NSW GOVERNMENT

DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

Climate Risk Ready NSW Guide

Practical guidance for the NSW Government sector to assess and manage climate change risks

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Acknowledgements

The NSW Government acknowledges Aboriginal and Torres Strait Islander peoples as the traditional custodians of the lands and waters of this place we now call New South Wales.

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Preface

Building the preparedness of organisations to respond to potential risks resulting from climate change is an emerging area of risk management. The Internal Audit and Risk Management Policy for the General Government Sector (TPP20-08) recommends that NSW Government agencies consider climate risks that might impact their ability to achieve government objectives.

The risk management function plays an important role in helping NSW Government achieve climate resilience objectives, outlined in policies and strategies such as the NSW Climate Change Policy Framework, State Infrastructure Strategy 2018–2038, NSW Critical Infrastructure Resilience Strategy and NSW 2040 Economic Blueprint.

The increasing frequency, duration and intensity of extreme weather events such as bushfires and floods and changing weather patterns have the potential to affect NSW as our climate changes.

In response, the Department of Planning, Industry and Environment with support from NSW Treasury has developed the Climate Risk Ready NSW Guide: Practical guidance for the NSW Government sector to assess and manage climate change risks (the Guide). The Guide aligns with core requirements and recommended procedures outlined in the NSW Government's Internal Audit and Risk Management Policy for the General Government Sector and Risk Management Toolkit for NSW Public Sector Agencies (TPP 12-03).

Government plays a key role in helping address the economic and social impacts of climate risks for example by reducing disruptions to public services, protecting government assets, and supporting community adaptation. Adaptation approaches go hand-in-hand with the broader objective of the NSW Government to reach net zero emissions by 2050 as outlined in the Net Zero Plan Stage 1: 2020–2030.

By applying the process in this Guide, the NSW Government sector can achieve a consistent approach to climate risk assessment and management. The Guide outlines steps to consider the potential climate risks to an enterprise, program or project and encourages integration of these risks into enterprise risk management frameworks and procedures. This will support agencies to holistically and systematically address significant risks to objectives and financial management.

Michael Pratt AM
Secretary
NSW Treasury

Jim Betts
Secretary
Department of Planning, Industry and Environment

Approaches to adapt to climate change go hand-in-hand with the broader objective of the NSW Government to reach net zero emissions by 2050.

Introduction

The climate in New South Wales is already changing, with extreme weather events becoming more frequent and intense, as well as long-term changes to weather patterns evolving.

These changes can exacerbate existing risks and create new systemic risks and opportunities for government.

The Climate Risk Ready NSW Guide has been developed by the Department of Planning, Industry and Environment (DPIE) with support from NSW Treasury to help NSW Government staff to lead, influence and enable their organisations to better understand their exposure to climate change risks and opportunities, and to develop plans to address them. Applying this guidance will support NSW Government to successfully adapt to climate change, and seize potential opportunities.

Climate change is increasingly shaping our community and has the potential to impact how government plans and delivers the critical services and infrastructure we depend upon. The reliance of the NSW community on government assets and services is often emphasised during times of crisis, for example when critical networks are damaged or disrupted by extreme weather events.

The rise in Australia's average temperatures has accelerated in recent decades (see Figure 1). Current temperatures are about 1.4°C higher than they were in the 1950s (BoM 2020), and further warming expected (DPIE n.d.).

Figure 1 uses Bureau of Meteorology data to illustrate observed and simulated temperature anomalies for Australia, with and without the effect of human activities. It illustrates projected climate change that can be expected if emissions are not adequately abated.

Global emission targets: the Paris Agreement

The Paris Agreement is a global climate agreement that provides a framework for all countries to act on climate change. It was reached by 197 countries as part of the United Nations Framework Convention on Climate Change (UNFCCC) 21st Conference of the Parties (COP21) in Paris on 12 December 2015. The Paris Agreement includes a goal to limit the increase in global temperatures to well below 2°C and pursue efforts to limit the rise to 1.5°C.

As a signatory to the Agreement, Australia has committed to help achieve this goal by transitioning to net zero emissions nationally around 2050. While global efforts may be able to limit global temperature rise to below 2°C, physical impacts of climate change associated with this rise are expected.

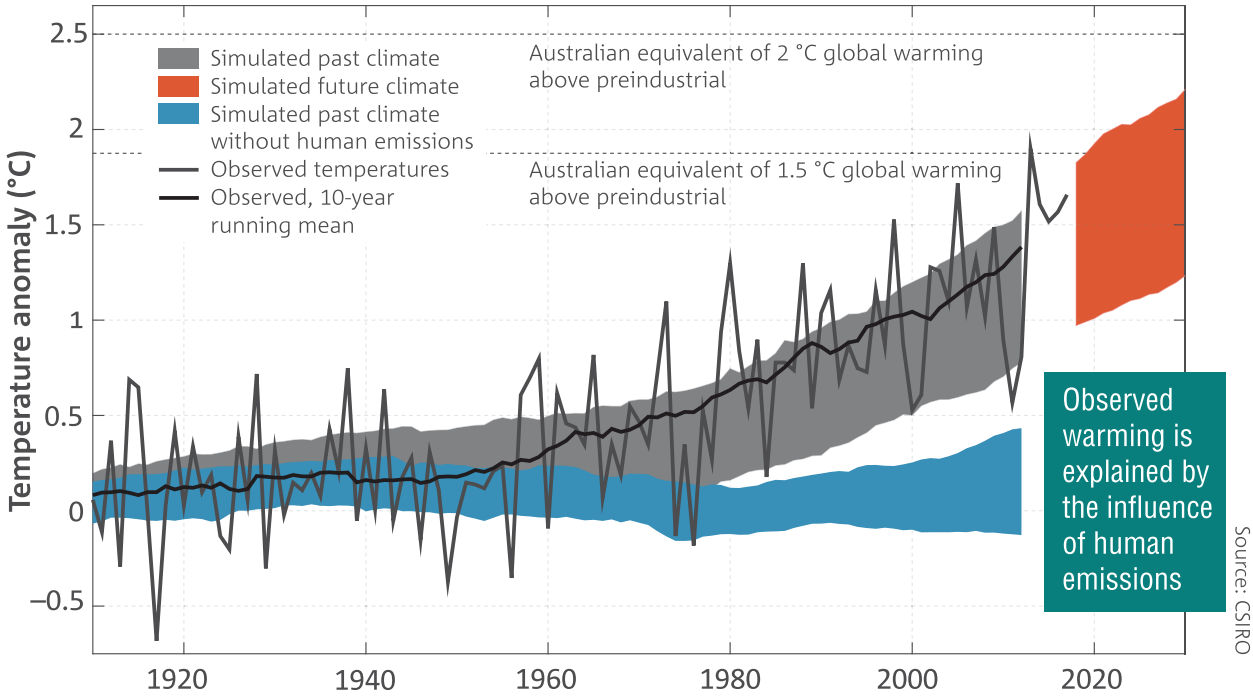


Figure 1: Observed and simulated temperature anomalies for Australia, with and without the effect of human activities

(Australian Government Climate Change Authority 2020)

Impacts from climate change will be felt differently across New South Wales and is likely to result in risks to our natural resources, health and wellbeing, and economic prosperity.

It is estimated that unchecked climate change will reduce the size of the Australian economy by 6.3% by 2070, and lead to a net reduction of 880,000 jobs (Deloitte Access Economics 2020). Further modelling by a global group of 66 central banks, including the Reserve Bank of Australia, warns that global domestic product could fall by 25% by 2100 if no action is taken (NGFS 2020). Disadvantaged groups, and those who do not have the financial capacity, social resources and necessary information to respond, will be particularly vulnerable; as will individuals and businesses in regions where the physical impacts are expected to be particularly severe.

Alternatively, limiting warming to 1.5 degrees and investing in climate adaptation measures is estimated to grow Australia's economy by $680 billion in present day terms and add over 250,000 jobs by 2070 (DAE 2020).

It is estimated that unchecked climate change will reduce the size of the Australian economy by 6.3% by 2070, and lead to a net reduction of 880,000 jobs.

(Deloitte Access Economics 2020)

As a provider and creator of public value, the NSW Government plays an important role in ensuring climate change risks are understood, integrated into decision-making, and acted upon. Investment in climate resilience yields multiple dividends; for example:

- avoided impacts of natural disasters when they occur
- reduced costs of maintenance and upgrades to public assets
- cost savings achieved through shared risk management
- delivery of co-benefits that arise even in the absence of a disaster (ABR 2017); for example, through increased efficiency or productivity. Studies in the United States measured that every US$1 invested in adaptation measures has delivered US$6 return (National Institute of Building Sciences 2018).

Responding to climate change risk doesn't necessarily require major projects or investment. In many instances, greater accountability, planning and preparedness will help organisations address climate risk and opportunities.

Image of fire ground taken with a NSW National Parks and Wildlife Service ParkAir drone to collect information for fire crews after a bushfire. Photo: G Pickford/DPIE

Why this Guide matters

Delivering government priorities and objectives

From school classrooms, health centres and police stations to transport, water and energy infrastructure, there is an opportunity for the NSW Government to better prepare for future disruptions from climate change and to build resilience. Climate risks may impacts Government's ability to meet statutory mandates and/or its reputation as a reliable provider of services. Figure 2 illustrates examples of potential climate impacts and risks to delivering on government objectives.

Applying this guidance will help your organisation to:

- **protect core functions** – understand how physical climate risks may impact core organisational objectives and operations
- **prioritise responses to climate change risk** – highlight areas that warrant further investigation or investment
- **seize opportunities** – increase understanding, and capacity to respond to climate-related opportunities
- **improve enterprise-level oversight of climate change risks** – embed climate risk management in existing frameworks and procedures
- **adapt and build climate resilience** – inform decisions about risk treatments to be implemented over time.

Key messages

- This Guide is aligned to the NSW Treasury Internal Audit and Risk Management Policy (TPP20-08) and Risk Management Toolkit (TPP 12-03).
- Climate risk management and adaptation should be integrated into existing frameworks and procedures where possible.
- It is recommended that where resources permit, NSW Government organisations allocate a Climate Change Risk Officer to oversee climate risk responses.
- Organisations should allocate a minimum 8 months to complete a climate change risk assessment.

Department of Primary Industries	Department of Health	Department of Education	Sydney Metro	Department of Planning, Industry and Environment
Objective We play a key role in increasing the value of primary industries in NSW.	**Objective** We help people stay healthy and provide access to timely, high quality, patient-centred health care.	**Objective** We deliver high quality public education to two-thirds of the NSW student population.	**Objective** We commit to easy, safe and reliable turn-up-and-go services.	**Objective** We manage sustainable and secure water resources.
Climate impact Increased frequency and duration of drought can impact agricultural productivity and regional economic growth.	**Climate impact** Heatwaves of greater frequency and duration can increase heat-related health issues and morbidity, placing greater pressure on health services.	**Climate impact** Increased extreme bushfire weather can threaten school buildings and reduce attendance.	**Climate impact** Increased intensity of rainfall and flash flooding can disrupt train operations and damage assets.	**Climate impact** Increased frequency and duration of drought can impact potable water quality and availability.

Figure 2: NSW Government organisation objectives and potential climate impacts and risks

Using this guide

This Guide outlines foundational activities and a four-step process for climate change risk assessment and management that can be adapted to suit your organisation (outlined in Figure 3 and Table 1).

At each step, the Guide outlines actions and objectives. It makes recommendations about sources of information and data, drawing upon the NSW Government's AdaptNSW website and NSW and ACT Regional Climate Modelling project (NARCliM) projections. It provides tools to support implementation and highlights case studies of real practice in NSW Government.

