarised in Table 46 are the risk statements which have been identified as 'Tier 1 Adaptation Urgency' and 'Tier 2 Adaptation Urgency Risks'.

The Tier 1 risks are discussed in further detail on pages 96-99.

Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 46: Summary of natural disaster readiness risk statements

Tier 1 Adaptation Urgency Risks	
D1	Risk of increasing demand on emergency services and management
D2	Risks to flood and coastal defenses
Tier 2 Adaptation Urgency Risks	
D3	Risks to food and grocery assets
D4	Risk of maladaptation or that impacts are exacerbated

Natural disaster readiness | Risk statements and ratings

Summarised below are the ratings assigned to each of the natural disaster readiness risk statements. The risk statements which have been identified as ‘Tier 1 Adaptation Urgency’ are discussed in further detail on pages 96-99. Refer to [Appendix A](#) for the descriptions of the assigned ratings.

Table 47: Natural disaster readiness risk statements and ratings

Code	Risk type	Risk statement	Consequence ratings			Adaptation shortfall	Confidence	Adaptation Urgency
			Present-day	2050	2090			
D1	Physical	Risk to emergency services and management (fire, police, ambulance, volunteers etc.) due to increased frequency and intensity of extreme weather events (extreme rain, extreme heat, floods, cyclones, storm damage) causing a rise in event related emergencies. This may result in natural disaster preparation and management systems not being prepared to absorb, accommodate, adapt, transform or recover from the effects of natural hazards in a timely or efficient manner (particularly for remote communities).	Moderate	Major	Extreme	Medium	Low	Tier 1
D2	Physical	Risks to flood and coastal defences (sea walls, levees, dykes, dunes) due to increased frequency and intensity of extreme weather events (extreme rain, floods, cyclones, storms and storm surge) and ongoing sea level rise increasing vulnerability, damage, operational and capital expenditure, and decreasing the effectiveness of flood and coastal defences.	Moderate	Major	Extreme	High	Medium	Tier 1
D3	Physical	Risks to food and grocery assets (facilities for manufacturing, processing, packaging, distribution and supplying) due to changes in chronic temperature and precipitation affecting water availability, and extreme weather events (bushfires, floods, extreme rain, winds) causing damage and increased operational and capital expenditure.	Major	Extreme	Major	Medium	High	Tier 2
D4	Transition	Risk of maladaptation or that impacts are exacerbated across all domains because current institutional arrangements, practices or tools do not account for uncertainty or long-term change.	Moderate	Moderate	Major	Medium	High	Tier 2

Natural disaster readiness | Tier 1 Risk Profile | D1: Risks to emergency services and management

Physical risks to emergency services and management (fire, police, ambulance, volunteers etc.) due to increased frequency and intensity of extreme weather events (extreme rain, extreme heat, floods, cyclones, storm damage) causing a rise in event related emergencies. This may result in natural disaster preparation and management systems not being prepared to absorb, accommodate, adapt, transform or recover from the effects of natural hazards in a timely or efficient manner (particularly for remote communities).

Table 48: Emergency services and management risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence	Major consequence	Extreme consequence
	Currently, the climatic conditions and extreme weather events in the NT have moderate consequences for the Territory's emergency services. These consequences create moderate, short-term change/disruption to the ability to prevent, prepare, respond and recover from the impacts.	By 2050, the NT is likely to experience a major increase in climatic changes, and more intense and frequent extreme weather events. This will likely result in widespread, short-to-medium term change/disruption to the Territory's emergency services and its ability to prevent, prepare, respond and recover from the impacts.	Climate projections for 2090 indicates that the NT will likely experience an extreme increase in climatic changes and extreme weather events. These worsened conditions will likely have extreme consequences for the Territory's emergency services, resulting in widespread, long-term change/disruption to the ability to prevent, prepare, respond and recover from the impacts.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	The NT emergency services include the NT Police, NT Fire and Rescue Service (NT FRS), Police, Fire and Emergency Services (NTPFES), NT Emergency Service (NT SES), and the St John Ambulance. Climate projections for the NT indicates that the Territory is likely to experience an increase in the intensity and frequency of extreme weather events. Listed below are the impacts this may have on the Territory's emergency services: • Increase in demand on emergency service staff and volunteers that are already struggling with meeting the community needs.³ This may mean that some communities and individuals may have longer wait-times for support, which can be distressing and detrimental to their health and safety. It is likely that this will be particularly pronounced in remote communities. • Increased staff and volunteer fatigue and burn-out concerns. This can result in challenges in retaining and attracting new staff or volunteers. • Increased health and safety risks for staff and volunteers. • There is a known linkage between the frequency and intensity of crimes committed during periods of increased temperature. This puts additional pressures particularly on police services, as they are required to respond to more calls for support. • The staff and volunteers that make up these services will be highly exposed to heat-related challenges, such as heat-related illnesses and increased demand for services from the communities they serve.		

Natural disaster readiness | Tier 1 Risk Profile | D1: Risks to emergency services and management (cont.)

Table 48 (continued): Emergency services and management risk profile

Risk component			
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- Despite increasing demand for emergency service volunteers, they are becoming increasingly difficult to attract and retain. Volunteering rates in Australia have been steadily declining over the past 15 years.³ As of 2020, 28.4% of the NT population engaged in formal volunteering, and 36.2% engaged in informal volunteering. This rate, however, has been on a steady decline.¹ - The NT is already facing shortages in its full-time and part-time emergency services staff, while demand for these services are significantly increasing.² - Emergency services and the people that make up these services are acutely vulnerable to extreme weather events due to their proximity to dangerous conditions. Their social and health status also contributes to vulnerability. - Remote and Aboriginal communities are particularly vulnerable to the impacts of extreme weather events, facing logistical constraints, communication barriers, and limited access to emergency services and support networks.		
	NT emergency services are confronted with complex cascading risks arising from climate change impacts, challenging their capacity to respond effectively to evolving threats. Some of these risks include: - Climate change impacts erode community resilience and adaptive capacity, increasing vulnerabilities to natural hazards and hampering emergency preparedness, response, and recovery efforts, particularly in disadvantaged and marginalised communities (C2 and C5). - Extreme heat events and natural disasters can lead to public health emergencies, including heat-related illnesses, injuries, and outbreaks of waterborne diseases, requiring coordinated emergency medical response and public health interventions. This puts significant strain on emergency services, staff and volunteers (C2). - Highly strained emergency services may increase additional pressures on other services across the NT, such as charities, not-for-profits, social welfare, and healthcare services. These impacts can also be reversed, where strained services can increase demands on emergency services to supplement gaps (C8, E4 and E6).		
Adaptation	Adaptation shortfall: Medium	Confidence: Low	Adaptation urgency rating: Tier 1
	There are a number of adaptive actions in place, however there is no clear policy, strategy or plan in place in the NT to manage climate-related risks to the Territory's emergency services.	Due to the strained and vulnerable nature of emergency services in the NT, there is low confidence in the ability of the current adaptation actions to ensure that emergency services are able to adapt to the challenges presented by the changing climate.	Emergency services play a critical role in supporting the NT communities day-to-day and to respond to and recover from extreme events. It is therefore critical that new stronger or different government policies or implementation activities, over and above those already planned, are needed in the next five years to reduce longer term climate change risks.

Natural disaster readiness | Tier 1 Risk Profile | D2: Flood and coastal defences

Physical risks to flood and coastal defences (sea walls, levees, dykes, dunes) due to increased frequency and intensity of extreme weather events (extreme rain, floods, cyclones, storms and storm surge) and ongoing sea level rise increasing vulnerability, damage, operational and capital expenditure, and decreasing the effectiveness of flood and coastal defences.

Table 49: Flood and coastal defences risk profile

Risk component	Current	2050	2090
Consequence <i>Level of change or impact, is this sustained, or irreversible?</i>	Moderate consequence	Major consequence	Extreme consequence
	Presently, extreme weather events and climatic changes have moderate consequences for the Territory's flood and coastal defences. These moderate consequences include short-term disruptions which are reversible through appropriate interventions and actions from NT agencies.	Climate change projections for 2050 indicates a likelihood of more intense and frequent extreme rainfall and storm surge events. Sea level rise will also continue to increase. It is likely that this will impact on the Territory's flood and coastal defences, resulting in short-to-medium term change/disruptions in the ability of the defences to protect the NT communities and infrastructure, such as homes and businesses. While major, the consequences can be reversed through significant intervention and investment.	Climate projections for 2090 indicates that the NT is likely to experience significant increases in extreme rainfall events, storm surge, and relative sea level rise. These conditions are likely to have extreme consequences for the Territory's flood and coastal defences, causing widespread, long-term change and disruption to the infrastructure and its ability to protect the NT communities.
Exposure <i>What is impacted and where (i.e., ecosystem, industry, community, etc.)?</i>	Coastal defences: - The NT coastline extends for 10,953 km, including 887 islands.¹ - Some of the coastal defence infrastructure currently in place across the NT coastline includes: Seawalls along from Fannie Bay to Nightcliff, and Bayview sea wall (Darwin). - Continued sea level rise coupled with more frequent and intense storm surge and cyclone events will likely increase along the shoreline of the NT. Climate projections indicate that the NT coastline is likely to experience a 22cm relative rise in sea levels, which will increase to 57cm by 2090. This will likely put further pressure on the Territory's coastal defences, such as seawalls. The infrastructure may become at risk of being overtopped and become structurally unstable in areas where coastal erosion occurs, such as Darwin.² The loss of this protective infrastructure can be detrimental for the infrastructure and communities located behind it. - Rising sea levels exacerbate coastal flooding and erosion, undermining the integrity of flood and coastal defense infrastructure and diminishing their ability to withstand storm surges and high tides. Flood defences: - The flood defence infrastructure in the NT is made up of levee banks, stormwater drainage systems (e.g., major trunk drainage infrastructure), embankments, and detention bins. Some of the most significant flood defences in the NT includes the recently implemented Alice Springs Eastside Levee, Katherine Flood Mitigation Levee South, the Kulaluk Flood Mitigation Infrastructure,³ the Marrara detention bin.⁴ - The projected increase in extreme rainfall, floods, cyclones, storms, and storm surges will likely place significant stress on existing flood and coastal defenses, leading to more frequent breaches and failures. The need for frequent maintenance, repair, and upgrades of flood and coastal defenses imposes substantial operational and capital expenditure burdens on government agencies and local authorities, straining limited resources and budgets.		

Natural disaster readiness | Tier 1 Risk Profile | D2: Flood and coastal defences (cont.)

Table 49 (continued): Flood and coastal defences risk profile

Risk component			
Vulnerability <i>How susceptible is the system to the driver, level of resilience, can it adapt?</i>	- Coastal defence infrastructure, such as seawalls, in the NT may be vulnerable to sea level rise, storm surge, and cyclones due to the ageing and insufficient design of these defences, and inadequate maintenance and repair practices. Such vulnerabilities pose a substantial threat to the efficacy of essential coastal protection and management infrastructure, such as seawalls and beach nourishment projects. As a result, the ability of these vital structures to effectively mitigate coastal hazards is compromised, leaving coastal communities in the NT increasingly susceptible to the adverse impacts of natural phenomena and human activities. - Flood mitigation infrastructure and practices may not be sufficient to address and withstand future flood-levels. This vulnerability is likely to manifest in flood mitigation infrastructure located in Barkly, Big Rivers, Central Australia, Darwin, Palmerston, Litchfield, and the Top End, as climate projections for these regions indicate significant increases in the wettest day rainfall and frequency of extreme rainfall days.		
	The NT faces complex cascading risks from climate change impacts on flood and coastal defenses, with interconnected consequences across various sectors. These risks highlight the urgent need for integrated adaptation strategies to enhance resilience and protect communities, infrastructure, and ecosystems: - The overflow and destruction of flood and coastal defences can impact on areas that hold cultural significance for Aboriginal communities in the NT, with numerous sacred sites, burial grounds, and cultural landscapes at risk from climate change-induced coastal erosion and inundation (N6, C2, C3 and C6). - The impacts of climate change on flood and coastal defenses in the NT have significant socio-economic consequences, including property damage (B1 and C4), loss of livelihoods (C1 and C2), displacement of communities (C3 and C5), and disruptions to economic activities such as tourism, agriculture, and fishing (E1, E2, E8, and E10).		
Adaptation	Adaptation shortfall: High	Confidence: Medium	Adaptation urgency rating: Tier 1
	Although a great deal of investment has been made in upgrading flood and coastal defences in the NT, there are not yet any clear strategies or policies in place to drive adaptation of these defences in consideration of the impacts of climate change.	There is some degree of confidence in the effectiveness of the adaptation actions implemented and planned in the NT to manage flood and coastal risks.	Addressing the evolving risks to flood and coastal defenses requires long-term adaptation strategies, including coastal management plans, land-use regulations, and ecosystem-based approaches, to enhance resilience and sustainability in the face of climate change impacts. The effectiveness of flood and coastal defenses is critical for protecting communities, infrastructure, and natural assets from the impacts of extreme weather events and sea level rise, safeguarding livelihoods and enhancing community resilience to climate-related risks.

Natural disaster readiness | Tier 2 risk statements

Listed below are the three Tier 2 Adaptation Urgency risk statements for Natural Disaster Readiness. For each of these risk statements, more information is required (for example, through a new study or additional research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.