To encourage continuous improvement, options to increase the climate change risk maturity of your organisation are identified. This is a key determinant of how successful an organisation will be in adapting to climate change.

This Guide draws on national and international leading practice in climate risk management, and industry and government experience. It is aligned to the general process and considerations contained in ISO 31000:2108 – Risk management guidelines and ISO 14091 – Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment.

Figure 3 summarises the Climate Risk Ready NSW process.

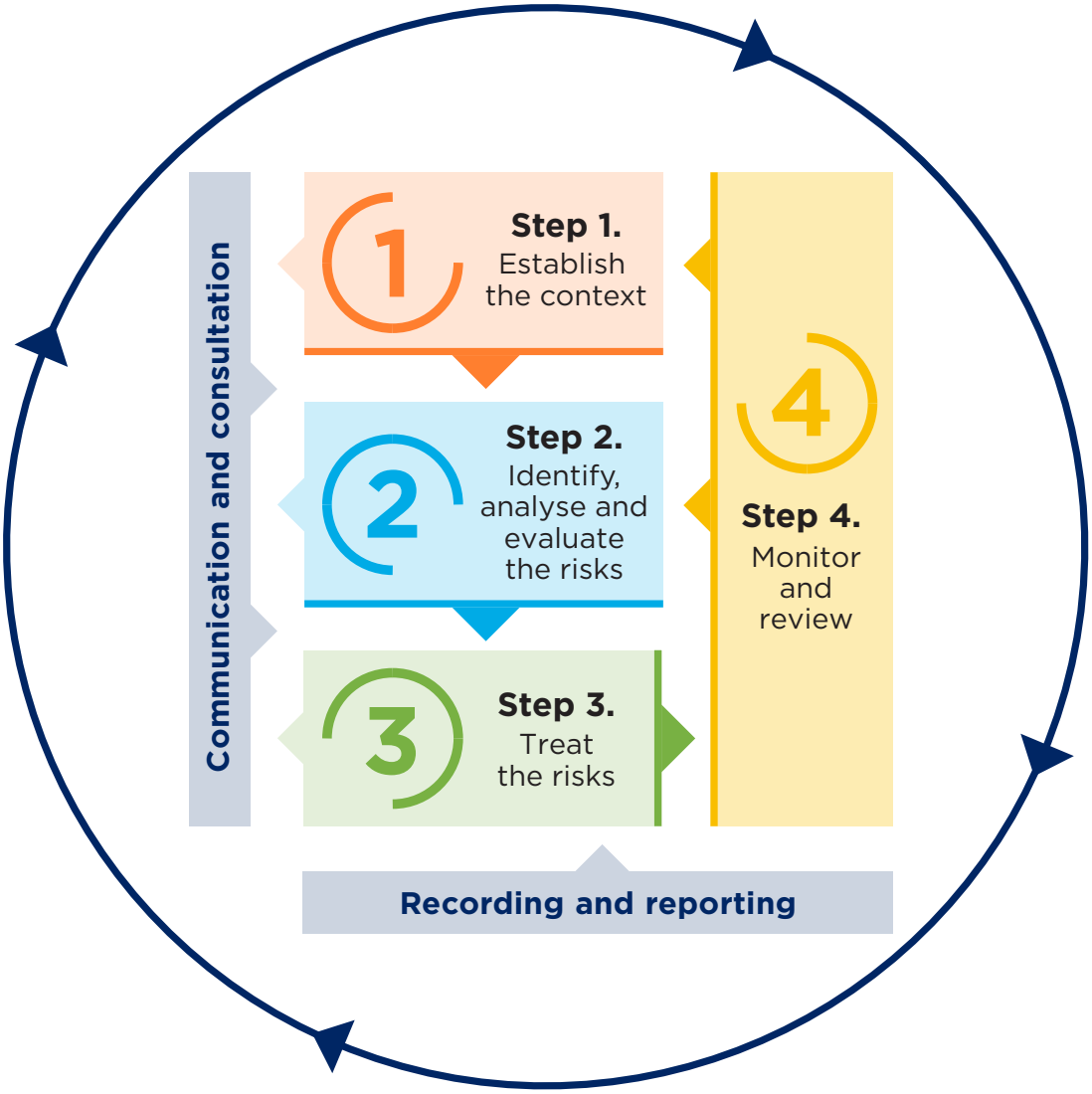


Figure 3: Outline of the Climate Risk Ready NSW process aligned to ISO 31000

Table 1: Climate Risk Ready risk assessment and management process

Process step	Page	Indicative timeframe	Outputs
1 **Step 1. Establish the context** Establish an authorising environment and resources for climate change risk assessment and management			
Understand your organisation's climate risk management maturity	25	2 weeks	Completed Climate Risk Maturity Health Check Tool
Establish the reason for a climate change risk assessment and secure approvals	28	3 weeks	Briefing paper to secure an executive sponsor.
Identify stakeholders and establish an assessment team	30	2 weeks	List of stakeholders and assessment team members.
Determine the scope of the climate risk assessment	33	2 weeks	An agreed climate risk assessment scope
2 **Step 2. Identify, analyse and evaluate the risks** Establish a plausible climate future and document priority climate change risks			
Understand past and recent climate hazards and trends	41	3 weeks	A list of climate variables relevant to your context
Consult relevant climate projections	43	2 weeks	An understanding of projected climate change impacts
Identify risks and opportunities	46	3 weeks	A list of climate change risk statements
Analyse and evaluate risks	49	3 weeks	Priority climate risks with agreed risk ratings
3 **Step 3. Treat the risks** Develop an adaptation plan to treat priority climate change risks and increase climate risk maturity			
Identify and prioritise adaptation actions	53	3 weeks	A resourced adaptation plan including actions to improve climate change risk maturity
Develop and implement an adaptation plan	56	4 weeks	
4 **Step 4. Monitor and review** Monitor implementation of adaptation plans, climate change impacts and embed reviews in existing procedures and systems			
Develop a monitoring and evaluation plan	64	2 weeks	A plan to track adaptation implementation, and monitor climate risks
Integrate monitoring, review and learning into existing systems	68	4 weeks	An updated risk register

Recommended roles and responsibilities

At each of the four steps in the Climate Risk Ready process, recommended roles and responsibilities are outlined for the executive, climate risk officers, and assessment teams.

Together, these roles are required to provide and support an authorising environment for effective identification, oversight and management of climate risks. Priority risks should be managed by identified risk owners, as per standard risk management practice outlined in the NSW Treasury Risk Management Toolkit (TPP12-03).

Climate change risk assessments should be led and conducted with in-house expertise where possible. Where it is necessary to procure external support for an assessment, a capability building approach should be employed to build internal skills.

It is recommended that organisations designate a **climate change risk officer** with oversight of climate change risk management and maturity. This responsibility may be incorporated into an existing role in the organisation, or it may be a new role.

Increasing severity of droughts under climate change may influence dust storms and impacts, as seen here in the Hunter Valley. Photo: Nick Cubbin/DPIE

Alignment to existing NSW Government policy and guidance

The Climate Risk Ready process is aligned to ISO 31000:2018 Risk Management – Guidelines and NSW Treasury Internal Audit and Risk Management Policy (TPP20-08) (the policy). The policy is supplemented by the NSW Treasury Risk Management Toolkit (TPP 12-03).

Integrating consideration of climate change into existing enterprise risk management frameworks, processes and governance supports Core Requirement 1.2 of the policy.

Under Core Requirement 1.2, the policy requires organisations to consider **emerging risks** such as climate related risks when assessing risks that might prevent an organisation from achieving its objectives. Audit and risk committees are responsible forseeking assurance from management that emerging risks, such as climate change risks, are being identified and addressed.

Further related obligations are outlined in Appendix A.

Increasing storm weather is expected to worsen coastal beach erosion, as seen here on Collaroy Beach, a developed coastline on Sydney's northern beaches. *Photo: Joanna Munnelly/DPIE*

CASE STUDY

Applying the Climate Risk Ready process at the Sydney Opera House

The Sydney Opera House undertook a climate change risk assessment over two workshops in late 2019 to pilot the Climate Risk Ready process, focusing on physical climate risks to the Sydney Opera House.

The first step was a review of existing risk assessments and climate projections for the metropolitan Sydney region. A 'first pass' desktop assessment was carried out to identify key risk themes:

- Operations and Maintenance
- Structure and Landscape
- Safety, Governance and Patron Experience.

An initial risk assessment workshop drew together around 20 staff from key function to validate the first pass risks identified. Those handling strategic risk included the heritage manager and the strategic asset manager. Operational staff ranged from managers to directors, including those in emergency response, food and beverage, building and safety, events and visitor experience. Risks identified included supply chain risks as well as managing the impact of rising sea levels on the structure itself.

Using input from the initial workshop, a list of priority risks was identified and grouped. A second workshop was held with the same staff to validate the prioritised risks and identify existing controls. Given the sustainability maturity of the Opera House many risks were already being managed; however, the process identified two immediate needs to strengthen its climate risk readiness:

- improving collaboration between staff in strategy-related roles who assessed future risk for long-term strategic responses, and operational staff who were focused on finding a solution to incidents at hand
- solutions that address both strategic and operational risks as important considerations.

The risk assessment process was augmented with a technical engineering study to further understand priority risks associated with sea level rise on the built structure. The Opera House will review its processes and develop new adaptation pathways and triggers for managing identified risks including peak high tides and storm surges, and severe weather events.

The world heritage-listed Opera House conducted a climate change risk assessment to understand the potential impacts of climate change. Photo: Hamilton Lund

What is climate change risk?

Climate change risk refers to potential negative or positive impacts of natural hazards and climate under the influence of rising global greenhouse gas emissions. In this Guide, the terms climate change risk and climate risk are used interchangeably.

Impacts can be event-driven (acute shocks) or longer-term shifts (chronic stresses) in climate patterns. There are three types of climate risk: physical, transition and liability (Bank of England 2020). This Guide focuses primarily on physical climate risk. Climate risks arise from a chain of consequences like those illustrated in Figure 4, and elaborated upon further in Figure 7.

Physical risks result from the direct impacts from rising aggregate global temperatures (CSIRO 2016). Examples include damage or disruption to assets or infrastructure, supply chain impacts, or health impacts.

Physical risks can be determined based on past and current experience of natural hazards, climate change projections and identification of relevant climate variables.

Transition risks or opportunities may result from the move to a lower-carbon economy. Examples include changes in market demand, reputational risks or legal risks associated with regulatory change to limit greenhouse gas emissions.

Liability risks are those associated with people or businesses seeking compensation for losses they may have suffered resulting from climate change, including as a result of physical and transition risks (Bank of England 2020).

Climate vs weather

Weather is the mix of events that happen each day in the Earth's atmosphere. Whilst there is only one atmosphere, weather varies in different parts of the world and changes over minutes, hours, days and weeks.

Weather refers to short-term changes in the atmosphere, while climate describes what the weather is like over a long period of time in a specific area.

Risk is defined as 'the effect of uncertainty on objectives, noting that effect is a deviation from the expected and may be positive and/or negative' (NSW Treasury 2012).

Climate resilience is the ability to anticipate, prepare for, respond and adapt to acute and chronic climate change, so as to continue delivery of services and assets, and meet community expectations.

Adaptation refers to actions undertaken to manage or reduce the adverse consequences of climate change, as well as to harness any benefits or opportunities. This may include transitional or transformational action.