Table 50: Resource security risk Tier 2 risk statements

Risk statement		
D3	Physical	Risks to food and grocery assets (facilities for manufacturing, processing, packaging, distribution and supplying) due to changes in chronic temperature and precipitation affecting water availability, and extreme weather events (bushfires, floods, extreme rain, winds) causing damage and increased operational and capital expenditure.
D4	Transition	Risk of maladaptation or that impacts are exacerbated across all domains because current institutional arrangements, practices or tools do not account for uncertainty or long-term change.
D3	Physical	Risks to food and grocery assets (facilities for manufacturing, processing, packaging, distribution and supplying) due to changes in chronic temperature and precipitation affecting water availability, and extreme weather events (bushfires, floods, extreme rain, winds) causing damage and increased operational and capital expenditure.

A photograph of Uluru at sunset, viewed through the windshield of a car. The car's interior, including the rearview mirror and dashboard, is visible in the foreground, creating a sense of being on a road trip. The landscape is arid with sparse vegetation, and the sky is a mix of orange and blue.

Climate change opportunities for the Northern Territory

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Climate change opportunities for the NT

Listed below are the high-level climate change-related opportunities related to the Transition of the Northern Territory to a low carbon economy. The eleven opportunity statements have been identified through literature review and further refined through discussion with workshop participants.

Table 51: Opportunity statement by liveability measure

Code	Opportunity statement
Safe and stable built environment	
01	Opportunities for improving public and active transport infrastructure and services to improve traffic congestion, efficiency and safety, and reduce transport emissions for individuals and some businesses.
02	Opportunities for improved planning legislation to allow for sustainable buildings and urban design, and support the infrastructure needs for low emissions technology and circular economy across different sectors within NT.
Safe and stable natural environment	
03	Opportunity to optimise waste systems to reduce impact on the environment, including reducing waste to landfill, improved collection and increased recyclability for products.
04	Opportunities to natural environment (biodiversity, water quality and efficiency, air quality) from decarbonisation actions, e.g., deploying renewables, urban greening and carbon and biodiversity offset programs.
Economic sustainability	
05	Opportunities for NT businesses to improve business profitability through improved energy efficiency and productivity, gaining reputation and access to green finance, and creating new revenue streams from offset schemes (carbon farming) and technology adoption within agriculture and aquaculture sectors.
06	Opportunities for NT's economic growth resulting from large projects such as increased renewable energy generation, and through climate and low emissions research centres and research capability.
Community health and wellbeing	
07	Opportunities for increased social cohesion, improved health and wellbeing through resiliency improvements.
08	Opportunities for education and skill development in emerging markets (e.g., hydrogen, renewable energy), resulting in improved employment and financial wellbeing.
09	Opportunities for Aboriginal culture, values and principles, and financial health and wellbeing from Indigenous led offset programs and adaptation programs delivered through traditional and indigenous knowledge.
Resource security	
010	Opportunities for improved flexibility and reliability within electricity infrastructure from increased renewable energy generation
011	Opportunities for improved energy and water efficiency and energy productivity resulting from technology improvements and utilisation of renewable water resources such as sea and wastewater.

Recommendations

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Overarching recommendations

In this Chapter, we provide a series of recommendations and key actions for NT Government to address the climate change risks that have been discussed throughout this Technical Report. We provide some broad overarching recommendations that will support the Northern Territory to implement an adaptive/iterative approach to its adaptation planning ensuring that risk assessments are updated and reviewed at a regular basis and the effective monitoring and evaluation is undertaken (Table 52). A set of liveability measure specific recommendations are provided in the next few pages presenting some high-level prioritised actions that can be considered within the next five years to achieve immediate and long-term benefits.

Table 52: Overarching recommendations

Overarching recommendations	Description	Key actions
Review and update Climate Change Risk Assessment every five years	The NT CCRA should be revisited and reassessed every five years due to the dynamic nature of climate change. This will ensure that the latest data, trends, and projections are incorporated, providing a more accurate understanding of current and future risks for the NT. Importantly it will enable the NT to build on any actions that have been implemented and reprioritise or identify additional actions.	• Keep abreast of global and Australian climate change trends. • Develop a robust monitoring process and review the risks and adaptation actions every five years. • Consider new scientific research and data sources. • Compare progress against previous assessments.
Design and implement a cohesive monitoring and evaluation program	Monitoring and evaluation helps to guarantee the enduring success of climate adaptation initiatives, plans and actions. They play an important role in the following three aspects of adaptation:¹ • Monitoring the effectiveness of activities conducted during the development of an adaptation strategy (e.g., involvement of stakeholders). • Assessing whether the intended outputs and outcomes from adaptation efforts have been achieved. • Evaluating against current trends and other climate change initiatives supports leading practice.	Develop and implement a monitoring and evaluation plan/program to support the implementation of the NT CCRA and subsequent adaptation actions and recommendations. These actions could include: • Indicators will be selected to measure success and progress of climate risk management over time. • Actions should be designed to have clear and measurable objectives. • Based on progress measurement data, the effectiveness of actions can be measured and used to inform any updates to the current approach. • The program should be revised and reviewed every five years.
Conduct more detailed and granular climate change risk assessments	More detailed assessments at either the liveability measure or risk statement level, is crucial for understanding impacts and vulnerabilities that are crucial to be addressed. Moreover, such assessments help identify vulnerable populations and areas disproportionately affected by climate hazards allowing for more tailored and tangible outcomes from the risk assessment process. Tailoring adaptation strategies to address these nuanced risks is facilitated by more detailed risk assessments, ensuring that adaptation actions and strategies meet the unique needs of each community.	• Conduct a more detailed second pass risk assessment focusing on emergency management, identifying the key complex risks associated with an emergency climate event in the Territory to inform future funding and investment in resilience building activities. • Conduct a more detailed second pass risk assessment focusing on liveability measures relevant to remote regions and communities in the Territory. As part of this assessment the Territory could identify the most vulnerable remote communities to climate risks. • Incorporate climate change scenarios and risk information inland land-use and urban planning processes. By proactively considering these factors, future housing, industrial developments, and infrastructure projects can be strategically located to avoid high-risk areas. This approach will reduce the likelihood of emergency management interventions and recovery operations, fostering more resilient and sustainable community growth. • Incorporate heat mitigation measures in land-use planning, precinct and building designs. These measures will enhance the Territory's ability to cope with rising temperatures, ensuring more sustainable and resilient development.
Increase cross-government collaboration	Establish a coordinated, multi-agency response to implementing climate adaptation measures across all levels of government. This unified approach will streamline budget planning, minimise resource duplication, enable broad stakeholder engagement and ensure buy-in from key stakeholders.	• Identify opportunities across all levels of government to enhance the coordination of resources targeting climate adaptation. This enhanced collaboration should focus on creating cohesive and efficient strategies for climate adaptation, ensuring that resources are optimally allocated, and initiatives and policy action are complementary.

Near-term recommendations to address the Tier 1 risks



Community health and wellbeing

Table 53: Community health and wellbeing Tier 1 risk statement recommendations

Risk statement	Near-term recommendations
C5 Physical risks to Northern Territory communities (including remote communities)	• Assess and determine the most at-risk communities in the Northern Territory, particularly focussing on remote communities. Develop community-specific adaptation plans and strategies to address the most key risks for the communities. • Strengthen Emergency Management and Response Systems. The Territory could invest in advanced early warning systems where relevant for extreme weather events such as cyclones, floods, and bushfires, ensuring they are accessible and actionable for all communities, including remote areas. Develop community-specific emergency response plans that include detailed evacuation routes, communication strategies, and emergency shelters, tailored to the unique needs and vulnerabilities of each region. • Increase the capacity and readiness of emergency services to respond to climate-related disasters. This includes providing training, resources, and equipment to local emergency responders. Foster partnerships with local community groups and Indigenous organisations to leverage their knowledge and enhance community-based disaster resilience. • Develop and implement heat mitigation strategies, such as creating green spaces, increasing tree canopy cover, and improving building designs to reduce heat exposure in urban and remote areas. Enhance air quality monitoring and implement measures to reduce pollution and manage smoke from bushfires, protecting public health during extreme weather events.
C6 Physical risks to cultural heritage including Aboriginal cultural heritage	• Due to the diverse nature and widespread geographical locations of the Territory's cultural heritage, a more granular and detailed assessment will be required to identify which tangible and intangible heritage sites are the most significant, what is most exposed and vulnerable, and what the key risks are that will need to be addressed through targeted adaptation actions and management actions. For example, relocating assets, implementing new and/or more flood and bushfire protective measures, and embedding climate change projections into decision-making and management strategies for cultural heritage sites.² • Collaborate closely with Traditional Owners and communities to co-develop strategies rooted in Traditional Knowledge, supported by strong partnerships and capacity-building initiatives for shared learning and effective heritage preservation. • Collaborative partnerships between Aboriginal communities and government agencies to facilitate the development of adaptive strategies that respect and incorporate Traditional Knowledge and perspectives.
C7 Physical risks to skills and education	• Develop and implement a new policy to assess the Territory's needs and to guide the attraction and retention of new workers, in consideration of the impacts the changing climate will have on existing challenges in attracting and retaining staff. • Identify schools which are most at-risk from different climate pressures, and which adaptive actions must be implemented. For example, identifying which schools do not have sufficient air-conditioning or cooling solutions.

Near-term recommendations to address the Tier 1 risks



Safe and stable built environment

Table 54: Safe and stable built environment Tier 1 risk statement recommendations

Risk statement		Near-term recommendations
B3	Risks to communications and ICT	- Collaborate with telecommunication providers and the Australian Government to enhance communication infrastructure in remote NT communities, ensuring resilience against climatic events and reliable connectivity. - Explore opportunities to transition communities to more dependable and cost-effective NBN services where feasible infrastructure exists, promoting improved connectivity and community access to essential services.
B6	Risks to transport and logistics	- Ensure that all new developments, including supply chain hubs, are constructed with resilience to future climate conditions and scenario analysis in mind. - Pursue investment opportunities to strengthen the resilience of road and rail networks, particularly those linking remote communities and facilitating logistics operations. - Develop adaptation strategies for transport and logistics, incorporating a detailed second-pass climate risk assessment and adopting a holistic approach to addressing transportation-related risks. - Review contingency plans for the most vulnerable remote communities, identified through a second pass risk assessment, to mitigate the risk of isolation during flooding events and ensure continuity of essential services.
B7	Risks to waste collection and storage	- Develop and enact an Emergency Waste Management Strategy to handle waste management throughout all stages of climate-related events, accommodating increased pressures during response and clean-up activities. This strategy should incorporate guidelines for future waste and storage design, accounting for additional waste generated during disasters, preventing runoff into waterways, and addressing e-waste management. - Identify high-risk and inadequately designed waste facilities in the NT through a detailed second-pass risk assessment. - Establish a coordinated approach to waste management, involving collaboration among relevant government agencies and local governments, to ensure a holistic and effective response.



Resource security

Table 55: Resource security Tier 1 risk statement recommendations

Risk statement		Near-term recommendations
R2	Risks to water resources and associated infrastructure	- Identify communities disproportionately affected by water quality and scarcity issues, prioritising those most impacted for targeted interventions. - Conduct assessments of water resources to pinpoint climate change-related risks, informing future adaptation strategies. - Assess water infrastructure to identify vulnerabilities to climate change impacts, guiding adaptation planning. - Collaborate closely with Aboriginal communities and Traditional Owners to integrate Traditional Knowledge into water management practices, ensuring culturally sensitive and sustainable approaches to water allocation and usage in the NT.

Near-term recommendations to address the Tier 1 risks



Economic sustainability

Table 57: Economic sustainability Tier 1 risk statement recommendations

Risk statement		Near-term recommendations
E3	Risks to banking, finance and insurance institutions, and fiscal and financial systems	- Provide ongoing updates on NTG website presenting summarised climate reporting requirements such as International Sustainability Standards Board (ISSB) IFRS 1 and 2 sustainability and climate reporting disclosures. This could support the financial sector to keep up to date with latest information and expectations regarding embedding of climate risk into financial statements. - Establish incentives and funding mechanisms to encourage banks to prioritise investments in climate-resilient infrastructure projects, renewable energy initiatives, and sustainable development initiatives within the Territory. Offer financial support and grants to facilitate the transition towards low-carbon and climate-resilient economies.
E7	Risks to mining	- Conduct mapping and risk assessments of Government-owned assets supporting the mining sector, overlaying predicted climate impacts to guide adaptation actions for resilient mining supply chains in the NT. - Collaborate with the mining sector to promote lower carbon-intensive operations through efficiency improvements, alternative fuels, and onsite renewable energy adoption. - Advocate for updates to the NT Environment Protection Legislation Amendment (Mining) Bill 2023 to explicitly address climate change concerns. - Establish mechanisms facilitating industry-researcher collaboration to enhance environmental practices and reduce business impacts.
E9	Risks to manufacturing	- Conduct detailed mapping and risk assessments of key manufacturing locations across the Territory to identify and prioritize climate risks faced by the sector. - Engage with industry representatives to enhance their understanding of NT's future climate, enabling tailored approaches to climate risk management. This could involve updating heat policies for factories and outdoor workers, implementing disaster management plans for climate-related disruptions, and outlining contingency operations. - Develop mechanisms facilitating industry-researcher collaboration to enhance environmental practices and reduce business impacts.
E10	Risks to small and medium enterprises	- Climate adaptation resources should be made available to small and medium business owners to increase adaptation knowledge such as diversifying suppliers and transport routes, invest in adequate air-conditioning for workers, allow for appropriate breaks to adapt to increasing temperatures and update emergency plans based on current climate projections factoring in extreme heat, flood and bushfire situations and the expected response from employees and patrons. - Support small businesses to complete due diligence checks on suppliers to understand any climate risks associated with products in their supply chain that could lead to delays in their business, impacting operations. This can be through development of targeted guidelines.
E13	Risks to financial position of NT businesses due to premature write-downs of fossil fuel assets	- Assist businesses in proactively planning for upcoming climate-related regulations and standards by providing support to understand when they come into effect. - Additionally, help businesses assess their climate risks comprehensively, including identifying potentially stranded assets in the future using climate modelling techniques.
E14	Risks to NT's economic growth due to slow, ineffective or no action	- Ensure the Territory remains on track to achieve net zero emissions by 2050 by integrating climate risk and decarbonisation goals into existing economic plans and strategies. - Continue to incentivise the development of low-carbon businesses by offering grant support to small businesses pursuing energy efficiency improvements or producing circular economy-aligned products and services.