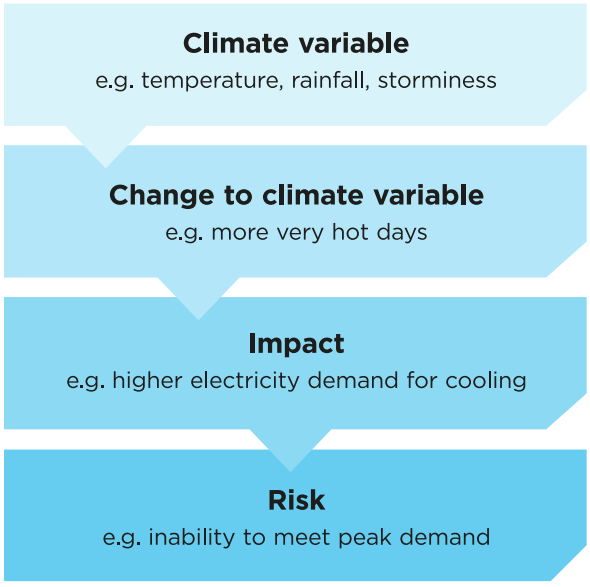


Figure 4: Links between climate change and risk (AGO 2006)

Adaptation or mitigation?

The severity of climate change impacts over the medium to long term depends on how fast global greenhouse gas emissions can be reduced. Greenhouse gases already built up in the atmosphere will result in some unavoidable short term warming. Adaptation will help manage potential climate risks resulting from current and projected warming.

Climate change adaptation refers to the process of making decisions and taking actions to manage or reduce the adverse consequences of climate change, as well as to harness any benefits or opportunities.

Climate change mitigation includes actions we take globally, nationally and individually to limit changes caused in the global climate by human activities. Mitigation activities reduce greenhouse gas emissions and/or remove greenhouse gases from the atmosphere.

In some instances, action to adapt (address climate change risks) may also achieve climate change mitigation outcomes. Figure 5 illustrates the difference between mitigation actions and adaptation actions and the overlap between the two.

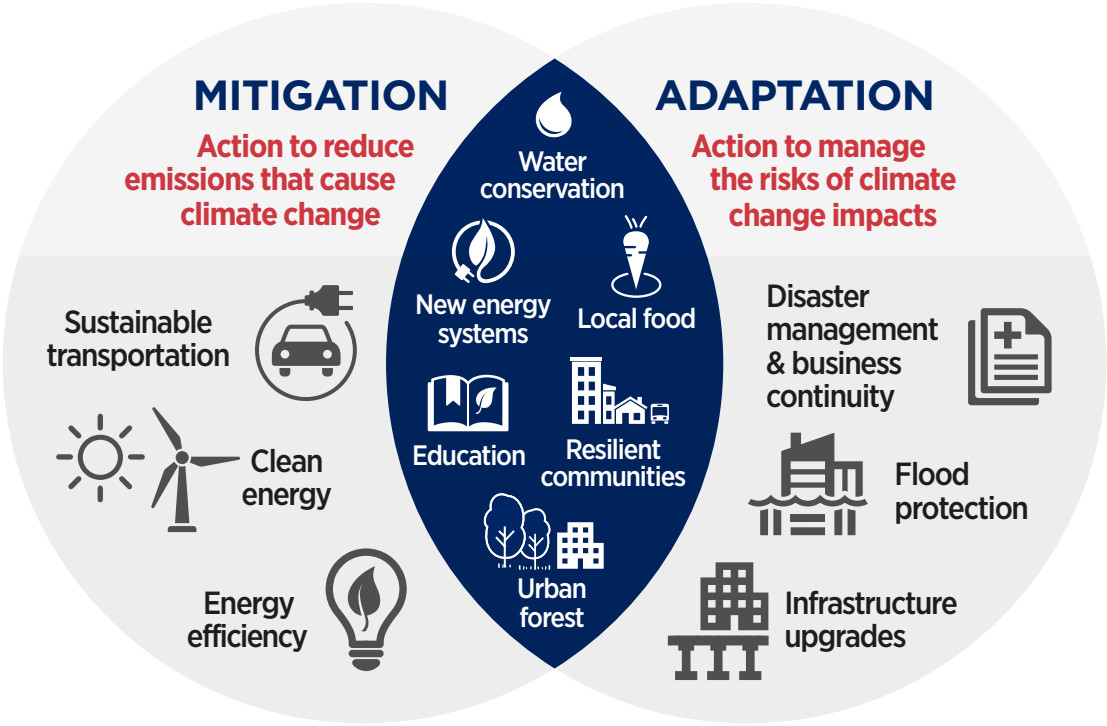


Figure 5: Examples of climate change mitigation and adaptation actions and complementary approaches.

Climate-related financial risks

There is an increasing expectation that organisations in the private and public sectors are proactively managing climate change risks.

The Reserve Bank of Australia, the Australian Prudential Regulation Authority and the Australian Securities and Investments Commission have recognised climate change as a material economic risk to the Australian economy. The Ratings Agencies Moody's and S&P are increasingly considering climate risk as part of their credit rating assessment of state governments.

This increasing attention has been in part catalysed by the Task Force on Climate-related Financial Disclosures (TCFD). The TCFD was established by the global Financial Stability Board in December 2015. The TCFD seeks to help manage the exposure of the financial system to climate-related risks through more informed investment decision-making and by supporting targets set out in the Paris Agreement to limit global warming this century to well below 2°C.

Its 2017 recommendations provide a framework to guide disclosure of climate- related financial risks to investors, regulators and governments (TCFD 2017). Figure 6 outlines types of climate-related financial risks and opportunities for an organisation.

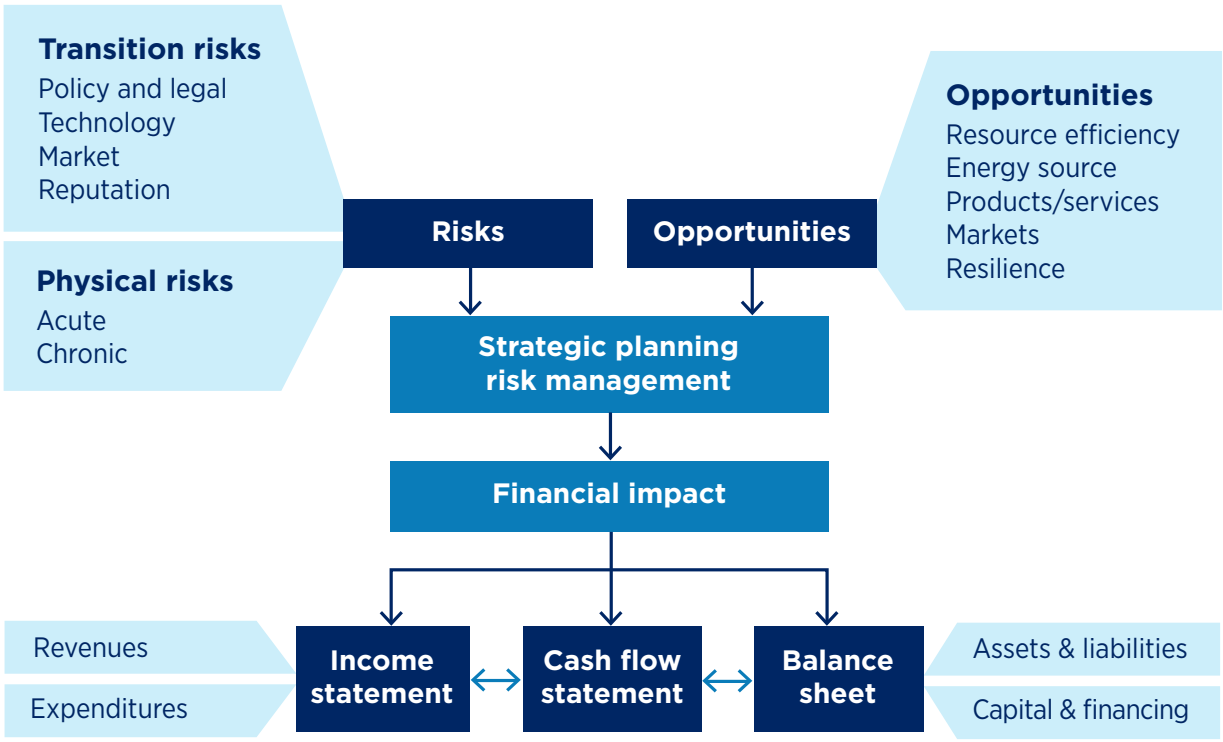


Figure 6: Climate-related financial risks, opportunities and their financial impact (TCFD 2017)

There is wide and continued uptake globally of the TCFD recommendations. Global benchmarks such as Carbon Disclosure Project and Global Real Estate Sustainability Benchmark are increasingly aligning to TCFD recommendations. The Australian Government's Senate inquiry into carbon risk disclosure also recommended that government commit to implementing the TCFD recommendations (Senate Economic References Committee 2017).

Addressing climate change risk

Unique features of climate change risk management

Climate change has the potential to multiply existing threats and may increase existing vulnerabilities and risk exposure. Figure 7 illustrates the relationship between climate risk and the concepts of hazard, vulnerability and exposure.

First pass risk assessments are generally qualitative as they require a number of assumptions to be made about what a plausible future climate may look like, and how this may influence the likelihood and consequence of potential risks

Potential challenges of managing climate change risks include:

- uncertainty about the precise nature and timing of climatic changes, particularly at regional and local scales
- uncertainty regarding societal, economic and technological changes that may influence global emissions over time
- long-term horizons that may not align to other planning timeframes
- dispersed governance of the functions and roles that can help governments effectively adapt, and of the systems that may be impacted by climate.
- capacity for transitional or transformational adaptation.

These challenges reinforce the need for an adaptive management approach that utilises evidence as it becomes available to maximise risk management and adaptation outcomes over time.

Figure 7 illustrates the influence of climate change on existing risks and the role of adaptation in reducing potential negative impacts.

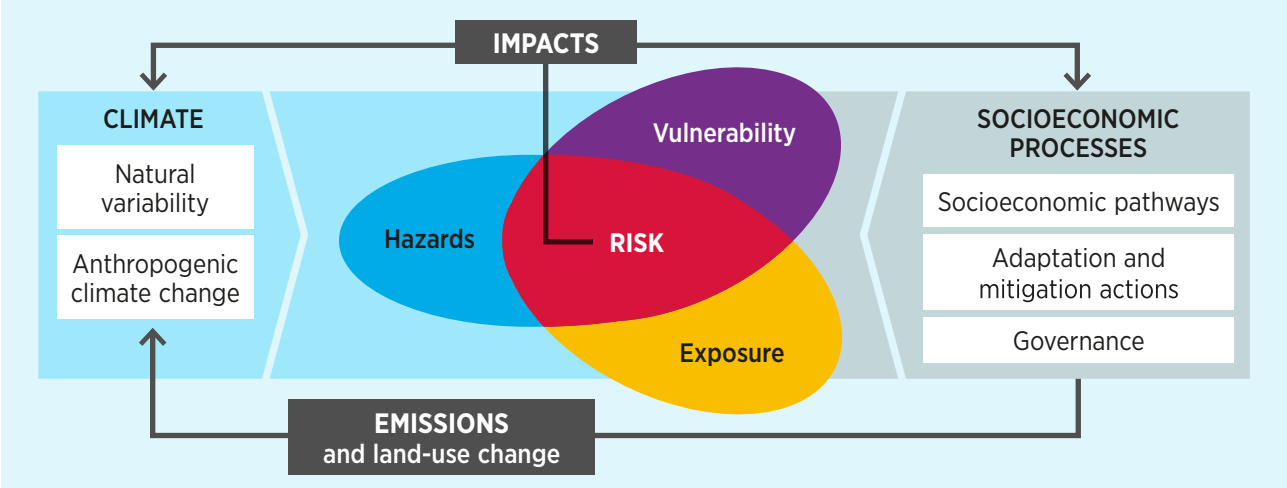


Figure 7: Illustration of how the concept of climate risk results from an interaction of climate-related hazards, and the vulnerability and exposure of human and natural systems

(IPCC 2014)

Leading practice in climate change risk management

Climate change risk management is an emerging area of risk management and is evolving in response to increasing extreme events, improved risk management culture, and the expectations of key stakeholders such as investors, insurers, credit rating agencies and communities.

A leading organisation will have:

- an executive that understand climate risks to the organisation and are committed to addressing them
- allocated oversight of climate risk to a central, ongoing role (a climate risk officer)
- clear accountability for addressing climate risk
- a risk management process that explicitly identifies climate risks
- integrated consideration of climate risk into existing risk management, monitoring and reporting systems
- a continuous improvement process in place to periodically review management of climate risks
- appropriate resourcing for knowledge and capability building over time.

CASE STUDY

Landcom – leading practice in the NSW Government sector

Landcom's Sustainable Places Strategy is founded on four pillars covering environmental, social, economic and governance sustainability. Its environmental pillar Climate Resilient Places includes Landcom's leadership goal to be carbon neutral and water positive, with zero waste and net positive ecological outcomes by 2028.

The recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) and Global Real Estate Sustainability Benchmark (GRESB) Resilience Module inform how Landcom approaches climate risks to its assets and organisation and guided the adoption of its Climate Risk Management Plan.

In accordance with the plan and its Sustainable Places Strategy targets, Landcom completes climate change risk assessments for all new and emerging projects in accordance with IPCC AR5 Representative Concentration Pathways 4.5 and 8.5 climate projections (IPCC 2000). These assessments are provided to executive and board prior to acquisition approval, accompanied by adaptation and mitigation strategies.

Landcom has also embedded climate-related risks into its suite of risk registers, and proactively monitors and reports ongoing or emerging physical, social or transition risks to its executive monthly, and to the board on a quarterly basis.

Landcom carries out climate change risk assessments for all new projects such as this playground at the corner of Badgally Road and Clydesdale Drive in Claymore. Photo: Landcom

Recommended minimum standard

Some NSW Government organisations may be at the start of integrating climate risk into their existing risk management frameworks. This Guide includes a tool in Appendix B to help organisations identify how mature their climate risk management practice is. The tool reflects the maturity levels in NSW Treasury's Risk Maturity Assessment Tool (TPP20-06), as outlined in Table 2.

It is recommended that NSW Government organisations seek to meet a **systematic level** of climate risk management maturity. At an enterprise level, systematic maturity is distinguished by standard, consistent processes. Recommended areas of improvements are outlined below.

Table 2: Progression through the climate change risk maturity levels

Fundamental	Climate change risk assessments have been undertaken in isolated parts of the organisation. Climate change risk is not considered in risk frameworks.
Repeatable	Climate change risk is considered in risk management frameworks and processes. Climate risk assessments are undertaken in isolated parts of the organisation.
Systematic	Clear and disciplined climate change risk management processes are established and proactively managed with an annual review of adaptation action implementation. A climate risk officer role is established in a central corporate function.
Embedded	Priority climate change risks for the organisation have been identified. An organisation-wide adaptation strategy for managing climate risks has been established. Monitoring, learning and reporting on climate risks is consistent.
Advanced	Climate change risk assessments and adaptation responses consider broader economic, financial, social and environmental resilience. Shared and interdependent risks are being actively managed. Monitoring, learning and reporting on climate risks results in continuous improvement.

Storm over Lindsay Rock Tops, Mount Kaputar National Park. Photo: Fiona Gray/DPIE

Reviewing and enhancing existing risk management frameworks and processes

Where possible, existing risk management frameworks and procedures should be used and enhanced to enable effective climate risk management. This will ensure that the outcomes of a climate risk assessment are accurately reflected and monitored as part of business-as-usual risk management. Improvements to consider are outlined below.

Leverage inclusion of climate hazards in existing risk registers

Information on climate hazards already identified in existing risk registers (separate to existing standalone/asset specific climate risk assessments) can be leveraged in your climate risk assessment. For example, flooding may already be considered but risk ratings may be based on current or historical flooding information rather than climate projections.

Integrate climate risk into existing risk categories where possible

Existing risk registers should be used where possible. Building on the previous example, it is likely that extreme weather such as flooding are already considered under existing risk categories such as safety or business continuity. Depending on your organisation's maturity, it may be feasible to embed climate risk into existing categories. If your organisation is less mature, or highly exposed, it may be necessary to create a specific climate risk category to elevate management.

Adopt an enterprise-wide climate change risk statement

Integrating a climate change risk statement into an enterprise risk register can support those with oversight of risk management to seek further assurance that climate risks are being addressed, thus elevating risk awareness. It can help highlight the need for coordinated management across the organisation. Examples of climate change risk statements include:

'There is a risk the organisation has not adequately assessed the potential impacts of climate change on its business objectives, resulting in increased exposure across multiple areas of risk.'

'There is a risk the organisation is not implementing sufficient actions to adapt to climate change, resulting in risks to objectives and potential inability to maximise opportunities.'

Enhance existing risk management systems and guidance

Existing risk matrices may need to be enhanced to better reflect the uncertainty and long time periods associated with climate risks. This will enable climate risks to be considered consistently alongside other enterprise risks.

The Australian Government's Climate Compass recommends adding an additional likelihood criterion of 'Uncertain' and assigns higher risk ratings to these risks (CSIRO 2018). Some organisations may include factors such as community confidence in consequence criteria to help to capture chronic stresses (low level disruptions) associated with a lack of adaptation – even if service delivery disruption or cost implications are low.

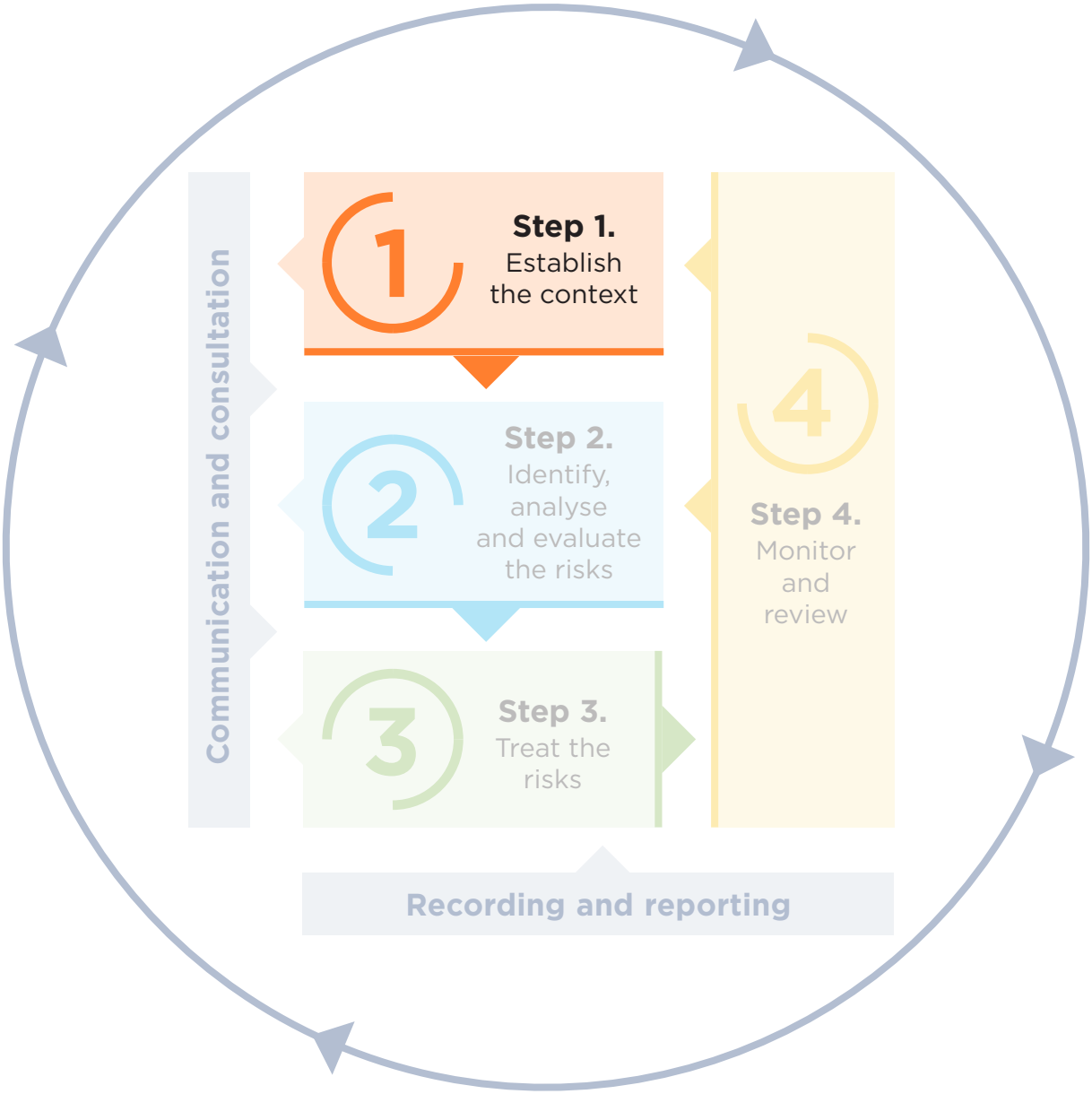
It may also be appropriate to review risk escalation points for climate risks, so that efficiencies in adaptation, or risk treatment, can be planned.

Assign clear accountability for oversight of climate change risk

Clear accountability and authority for managing risks is required under NSW Treasury's risk management policy (TPP20-08). It is recommended that a climate risk officer with an appropriate mix of skills has oversight of climate risks for the organisation, including implementation of adaptation actions. Responsibilities of the role should include monitoring emerging climate risk management obligations and expectations, updates to climate change projections and new research into sector-specific impacts.

Step 1.
Establish the context

Establish an authorising environment and resources for climate change risk assessment and management



Key messages

- • Building an authorising environment is a foundational step to before commencing a climate **risk assessment**.
- Completing the Climate Risk Maturity Health Check Tool (**Appendix B**) is recommended to identify the climate risk management maturity of the organisation, and support communications with decision-makers.
- It is recommended that climate change risk assessments are updated on a regular basis, generally every two to five years, and reviews of implementation are undertaken annually.

Actions and outputs

Actions	Indicative timeframe	Outputs	Key resources
Understand your organisation's climate risk management maturity	2 weeks	• Completed Climate Risk Maturity Health Check Tool	• Climate Risk Maturity Health Check Tool (**Appendix B**) • NSW Treasury Internal Audit and Risk Management Policy (TPP20-08) • NSW Treasury Risk Management Toolkit (TPP 12-03)
Establish the reason for a climate risk assessment	3 weeks	• Briefing paper to secure an executive sponsor for a climate change risk assessment	
Identify stakeholders and establish an assessment team	2 weeks	• List of stakeholders and assessment team members	
Determine the scope of the climate risk assessment	2 weeks	• An agreed climate risk assessment scope	

Recommended roles and responsibilities

Executive	Climate change risk officer	Assessment team
Sponsors a climate risk assessment Communicates the importance of addressing climate risk in the organisation Identifies a climate risk officer	Leads engagement with decision-makers Establishes the organisation's climate risk context Endorses the scope of the climate risk assessment	Develops the scope of the climate risk assessment Completes the Health Check Tool Supports communication with decision-makers

Understand your organisation's climate change risk management maturity

A **Climate Risk Maturity Health Check Tool** (the Health Check Tool) has been developed to help organisations conduct a simple exercise to understand their adaptive capacity that is aligned to the NSW Treasury Risk Maturity Assessment Tool (TPP20-06). It is informed by national and international leading practice in climate change adaptation and climate risk management.