Near-term recommendations to address the Tier 1 risks



Natural disaster readiness

Table 59: Natural disaster readiness Tier 1 risk statement recommendations

Risk statement		Near-term recommendations
D1	Risk of increasing demand on emergency services and management	• Incorporate climate change considerations into NT Government agencies' resilience practices, including enterprise risk management, business continuity planning, crisis management, emergency management, and security management. • Integrate climate change into emergency risk management approaches to enable risk-informed planning practices. • Expand existing community education and engagement programs to include climate change science and impacts, ensuring awareness across diverse linguistic and cultural communities. • Provide climate change education and training for the emergency management workforce. • Partner with educational institutions and professional bodies to embed climate adaptation and emergency management into curricula and professional development programs. • Promote community self-sufficiency and resilience through pre-disaster preparation and response activities.
D2	Risks to flood and coastal defenses	• Identify at-risk communities in need of enhanced flood and coastal defences through targeted second-pass risk assessments. • Assess the vulnerability of existing defences to ensure adequacy in the face of climate change impacts.



Safe and stable natural environment

Table 60: Safe and stable natural environment Tier 1 risk statement recommendations

Risk statement		Near-term recommendations
N7	Risks to biosecurity (invasive species)	• Develop a targeted monitoring program to identify any changes in invasive organisms spread across the Territory, enabling prompt response to biosecurity threats. • Conduct a comprehensive review of current invasive plant and animal management initiatives to pinpoint areas needing additional investment. Spatially map this data and overlay it with climate projections to identify intersections with significant areas like National Parks and agricultural lands, informing targeted adaptation actions.

A photograph taken from the driver's perspective inside a car. The car's interior, including the dashboard and rearview mirror, is visible in the foreground, slightly out of focus. Through the windshield, a winding asphalt road leads towards a large, reddish-brown rock formation (Uluru) under a sunset sky. The word "Conclusion" is overlaid in white text on the left side of the image.

Conclusion

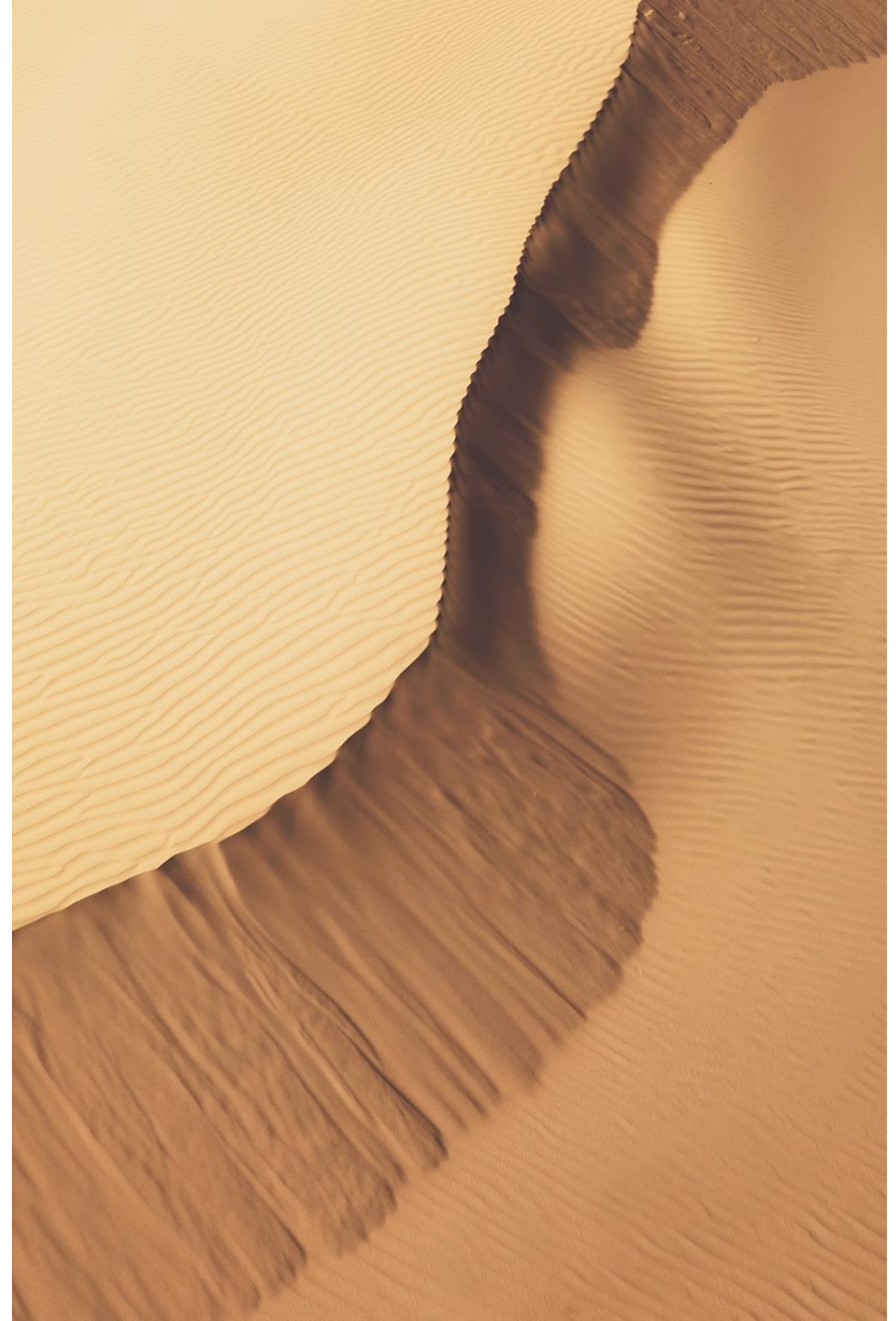
Conclusion

This iteration of the NT CCRA is a first pass risk assessment which identified and assessed 60 risk and opportunity statements for the Northern Territory.

A core element of the NT CCRA process has been thorough and collaborative stakeholder consultation to identify adaptation actions that are being implemented in the NT, and where there are shortfalls that should be addressed urgently within in the next five years.

Throughout this process, the NT CCRA identified a series of actions and recommendations that should be implemented in the next five years to support the NT to be more liveable in the future, in light of the changing climate.

As part of this, recommendations have been made to ensure that the NT CCRA is regularly updated to ensure it remains highly relevant to the NT, and is informed by the latest data, trends, and projections. Additionally, recommendations have been made regarding the development and implementation of a monitoring and evaluation strategy to assess the success of the actions and underpin future adaptation planning.