Completing the Health Check Tool before commencing a climate risk assessment is recommended to be completed before commencing a climate risk assessment. It will help identify the organisational context for managing climate risks. This includes the presence or absence of supporting policies, governance, leadership, stakeholder engagement, awareness of impacts and skills.

It is recommended that organisations identify a target level of maturity and embed actions to achieve this in their adaptation plan. Identifying target maturity should consider current barriers and enablers within the organisation. It may be appropriate to establish different maturity levels for different parts of the organisation. Appendix D provides examples of what success might look like over time at different levels of climate risk maturity.

NSW Government organisations are recommended to achieve **systematic maturity** at a minimum. The five levels are described in more detail, and their alignment to the NSW Treasury risk maturity levels (NSW Treasury 2020b), in Table 3 below.

The International Standard for Adaptation to climate change – *Guidelines on vulnerability, impacts and risk assessment* (ISO 14091), recommends that consideration of adaptive capacity is a key component of a climate change risk assessment.

How to use the Health Check Tool

The Health Check Tool should be completed in partnership with at least two to three other team members including representatives from sustainability and risk management. It may be appropriate to provide the opportunity for members of the executive level/leadership team and core assessment team to be involved.

The results of the Tool can be shared with internal stakeholders and provides a baseline to inform a decision about the level of maturity the organisation would like to reach, and appropriate steps to get there.

Table 3: Minimum maturity level users of this Guide are recommended to achieve

Maturity level	NSW Treasury risk maturity description		Corresponding climate change risk capability
	Distinguishing factors	Capability	
Fundamental	Un-coordinated	Risk management is unpredictable, vague and highly dependent on individuals	Climate risk assessments have been undertaken in isolated parts of the organisation. Climate risk is not considered in risk frameworks.
Repeatable	Disciplined process	Risk management is established and repeatable, documentation is limited	Climate risk is considered in risk management frameworks. Climate risk assessments are undertaken in isolated parts of the organisation.
Systematic	Standard, consistent process	Risk management is proactively managed, supported by defined process and is stable and measurable	Clear and disciplined climate risk management processes are established and proactively managed with an annual review of adaptation action implementation. A specialist climate risk officer role is established in a central corporate function.
Embedded	Predictable process	Risk management is formally defined, predictable, consistently delivered and meets defined objectives	Priority climate risks for the organisation have been identified. An organisation-wide adaptation strategy for managing climate change risks has been established. Monitoring, learning and reporting on climate change risks is consistent.
Advanced	Continuously improving process	Risk management is optimised, delivers to stretch objectives and is subject to continuous improvement	Climate risk assessments and adaptation responses consider broader economic, financial, social and environmental resilience. Shared and interdependent risks are being actively managed. Monitoring, learning and reporting on climate risks results in continuous improvement.

CASE STUDY

Using the Health Check Tool – NSW Education Department

The NSW Department of Education is the largest provider of education in Australia, delivering high quality education to 810,000 students across more than 2200 schools. We ensure the delivery of quality early childhood education and care for children from birth to school age, and support training, upskilling and lifelong learning to meet the skill needs of employers and the industry.

The **Climate Risk Maturity Health Check Tool** is a simple, dynamic and effective worksheet that helped stakeholders understand the existing climate risk management capacity of the department. It played an integral part in building the case for the department's executive to identify and plan to manage our climate risks while continuing to build climate change capability.

The risk team used the modules within the tool to facilitate discussions and manage expectations across a range of internal stakeholders, such as those from the department's Learning, Wellbeing, Infrastructure, Compliance and Finance business units.

Consultation outcomes

Stakeholder interviews were guided by the modules, and the emerging themes in the Health Check Tool informed how the team assessed the department's overall climate change capability. Responses were consolidated, which led the team to identify that sound practices were in place for:

- data management
- response strategies to climate risk events (such as bushfires and floods), and
- school infrastructure sustainability.

Responses also acknowledged the importance of a more holistic and coordinated approach to managing the impacts of climate change within education.

What's next?

The next step is to integrate climate risk into existing risk management processes and build capacity in key areas using the Health Check Tool. For more information, email the NSW Department of Education Risk and Governance team at risk@det.nsw.edu.au

Establish the reason for a climate change risk assessment and secure approvals

Climate change risk assessments may be triggered or driven by a range of internal or external policies, processes, or events. Understanding the driver for assessment will help determine its scope, who should be involved, and the level of detail required.

The PESTLE (political, economic, socio-cultural, technological, legal, environmental) model is a common approach to scan the external environment for potential drivers and trends that will impact your organisation.

Further information on this step can also be found in the NSW Treasury Risk Management Toolkit (TPP12-03).

Common reasons for conducting climate risk assessments include recent impacts from extreme weather events, increased realisation of the benefits of considering climate change in decision-making, or a change to government or market regulation. Figure 8 provides examples of triggers or drivers for a climate change risk assessment.

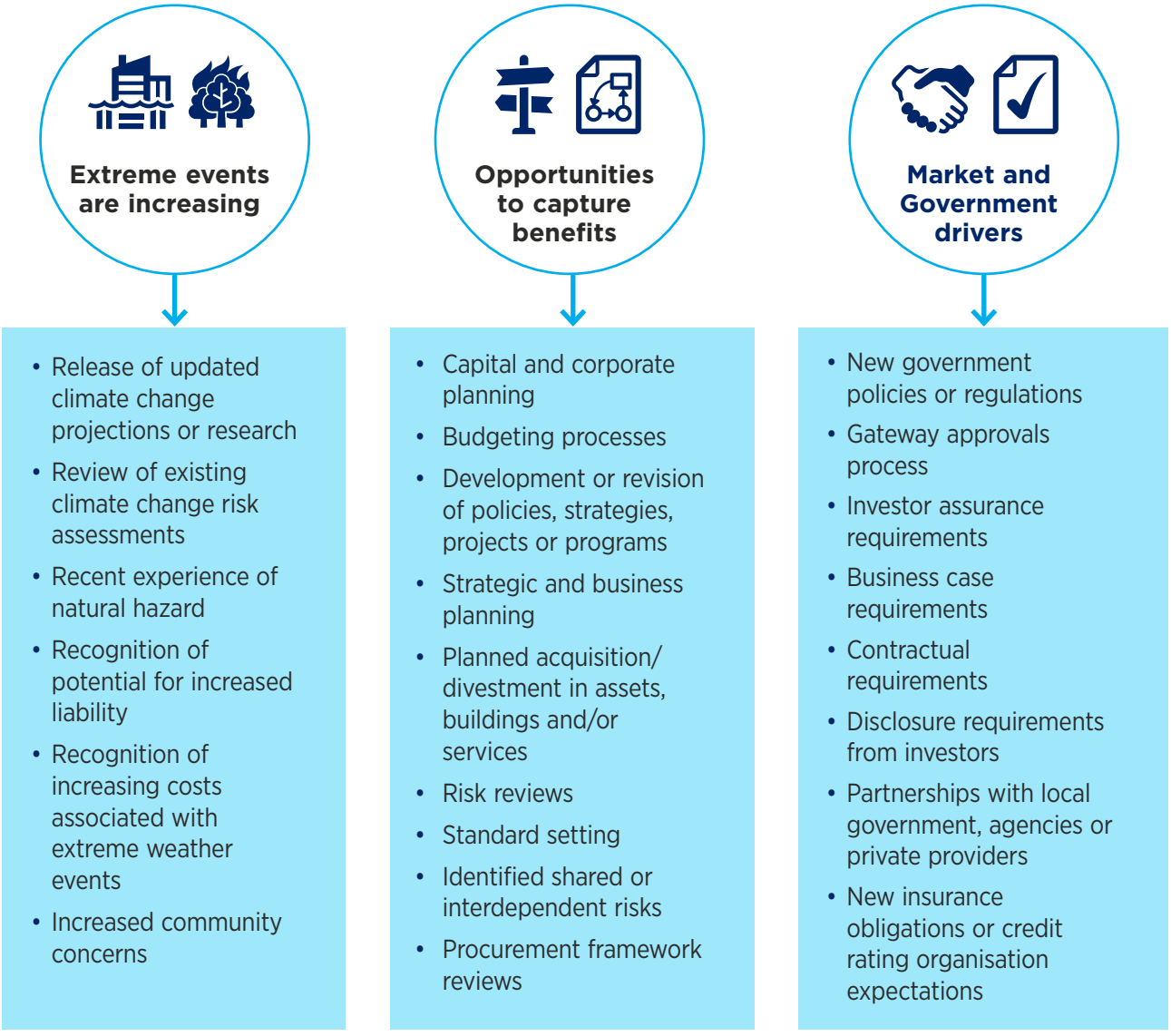


Figure 8: Potential reasons for undertaking a climate change risk assessment

Updating existing climate change risk assessments

Climate risk assessments should be updated on a regular basis, at least every five years, and reviews of implementation should be undertaken annually. When reviewing a climate risk assessment consider:

- status of implementation of adaptation action and responsibilities for implementation
- the need to updating climate projections in line with more recent climate change projections
- observed experience of climate events since completion of the climate risk assessment
- scope of the assessment and any changes to the related activities
- relationship to other risk assessments that have been undertaken.

CASE STUDY

Triggers for an assessment – Transport for NSW

Some industry bodies and NSW Government organisations have developed risk assessment policy or guidance for their own sectors that may trigger when and how a climate risk assessment has to be done.

Transport for NSW (TfNSW) has an Environmental and Sustainability Policy and Framework, supported by a statement of commitment. Under the framework, projects above a certain value must comply with the TfNSW Climate Risk Assessment Guidelines. The guidelines provide recommended steps and a pre-screening climate change risk checklist based on pre-selected impacts that are commonly rated as high or extreme over various time horizons. The checklist helps users identify potential risks that infrastructure may be exposed to, for further assessment.

Right: Extreme flooding prevents commuters from entering the train station to access platforms and disrupts the Sydney Train rail network. Photo: TfNSW

Identify stakeholders and establish a climate risk assessment team

Best practice risk assessment and management is an inclusive and collaborative process. This is particularly true for climate risks, because they:

- are systemic in nature, so benefit from diverse perspectives
- may have compounding effects across an organisation (e.g. across multiple climate variables)
- may present challenges for standard risk management practices
- may not be well understood by decision-makers.

When identifying the most relevant stakeholders, it is useful to consider diversity of perspectives and experience, representativeness, relevant expertise, their ability to influence the process, and their proximity to potential risks.

At a minimum, the following groups will likely need to be identified:

- executive/leadership team to sponsor the assessment
- staff who have influence over potential impacts and implementation of adaptation actions, including resourcing and funding
- staff or stakeholders who will be responsible for implementation of adaptation actions
- stakeholders who are most likely to be affected by the risks.

In leading practice organisations, external stakeholders will also be engaged in the assessment and management process to enable effective adaptation. Step 3 covers the attributes of best practice climate change adaptation in more detail.

Apsley Falls bridge construction, Oxley Wild Rivers National Park. *Photo: Gerhard Koertner/DPIE*

Staff will also need to be identified to form an assessment team. Members will be identified based on the scope of the climate risk assessment and can represent diverse organisation functions.

The assessment team will need:

- an executive to sponsor
- a project manager or lead to drive the process and document outcomes
- representatives from different operational areas to participate in the assessment and validate findings
- resources to undertake risk assessment activities such as workshops, advisory groups and peer reviews.

An internally run assessment can help organisations build on existing internal knowledge and develop new expertise, which will be vital as climate impacts change. Staff with a sound knowledge of the local area, environmental conditions, assets and operations, and risk assessment methodology are best suited to this project.

Roles that may be represented include risk and governance, planning and policy, asset management, operations and maintenance, community services, finance and IT managers, community engagement specialists, indigenous and Traditional Owner engagement staff, sustainability and environmental management, emergency management, legal, and frontline staff in customer service or safety.

The assessment team can be involved in a range of activities ranging from data provision and interpretation to identifying and evaluating risks. They will help build commitment to the process from executive and general staff. The assessment team should be involved in updating and agreeing on a risk assessment matrix that is suitable for evaluating the likelihood and consequence of climate risks

Further guidance...

Resources on best practice stakeholder engagement, including external stakeholders, can be found in the International Association for Public Participation Australasia 2015 Quality Assurance Standard for Community and Stakeholder Engagement (IAP2 2015).

Working with consultants

It is recommended that where external consultants need to be engaged, a dedicated staff member with understanding of climate risk management is allocated to the project from beginning to end. This gives a greater chance of successfully embedding the climate risk assessment results in existing risk management procedures, and of building a shared understanding of potential climate risks within the organisation. Organisations wishing to engage external consultants may find the CoastAdapt guidance, Working with consultants (CoastAdapt 2017) helpful.

Communicating climate change

It is important to consider how your audience will receive information about climate change. Effective communication about the projected impacts of climate change, and how to respond to them, is essential to reach consensus on the most effective ways to adapt. Understanding your audience is important when framing communications about climate change and climate risk. Consider the responsibilities, motivations, beliefs, knowledge and experiences of your stakeholders when planning your communications and engagement. Useful principles for communicating about climate change are described in Figure 9.

Figure 9: Principles for communicating about climate change

Further guidance on communicating about climate change:

- *The Uncertainty Handbook*, by the University of Bristol
- *Principles for effective communication and public engagement on climate change: A Handbook for IPCC authors*, by Climate Outreach
- Yale Program on Climate Change Communication website

Determine the scope of the climate change risk assessment

This step aims to build a comprehensive appreciation of all the factors that may influence the achievement of organisational outcomes. The scope of the climate risk assessment will be informed by your organisation's context and drivers for assessment, which you have completed in a previous step.

The scope should include a concise statement of the organisational objectives and specific criteria for success, the objectives and scope for risk management, and a set of key elements for structuring the risk identification activity in the next stage. A clearly defined scope will assist with resource allocation and managing stakeholder expectations.

Key considerations include:

- What objectives and decisions need to be made?
- Will the assessment focus on objectives, a portfolio of assets, a program or a specific project/asset?
- What timeframe do you need to address?
- What is the lifecycle of the assets, infrastructure or services being assessed?
- What physical location will your assessment focus on?
- What are the specific inclusions and exclusions?
- What outcomes are expected from the steps in the process?
- What risk assessment tools and techniques are appropriate?
- Who is responsible for what?
- What records are to be kept?
- What relationships are there to other projects, processes and activities?
- Are there anticipated flow-on impacts to your customers or stakeholders?

NARCliM projections should be considered at a minimum and provide two timescales for projected changes – for the near future to 2030 and for the far future to 2070.

CASE STUDY

Evidence-based climate change risk assessment – Sydney Trains

Sydney Trains undertook an evidence-based climate change risk assessment and adaptation plan in 2015 that assessed its vulnerability to increasing extreme weather events such as lightning strikes, storms, floods, landslips and bushfires. The process attempted to answer the following questions:

1. What are the most important extreme weather events and climate risks to Sydney Trains/NSW Trainlink?
2. What is the existing and future cost of extreme weather events, both in terms of direct impacts to assets and revenue, and indirect costs (including delay costs)?
3. Is there a correlation and/or causation between extreme weather events and patronage numbers?
4. How much do customers care about reduced performance during extreme weather?
5. What is currently being done across the whole rail sector to adapt to and manage risks?
6. What adaptation strategies should be implemented to improve Sydney Trains' management of risks and reduce the potential costs and impacts of climate change?

A key finding was that the direct cost from extreme weather events is approximately 1% of Sydney Trains' operational and maintenance budget. This is projected to escalate to approximately 2–5% by 2050–70 with the impacts of climate change, without significant adaptation.

This is an extremely conservative estimate, as it does not account for regular small-scale weather-related incidents. The cost of delays is also estimated to be over $11 million per annum (March 2020 figures).

More recent analysis has estimated that the direct costs to Sydney Trains from the 2019–20 bushfires was in excess of $25 million, resulting from essential asset repairs and maintenance. This does not include costs incurred from loss of revenue or provision of replacement transport services. In addition, over 540 trees were damaged on the Blue Mountains line alone.

To minimise the impacts of extreme weather events, Sydney Trains is continuing to improve asset resilience at least risk-cost. This includes sleeper replacements, tension-regulation of overhead wiring, lightning protection, advanced weather warning systems, modernisation of the signalling, electrical and communication systems, asset maintenance programs that consider climate risk, and targeted vegetation management, including removal of weed species to encourage propagation of more bushfire and drought-tolerant native species.

Nine days of extreme rainfall in 2013 caused a retaining wall to collapse at Harris Park train station. Photo: Carlos Furtado

A scaled approach to climate change risk assessment

The Climate Risk Ready process may be adapted to suit requirements at different scales of an organisation (adapted from Tonmoy et al. 2019):

- **Enterprise** – a high level assessment undertaken to understand how climate change may impact **organisational objectives**. This should identify delivery areas of the organisation that are particularly exposed and warrant more detailed risk assessment.
- **Program** – A more focused risk assessment of climate change risks to a **program, division or service** that aligns with the ISO 31000.
- **Project** – A risk assessment for a specific **project or asset (new or existing)**, required due to its high value, criticality, life span, or legislative requirements, and that aligns with ISO 31000.

The process may be applied to support common government functions to build climate resilience into decision making, such as:

- strategic, business and workforce planning
- delivery of existing assets, infrastructure and services
- planning new infrastructure or services.

Table 4: Aspects of climate change risk assessment that may be different at the enterprise, program and project levels

Aspect of climate change risk assessment process	Enterprise level	Program level	Project level
Use of the Health Check Tool	Applicable	May be applicable	Not applicable
Scope of assessment	Impacts to organisational objectives.	May be focussed on specific natural hazards or risk categories.	Specific project or asset. Interdependent risks may be identified.
Technical capacity required	Lowest	Moderate	Highest
Adaptation planning	Includes plans to increase enterprise climate risk maturity. Implementation driven through central business processes or delegated to appropriate risk owners. Economic evaluation of options unlikely to be required.	May include a plan to increase climate change risk maturity. Implementation driven through divisional or programmatic management processes. Economic evaluation of options may be required.	Likely to include incorporating assessment findings into specifications, detailed designs and management plans. Economic evaluation of options likely to be required.
Monitoring and review	Monitoring driven through the enterprise risk management framework.	Monitoring driven by processes such as business planning, risk management or program governance.	Monitoring driven through project management processes, legislative approvals, or operations and maintenance.

Prioritise exposed areas

Rather than addressing all activities undertaken by the organisation, it is appropriate to prioritise a subset of functions, programs or a portfolio of assets to focus on. This will be informed by a high level review of potential climate change impacts (such as projected rainfall, temperature changes or increased bushfire weather) that will help determine the level of exposure to climate hazards your organisation may face. Consider the principles and questions in Table 5 during the prioritisation process.

Table 5: Considerations for prioritising functions, programs or assets for climate risk assessment

Principle	Questions to consider
Criticality	• Is there potential for critical infrastructure or services to be impacted? • Is there potential for impacts that will influence the ability of the organisation to deliver its core objectives?
Leverage	• Are there existing assessments on similar projects or programs that can be applied to a new assessment, investment or planning decision?
Geographic exposure	• Are there organisation assets, infrastructure or services that are concentrated in geographic areas with a high exposure to acute or chronic climate hazards? • Are there specific assets or services that already experience frequent disruption from extreme weather such as flooding, storms, water shortage or heat?
Strategic importance	• Are there functions or assets of strategic importance that should receive greater scrutiny? • Are there new areas of service or delivery offerings that have not yet been assessed for climate risks?
Interdependency	• Does the organisation operate any critical infrastructure or deliver critical services that rely on service or infrastructure delivery managed by other agencies or external parties?

Considering transition risks and climate-related trends

While this Guide is focused on physical risk assessment, organisations may also wish to review their exposure to transition risks in accordance with the recommendations of the Taskforce on Climate-related Disclosures (TCFD 2017). The TCFD outlines potential climate-related transition risks and opportunities:

- **Market and technology shifts** such as changes in market demand for products or stranding of assets due to market shifts
- **Policy and legal changes** including increased liability due to failure to foresee and mitigate losses from any transition risks
- **Reputational damage** resulting from an organisation's failure to address changing stakeholder expectations.

Assessing transition risks starts with agreement on plausible emissions scenario/s and analysis of the trends that are likely to result. Trends resulting from a transition to a low carbon economy that may impact an organisation include:

- increased expectations on an organisation to limit emissions and implement adaptation measures
- increased consideration of environmental, social and governance (ESG) criteria in investment decisions
- more ambitious country-wide carbon emissions targets with the potential to impact planned growth
- increasing uptake of alternative fuels
- potential for changing insurance cover
- potential for autonomous vehicles to reduce private vehicle ownership and revenues related to private vehicle use
- increased electrification of vehicles
- 'just in time' freight transportation
- energy policy changes or instability
- increasing exposure to global price fluctuations of commodities and goods.

At the end of Step 1 you will have:

- Used the Health Check Tool to understand the climate risk management maturity of your organisation and how this may influence the outcomes of your climate risk assessment and adaptation planning process
- Established your organisation's context for undertaking a climate risk assessment and secured executive level support to progress
- Formed a risk assessment team to lead the risk assessment process and identified stakeholders across a range of functions to involve in the process
- Determined and secured endorsement of the scope of your climate risk assessment.

CASE STUDY

Impacts of climate change witnessed in action

Climate change is already increasing the severity, intensity and frequency of extreme weather events and weather patterns.

Sydney storms

In April 2015 a massive storm struck metropolitan Sydney and the Hunter and Central Coast, with severe rainfall (hourly rainfall rates of between 100 and 150 mm at some locations) and cyclonic winds.

The storms resulted in loss of life with three killed, significant flooding, significant damage to over 250 houses, power outages and public transport delays (Brigadier Darren Naumann AM 2015).

Sydney suffered another storm event in late June 2016, combining an east coast low with a king tide, causing severe damage including the loss of homes in the Northern Beaches. The extent of damage from this event triggered reviews to legislation and coastal defence liability.

NSW heatwave

From 30 January to 6 February 2011, New South Wales was affected by a severe heatwave, breaking numerous records. Near real-time emergency department (ED) and ambulance surveillance allowed rapid detection of an increase in the number of heat-related ED visits and ambulance calls during this period.

A 2012 study estimated that all-cause ED visits increased by 2%, all-cause ambulance calls by 14%, and all-cause mortality by 13%. Those aged 75 years and older had the highest excess mortality rates of all outcomes (Schaffer et al. 2012).