Appendices



Appendix A:

Criteria for assessing magnitude of consequence

Criteria | Magnitude of consequence

Magnitude of Consequence is the outcome of an event that may result from a hazard.

Below we provide magnitude of consequence criteria to be used in the analysis. These criteria are aligned with comparable state and federal government risk assessments.

Consequence level				
Insignificant consequence	Minor consequence	Moderate consequence	Major consequence	Extreme consequence
No significant change in impact territory-wide – can be handled through business-as-usual; or some local or regional impacts requiring no specialised management. Consequences are minor or insignificant and entirely reversible.	Some minor impacts at the territory scale that could be addressed through local or regional management and adaptation processes Consequences are short-term, not permanent and entirely reversible.	Significant impacts at the territory scale, of interest to NT agencies to control and respond to. Consequences are moderate, but reversible with appropriate interventions	Major impacts at the territory scale, of high interest to NT agencies to quickly control and respond to. Consequences are major, but reversible with significant intervention	Extreme impacts at the territory scale (or in a multiple NT regions), of heightened interest to NT agencies to urgently control or respond to. Consequences are permanent and irreversible. Consequences may completely compromise the system. May be of interest to NT partners or financial or insurance institutions.
Community health and wellbeing				
- No discernible changes to health, safety and wellbeing, social welfare and housing of community members, education, employment and/or community services. - Temporary disruption, no permanent dispersal or loss of connectedness, minor damage to cultural assets/delays to culturally important events.	- Limited to no impact on health, safety and wellbeing, social welfare and housing of community members. - Isolated and short-term disruption to education, employment and/or community services. - Minor impact on patterns of daily activity and behaviour. - Connectedness damaged, some recovery resources needed, some damage of cultural assets, delay or reduced scope of culturally important events.	- Moderate lasting impacts on health, safety and wellbeing, social welfare and housing of community members. - Moderate disruption to education, employment and/or community services. - Moderate impacts on patterns of daily activity and behaviour. - Connectedness broken, significant recovery resources needed, damage of cultural assets, delayed culturally important events.	- Prolonged disruption to health, safety and wellbeing, social welfare and housing of community members. - Prolonged disruption to education, employment and/or community services (including loss of human life). - Major impacts on patterns of daily activity and behaviour. - Connectedness significantly broken, extraordinary recovery resources needed, widespread damage/loss of cultural assets, postponed events.	- Health, safety and wellbeing, social welfare and housing of community members is significantly compromised across the region (including loss of human life). - Permanent disruption to education, employment and/or community services. - Patterns of daily activity and behaviour unable to continue. - Community ceases to function effectively/ widespread and permanent loss of cultural assets, culturally important activity cancelled.

Criteria | Magnitude of consequence

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Consequence level				
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Safe and stable built environment				
- Insignificant infrastructure disruption to utility services and road infrastructure. - Localised minor damage to commercial, health and residential buildings.	- Isolated and short-term infrastructure service disruption to utility services and road infrastructure. - No permanent damage; some minor restoration work required to commercial, health and residential buildings.	- Many short-term infrastructure service disruptions to utility services and road infrastructure. - Damage recoverable by maintenance and minor repair to commercial, health and residential buildings. Some buildings require immediate relocation and assessment.	- Widespread short-to-medium term disruptions to utility services and road infrastructure. - Extensive infrastructure damage requiring major repair to commercial, health and residential buildings. Significant number of buildings need to be immediately relocated.	- Widespread, long-term service disruption; significant permanent damage and/or complete loss to utility services and road infrastructure. - Immediate relocation to commercial, health and residential buildings. - Majority of government and non-commercial buildings require assessment for permanent relocation options.
Safe and stable natural environment				
- Indistinguishable impacts on ecosystems and access and availability of water resources. - Negligible impact on natural land and coastal areas.	- Temporary localised or minor effects on ecosystems and/or species and availability of water resources. - Short-term loss/minor decline in the ecological integrity/stability to a small minority of land and coastal areas.	- Sustained localised or shorter-term regional on ecosystems and/or species and availability of water resources. - Sustained localised or shorter-term regional change in the ecological integrity/stability of high-value protected natural areas (including marine protected areas).	- Widespread alteration of ecosystems and/or species at regional scales leading to significant ecosystem instability and/or species declines and compromised water resources. - Regional/medium term reduction in the ecological integrity/stability of most of land and coastal areas.	- Significant, irreversible and widespread alteration of ecosystems and/or species resulting in major ecosystem instability, serious loss of species and significantly compromised access and availability to water resources. - Major and widespread instability in land and coastal areas.

Criteria | Magnitude of consequence

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Economic sustainability				
- Limited economic losses (loss of asset value <0.004% of gross product produced). - Inconsequential industry or business sector disruption.	- Decline of economic activity and/or loss of asset value >0.004% of gross product produced. - Significant industry or business sector disruption, resulting in short-term (< 1 year) profit reductions.	- Decline of economic activity and/or loss of asset value >0.04% of gross product produced. - Significant industry or business sector disruption, resulting in medium-term profit (> 1 year) reductions.	- Decline of economic activity and/or loss of asset value >0.4% of gross product produced. - Significant structural adjustment required by identified industry to respond and recover.	- Decline of economic activity and/or loss of asset value >4% of gross product - Failure of a significant industry or sector in area of interest.
Natural disaster readiness				
Insignificant change/disruption to the ability to prevent, prepare, respond and recover from the impacts	Isolated and short-term change/disruption to the ability to prevent, prepare, respond and recover from the impacts	Moderate, short-term change/disruption to the ability to prevent, prepare, respond and recover from the impacts	Widespread, short-to-medium term change/disruption to the ability to prevent, prepare, respond and recover from the impacts	Widespread, long-term change/disruption to the ability to prevent, prepare, respond and recover from the impacts

Criteria | Magnitude of consequence

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Below we provide magnitude of consequence criteria to be used in the analysis. These criteria are aligned with comparable state and federal government risk assessments.

Consequence level				
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Resource security: Water				
• Insignificant disruption to water resources and related utility services and infrastructure • Insignificant disruption to access to water access and availability • Negligible change to water quality • Negligible damage to water infrastructure	• Isolated and short-term disruptions to water resources and utility services and infrastructure • Isolated and short-term disruption to water access and availability • Isolated and short-term change in water quality • No permanent damage; some minor restoration work	• Many short-term disruptions to water resources and related utility services and infrastructure • Many short-term disruptions to water access and availability • Many short-term changes in water quality • Damage recoverable by maintenance and minor repair to water infrastructure	• Widespread, short-to-medium term disruptions to water resources and related utility services and infrastructure • Widespread, short-to-medium term disruptions to water access and availability • Widespread short-to-medium term changes in water quality • Extensive infrastructure damage requiring major repairs	• Widespread, long-term service disruption to water resources and related utility services and infrastructure • Widespread, long-term disruptions to water access and availability • Widespread, long-term changes in water quality • Significant permanent damage and/or complete loss to water utility services and infrastructure
Resource security: Food				
• No discernible changes to the physical and economic access to food supply • No discernible changes the quality or availability of food	• Limited to no changes to the physical and economic access to food supply • Limited to no changes to the quality or availability of food	• Moderate changes to the physical and economic access to food supply • Moderate changes to the quality or availability of food	• Widespread, short-to-medium term changes to the physical and economic access to food supply • Widespread, short-to-medium term changes to the quality or availability of food	• Widespread, long-term changes to the physical and economic access to food supply • Widespread, long-term changes to the quality or availability of food

Criteria | Magnitude of consequence

Magnitude of Consequence is the outcome of an event that may result from a hazard.