2019/20 Black Summer bushfires

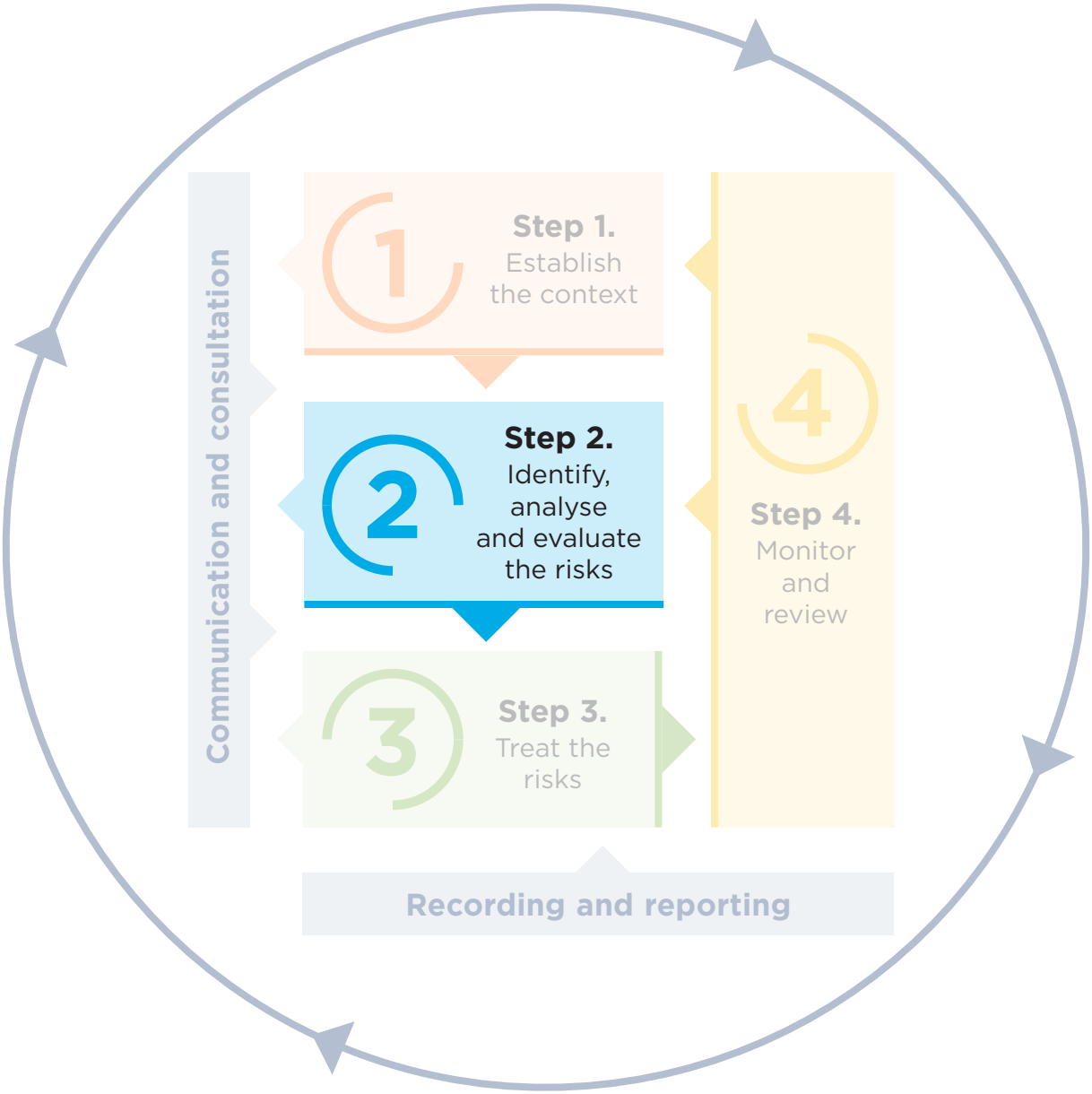
Australia's 2019-2020 summer was the worst bushfire season on record for NSW, in terms of intensity of the area burned and the number of properties lost (2,439). In total, bushfires in NSW burned through 5.4 million hectares and there were an estimated 800 million animals killed. Nationally, 34 people lost their lives and survey data revealed that 'the vast majority of' Australians (78.6%) were impacted either directly or indirectly (ANU 2020).

As of 27 August 2020, the Insurance Council of Australia received almost 300,000 claims from 2019-20 extreme weather events including the bushfires, totalling almost $5.4 billion losses and losses to the tourism industry was estimated to be $4.5 billion (AFR 2020).

Lightning strike above Spectacle Island Nature Reserve in Ku-ring-gai Chase National Park.
Photo: Kelly Nowak

Step 2. Identify, analyse and evaluate the risks

Establish a plausible climate future and document priority climate change risks



Key messages

- A climate change risk assessment includes consideration of both risks and opportunities posed by a changing climate.
- When assessing climate risks, information about plausible future climates and climate trends must be consulted rather than relying on historical climate and weather data.
- Involvement of stakeholders to validate and prioritise identified risks is crucial to developing a realistic and well-informed view of priority climate risks to the organisation.

Actions and outputs

Actions	Indicative timeframe	Outputs	Key resources
Understand past and recent climate hazards and trends	3 weeks	• A list of climate variables relevant to your context	• Climate Risk Assessment Tool (**Appendix C**) • NARCliM projections (AdaptNSW website) • Bureau of Meteorology Climate Data Online portal • CSIRO Climate Change in Australia website
Consult relevant climate projections	2 weeks	• An understanding of projected climate change impacts	
Identify risks and opportunities	3 weeks	• A list of climate change risk statements	
Analyse and evaluate risks	3 weeks	• Priority climate risks with agreed risk ratings	

Recommended roles and responsibilities

Executive	Climate change risk officer	Assessment team
Engages in risk assessment where relevant and encourages participation from staff Endorses or approves prioritised risks	Reviews and endorses risk assessment outputs Communicates assessment outcomes to decision-makers	Leads delivery of risk assessment and workshops Documents risk assessment outcomes

Understand past and recent hazards and trends

Before constructing a picture of a plausible future climate, you will build an understanding of how past and current natural hazards and climate trends affect your organisation. This step will assist in selecting the most relevant climate variables for your climate risk assessment.

Some common climate variables include:

- precipitation
- temperature (average daily minimum and maximum)
- wind speed
- humidity
- frost days
- soil moisture
- storm frequency and intensity
- snow amount
- drought weather
- evaporation.

Useful information to consult to build an understanding of current risk exposure, sensitivity and adaptive capacity may include:

- Bureau of Meteorology's Climate Data Online portal
- Local and indigenous knowledge
- warnings and updates provided by local government authorities
- climate modelling for geographic areas e.g. flood modelling, bushfire hazard mapping, and drainage designs
- existing natural hazard and socio-economic datasets, e.g. summarised in the NSW Government's Common Planning Assumptions.

Projections vs predictions

Projections of future climate change are not like weather forecasts. Short-term weather forecasts are definitive predictions based on observations. On the other hand, projections of climate change model how the climate system may respond, and evolve, to plausible scenarios in the future. Projections are not intended to give accurate predictions of future climate change, because this change is dependent on:

- future human and natural drivers of change
- models of the climate system, and
- the existence of internal climate variability.

Nonetheless, as greenhouse gas concentrations rise, we expect to see future changes to the climate system that are greater than those already observed. Complex computer models can be used to understand future climate change and characterise outcomes and uncertainties under specific climate forcing scenarios.

To address the uncertainty inherent in projecting future climate, sources such as NARCliM provide ranges of likely change that can be expected at different time intervals. Reliable sources of climate change projections like NARCliM will indicate a level of confidence in their projected ranges of change. In some cases the level of uncertainty may require further investigation or sensitivity analysis to inform risk management responses.

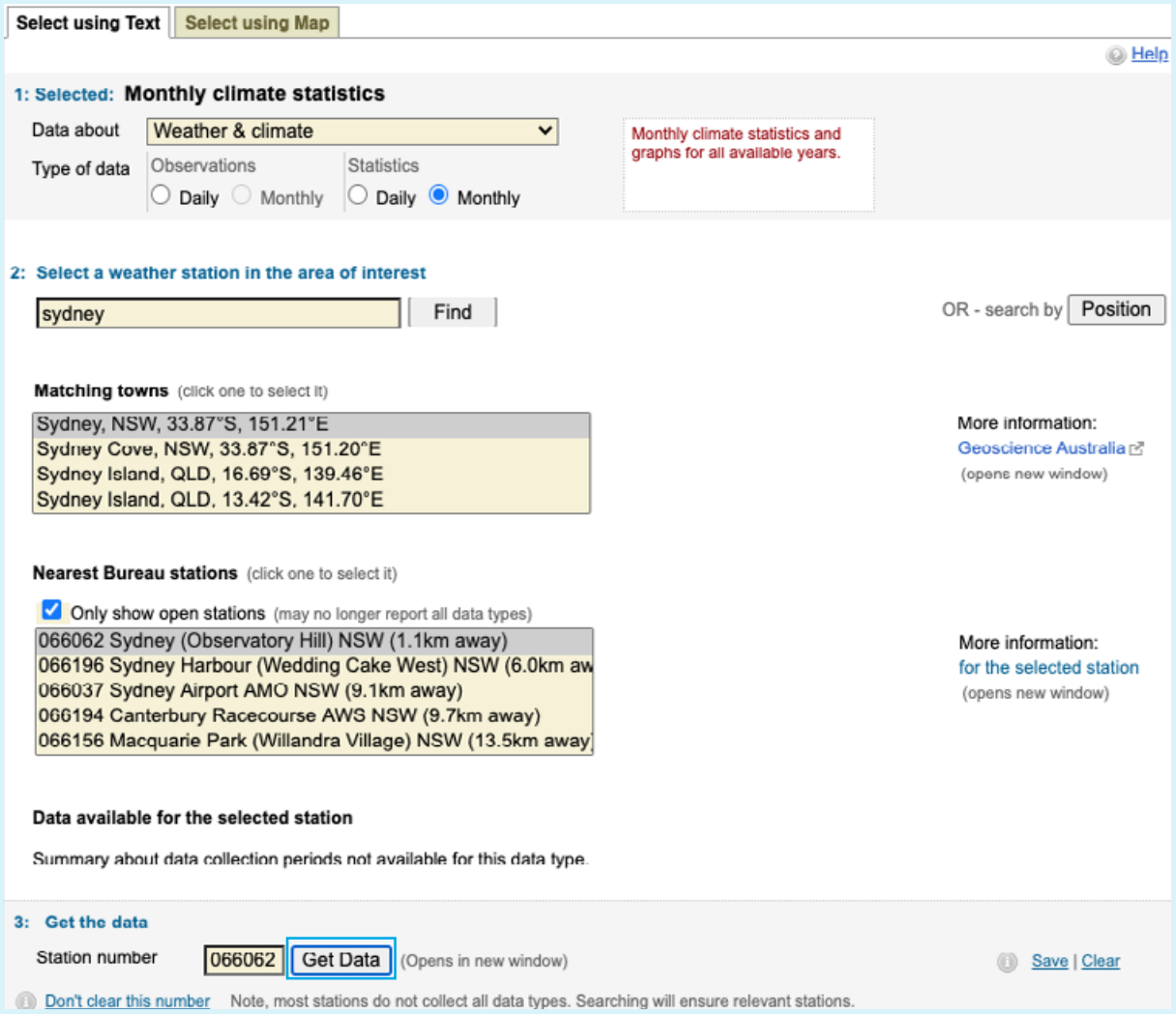
Source: Collins et al. (2013).