Below we provide magnitude of consequence criteria to be used in the analysis. These criteria are aligned with comparable state and federal government risk assessments.

Consequence level				
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Resource security: Energy				
• Insignificant disruption to energy utility services and infrastructure • Insignificant disruption to access to energy access • Negligible damage to energy infrastructure	• Isolated and short-term disruptions to energy utility services and infrastructure • Isolated and short-term disruption to energy access • No permanent damage; some minor restoration work	• Many short-term disruptions to energy utility services and infrastructure • Many short-term disruptions to energy access • Damage recoverable by maintenance and minor repair to energy infrastructure	• Widespread, short-to-medium term disruptions to energy utility services and infrastructure • Widespread, short-to-medium term disruptions to water access • Extensive infrastructure damage requiring major repairs	• Widespread, long-term service disruption to energy utility services and infrastructure • Widespread, long-term disruptions to water access • Significant permanent damage and/or complete loss to energy utility services and infrastructure

Criteria | Adaptation shortfall

The objective of adaptation shortfall is to assess whether risks or opportunities are being managed in the future and confidence aims to determine how sure we are of the accuracy of information used in the assessment. These criteria will be referred to in the workshop.

High (1)	Medium (2)	Low (3)
Policy, strategy or plan in place, with clear objectives (SMART) and actions designed to reduce risk to a low magnitude of consequence, across the range of future warming scenarios (2°C and 4°C at end of the century).	Policy, strategy or plan in place, but no clear objective. <i>Or</i> Policy, strategy or plan in place, however it only commits to managing risk for 2°C warming pathway, or no uncertainty consideration.	No policy, strategy or plan in place to reduce risk. <i>OR</i> There is a lack of evidence that PSPs are effective/implemented appropriately

Criteria | Confidence

High (1)	Medium (2)	Low (3)
High quality evidence of the effects of future adaptation in managing the risk and high agreement between experts.	Some evidence on the effects of future adaptation in managing the risk and/or high agreement between experts.	Little/no/ contrasting evidence of the effects of future adaptation in managing the risk and little agreement between experts.

Criteria | Adaptation urgency

Urgency score category	Urgency tier	Description
MORE ACTION NEEDED	Tier 1	High level of consequence is expected in the mid-term (2050). New, stronger or different government policies or implementation activities- over and above those already planned are needed in the next five years to reduce longer term climate change risks.
	Tier 2	Medium to high level of consequence is expected in the mid-term (2050). Some degree of adaptation efforts are underway; however, more adaptation efforts are required at a Territory-level including (new study/research) to fill significant evidence gaps to reduce uncertainty in the current level of understanding to assess the need for additional action.
SUSTAIN CURRENT ACTION	Tier 3	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. This includes any existing plans to increase or change the current level of activity.
WATCHING BRIEF	Tier 4	The evidence in these areas should be kept under review, with long-term monitoring of risk levels and adaptation activity so that further action can be taken if necessary.

Appendix B: Risk assessment and engagement approach

Risk assessment approach | Parameter definitions

Defined below are some of the risk parameters that forms part of the NT CCRA. This includes definitions of physical and transition risks and opportunities.

Physical Risks

Driven by extreme weather and long-term shifts in climate patterns that have direct impacts.



Acute

Risk of increasing intensity and/or frequency of extreme weather events (e.g., storm surge, bushfires, extreme rain, floods, extreme heat, drought)



Chronic

Risk of longer-term changes in the climate (e.g., temperature, rainfall, soil moisture, sea level rise)

Transition Risks

Driven by policy, regulation, technology development, reputation, and market shift as a result of goals to decarbonise.



Policy & Legal

Risk from existing and emerging regulations to address climate change adaptation and 'failure to act'



Markets

Risk from changing supply and demand as economies react to climate change



Technology

Risk from emerging technologies to support the global transition to low carbon



Reputation

Risks of damage to reputation from shifting public sentiment about climate change

Physical and Transition Opportunities



Resource Efficiency

Cost, security of supply, and improved productivity through improved water, energy and natural capital resource utilisation.



Investment

Access to investors who gain confidence that their investments are secure.



Reputation

Improved public sentiment and image.



Energy Source

Opportunities to achieve cost and emissions benefits through low-carbon and alternative energy value chains, including generation, storage, conversion, transportation and utilisation.



Resilience

Adaptive capacity to respond to climate change, for example increasing ability to identify, absorb and mitigate climate-related disruptions.



Workforce

Enhanced employee satisfaction, retention and development of a more skilled and diverse workforce.

Risk assessment approach | Risk assessment and engagement process

Described below is the detailed risk assessment and engagement process undertaken as part of the NT CCRA.

KEY ACTIVITIES		DESCRIPTION
1	Collected and reviewed existing reports and data (including climate projections).	- Existing mapping, reports, and studies were reviewed to better understand existing knowledge and gaps around major climate hazards and opportunities, and their distribution across the NT. - DEPWS provided access to a range of relevant documents. - This information gathered from this process was be used to support the workshop discussions throughout the engagement process adopted for the NT CCRA.
2	Scheduled risk assessment workshops with stakeholders.	- Three workshops were scheduled as part of the NT CCRA. - Using findings from our review in step 1a short discussion paper was developed highlighting the project background, major climate drivers in NT and workshop schedules. This discussion paper was circulated to the identified stakeholders to give some background and invitation to the workshops.
3	Organised and facilitated the NT CCRA Scoping Workshop.	- To help scoping the risk assessment, Workshop-1 (W1), we aimed to facilitate a discussion with NT stakeholders to identify the appropriate systems or liveability measures against which risk will be evaluated (e.g., human health and wellbeing, water security, natural disaster readiness, energy security, food security, and a safe and stable built and natural environment). - The 3-hour virtual workshop was conducted with targeted stakeholders. - Workshop participants received pre-read material prior to the workshop that provided them with the necessary context and background information on the project and the topics that was discussed. - This workshop discussed risk assessment parameters (consequence criteria, adaptation urgency criteria, etc.). - We prepared a short summary of the scoping workshop capturing main discussion outputs from the discussion.
4	Prepared and distributed materials to support stakeholder participation in the risk assessment process.	- To help complete stage 1-3 of the risk framework covering risk identification, analysis and evaluation, in the Risk Workshop (step 5), supporting materials were prepared and circulated to the workshop stakeholders. Workshop preparation materials included a number of basic narrative risk statements covering all liveability measures that have been identified in the scoping workshop. Additionally, we identify high-level top three transition risks in line with the TCFD. Risks, opportunities, impacts and narrative statements were recorded in a spreadsheet. - Risk identification: An assessment was completed of the Territory's key climate hazards, from now to 2090, using two climate scenarios. A range of data sources were used to present information to support the Risk Workshop discussions. - At the workshop a broad discussion on how liveability measures (e.g., human health and wellbeing, water security, natural disaster readiness, energy security, food security, and a safe and stable built and natural environment) are being affected by current climate and how these may change in the future based on the climate scenarios and time steps agreed on for the study. - Our Risk analysis and evaluation: To guide the discussion in the workshop, we will propose a set of materials on consequence criteria. - A pre-read was developed and provided workshop participants parameters to support their technical understanding of climate change.

Risk assessment approach | Risk assessment and engagement process

Described below is the detailed risk assessment and engagement process undertaken as part of the NT CCRA.

KEY ACTIVITIES		DESCRIPTION
5	Led and facilitated a full day NT CCRA 'risk workshop' (W2) covering risk identification, analysis and evaluation (stage 1 to 3).	- We facilitated a day-long 'risk workshop' (W2) with targeted stakeholders. The purpose of the W2 was to complete stage 1-3 of the risk assessment with stakeholders. This was split into three 2-hours sessions, each aiming to complete a single stage of the risk assessment process. - High-level physical and transition risks were cover in the workshop. Workshop discussions were captured on posters and through note taking to inform the desktop risk analysis and evaluation. Based on workshop discussions we finalised the risk rating of all risk statements for three timeframes and capture in a spreadsheet.
6	Led and facilitated a half day NT CCRA 'adaptation priority' workshop (W3) covering stage 4 and 5 of risk assessment process.	- Once the risk ratings were determined, we identified how some of the high and medium risks are managed now or if anything is planned for future. We developed an online survey for this. The survey outlined key risks and opportunities within different systems to identify relevant adaptation action within and external to Government. - Preliminary list of identified adaptation actions were identified from desktop research and were circulated to workshop participants as a pre-read. - The 'adaptation priority workshop' (W3) was delivered, with a preliminary list of findings from adaptation actions survey and desktop research presented and discussion of any gaps. The workshop also involved discussion and agreement on adaptation urgency and priorities using the previously drafted criteria for assessing adaptation shortfall and urgency. - Workshop discussions were captured to inform the desktop analysis. This information was synthesised along with accumulated information to date to identify where adaptation action is most urgent over the next five years.
7	Drafted the NT CCRA Report	- Agreed content from the project plan, methodology report, outputs from scoping workshop, risk workshop and adaptation priority workshop were combined to inform the final project phase, and write a full technical Report with risk assessment and adaptation action analysis findings. - This final technical report aims to outline key findings including methodology, criteria, priority risks and opportunities and qualitative (and quantitative where available) information including: risk summary and impact, regional distribution of hazard, exposure and vulnerability, interacting risks, confidence and adaptation urgency. - It will also include outcome of the consultation activities.
8	Drafted a summary NT CCRA report for public release [Editorial note for DEPWS: This is in the process of being finalised].	- We will deliver high-level summary report (approximately 10 pages), which is required to be in a format suitable for a broad public audience. - An outline of the summary component key components: - Summary of key risks overall and by systems or liveability measures. Approx. 5 pages. - Summary of workshop findings. Approx. 1 pages. - Summary of adaptation priorities including actions, opportunities and urgency. Approx. 2 pages - Recommendations on improvements for future assessments. Approx. 2 pages.

Appendix C: Scenario analysis background

Climate change scenarios

Described below are is more detailed information on the different climate change scenarios used in the process of scenario analysis.

Scenario ambition	Modelled scenarios	Overview	Key assumptions of the scenario	Why this this scenario was used
Limited Climate Action High (4°C) Emission Scenario	Physical: SSP3-7.0	Average-case of how global emissions would evolve if governments and markets make no changes to their existing policies and investments in low carbon.	- Socio-economic narrative: assumes low population growth but with high migration, strongly reduced inequality with high Gross Domestic Product (GDP) growth per capita and high material consumption. - Emission reduction policies are limited to the current policies, and global coordination on tackling climate change is lacking. - Continued use of fossil fuels, and energy intensive activities and lifestyles. - Momentum in clean energy is insufficient to offset the effects of an expanding global economy and growing population. - Effects of climate change require significant investments in adaptation measures to protect assets, infrastructure and communities.	- Most regional physical model data available. - Provides higher end of the risk spectrum for physical risks, however, the world may experience worse impacts due to ice sheet and tipping points not modelled (IPCC AR6).
Current Targets & Pledges Moderate (2.5°C) Emission Scenario	Physical: SSP2-4.5;	Emissions are curbed based on existing policies and announced commitments, including Nationally Determined Contributions, but fall short of meeting the Paris Agreement targets.	- Socio-economic narrative: assumes moderate population growth with medium migration, moderately inequality with uneven medium GDP growth per capita and intense material consumption. - Emissions are curbed based on existing policies and announced national commitments to reduce emissions but fall short of meeting the Paris Agreement. - Slow implementation of policies due to political, institutional and societal barriers. The transition to a low carbon economy is disorderly, uncoordinated and delayed. Transition happens faster in certain regions compared to others leading to differences in regional policies and implications on cost of doing business and global trade (e.g., carbon border tax).	- Most regional physical model data available. - Scenarios within this range are often considered to represent current emissions trajectory. - Explores the impact of late or disorderly transition to a decarbonized economy.

Appendix D: Stakeholder list

List of stakeholders that participated in NT CCRA

Attorney-General and Justice

Power and Water Corporation

Department of Environment, Parks and Water (DEPWS) – Office of Water Security

Department of Chief Minister and Cabinet

Department of Health

Department of Infrastructure, Planning and Logistics (DIPL) – Infrastructure NT

Northern Territory Fire, Rescue and Emergency Services

Department of Corporate and Digital Development

Territory Generation

DIPL – Environment and Sustainability Unit

Power and Water Corporation (PWC) – Water and Wastewater Treatment

DEPWS – Office of Climate Change

PWC – Solar connections

Department of Education

Department of Industry, Tourism and Trade

DEPWS – Environment and Policy

Department of Treasury and Finance

Territory Generation

Territory Families, Housing and Communities

NT Department of the Chief Minister and Cabinet

DEPWS- Asset and planning

DCDD – NT Property Management

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B3: Risks to communications and ICT

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B6: Risks to transport and logistics

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B7: Risks to waste collection and storage

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N7: Risks to biosecurity (invasive species)

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