A fire rating sign damaged by the Wambelong wildfires in 2013 indicating extreme fire danger. This rating is an example of a short-term prediction of risk. Photo: DPIE

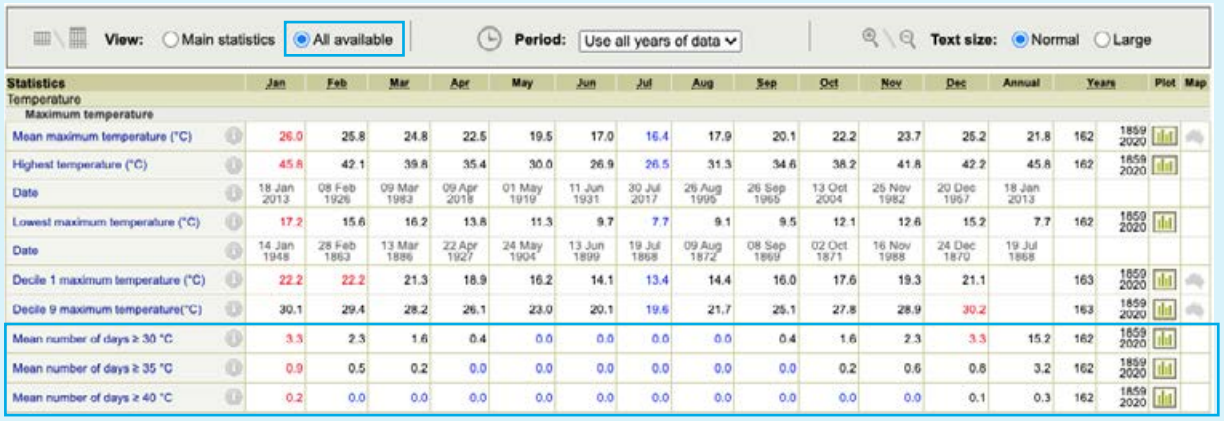
Accessing historical climate data on the Bureau of Meteorology's Climate Data Online portal

Historical weather data is available via the Bureau of Meteorology's Climate Data Online portal. The results provide insight into historical averages including extremes such as number of days over 35 degrees Celsius per year, daily rainfall records, and wind speeds.

Weather station selection – Sydney (Observatory Hill)



Output – Climate data from Observatory Hill weather station



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	Plot	Map
Temperature																
Maximum temperature																
Mean maximum temperature (°C)	26.0	25.8	24.8	22.5	19.5	17.0	16.4	17.9	20.1	22.2	23.7	25.2	21.8	162	1859 2020	
Highest temperature (°C)	45.8	42.1	39.8	35.4	30.0	26.9	26.5	31.3	34.6	38.2	41.8	42.2	45.8	162	1859 2020	
Date	18 Jan 2013	08 Feb 1926	09 Mar 1983	09 Apr 2018	01 May 1919	11 Jun 1931	30 Jul 2017	26 Aug 1995	26 Sep 1965	13 Oct 2004	25 Nov 1982	20 Dec 1957	18 Jan 2013			
Lowest maximum temperature (°C)	17.2	15.6	16.2	13.8	11.3	9.7	7.7	9.1	9.5	12.1	12.6	15.2	7.7	162	1859 2020	
Date	14 Jan 1948	28 Feb 1863	13 Mar 1886	22 Apr 1927	24 May 1904	13 Jun 1899	19 Jul 1868	09 Aug 1872	08 Sep 1869	02 Oct 1871	16 Nov 1988	24 Dec 1870	19 Jul 1868			
Decile 1 maximum temperature (°C)	22.2	22.2	21.3	18.9	16.2	14.1	13.4	14.4	16.0	17.6	19.3	21.1		163	1859 2020	
Decile 9 maximum temperature(°C)	30.1	29.4	28.2	26.1	23.0	20.1	19.6	21.7	25.1	27.8	28.9	30.2		163	1859 2020	
Mean number of days ≥ 30 °C	3.3	2.3	1.6	0.4	0.0	0.0	0.0	0.0	0.4	1.6	2.3	3.3	15.2	162	1859 2020	
Mean number of days ≥ 35 °C	0.9	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6	0.8	3.2	162	1859 2020	
Mean number of days ≥ 40 °C	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	162	1859 2020	

Consult relevant climate projections

Consulting climate change projections is one of the core activities that distinguishes your climate change risk assessment from a standard risk assessment process.

NARCliM projections for NSW model over 70 different meteorological and climatological variables. Climate projection data and information on 16 commonly used variables are available from the NSW Climate Data Portal (as customisable datasets) and AdaptNSW website (as impact snapshots, see Figure 11). The climate change snapshots have been developed for all NSW State Planning Regions for near future (2030) and far future (2070) time horizons.

NSW Government organisations are recommended to consult the NARCliM regional climate projections as the basis for a climate change risk assessment. The AdaptNSW website has climate change snapshots (Figure 10) for all NSW State Planning Regions for both the near future (2030) and far future (2070) time horizons, or customised datasets are available via the NSW Climate Data Portal.

Consulting climate change projections to understand how the climate in your region may change is one of the core activities that distinguishes your climate change risk assessment from a standard risk assessment process.

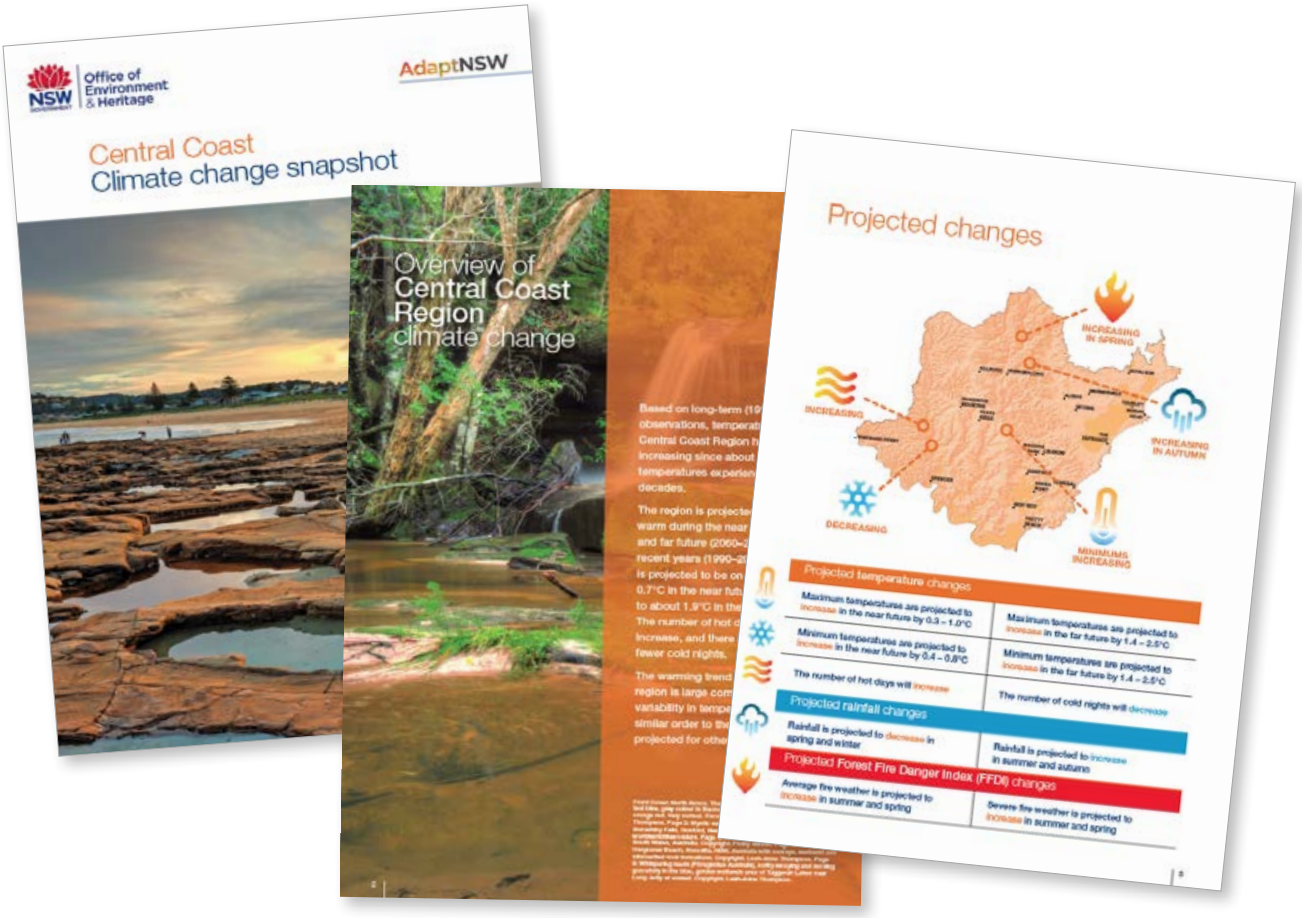


Figure 10: Example climate change snapshot for the Central Coast region of NSW, available on the AdaptNSW website

CASE STUDY

About the NARCliM model

The NSW and ACT Regional Climate Modelling project (NARCliM) was developed in a collaboration between the NSW and ACT governments, UNSW, Sydney Water, Hunter Water, and the Sydney Catchment Authority. It is a highly rigorous model that has been designed so that non-scientists can easily apply it to their decision-making in New South Wales.

The NARCliM projections are recommended for use in risk assessments and consist of:

- 10-kilometre square grids covering south-eastern Australia and 50-kilometre square grids covering Australasia
- modelling of four CMIP3 global climate models (GCMs) and three regional climate models (RCMs)
- a high emissions trajectory (SRES A2), which represents a business-as-usual emissions trajectory and is projected to result in warming of 3–4° C by 2100
- three time periods: 1990 to 2009 (baseline), 2020 to 2039 (near future), and 2060 to 2079 (far future).

NARCliM datasets are available on the NSW Government's Climate Data Portal on the AdaptNSW website and are suitable for advanced technical users.

How is uncertainty addressed in the NARCliM modelling?

Due to the uncertainties involved in producing climate projections, NARCliM provides a collection of 12 simulations (rather than just one single projection), each using the IPCC SRES A2 emissions scenario and six simulations for each RCP8.5 and RCP4.5. This approach provides robust regional climate projections that span the range of likely future changes in the region.

Both NARCliM iterations are configured using the Weather Research and Forecasting (WRF) model which downscales the GCMs to a suitable set of local atmospheric and land surface parameters.

Other sources of information that may be used to supplement the NARCliM projections include:

- specialist data sources and research programs
- local government flood data and maps
- Rural Fire Service bushfire maps
- previous climate change risk assessments
- mapping of ecosystems, refugia, fauna and flora, including endangered species and ecological communities (e.g. the Australian Government's MCAS-S tool)
- audits of critical infrastructure, services and assets (e.g. class, location and maintenance and depreciation status)
- regional/local climate adaptation plans
- local population and business profiles.

The assessment team should evaluate data quality and results as part of this step, and document data gaps and confidence ratings where relevant.

For example, CoastAdapt, Geosciences Australia, Bureau of Meteorology, CSIRO and Climate Change in Australia, research into natural hazards such as coastal erosion or bush fires, as well as potential indicators of localised climate change such as prevalence of invasive species.

Where an overarching climate adaptation plan for your region exists, climate projections from this may be used.

Understanding climate change projections

Climate change projections are based on climate change scenarios and are a means of understanding the potential impacts of climate change. Climate change scenarios are plausible and often simplified descriptions of a possible future climate state, as influenced by climate change. They are based on the best available science and a number of assumptions about:

- future levels of greenhouse gas in the atmosphere (the emissions scenario)
- the response of global average surface temperatures to increases in greenhouse gases
- local climate change resulting from changes to global average temperatures
- socioeconomic factors and patterns such as population growth, trade and economic policy and technological advances.

In its 2014 Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) released a new set of scenarios called Representative Concentration Pathways (RCPs). Each RCP provides a possible emissions trajectory over time (generally up to 2100). Figure 11 depicts the four RCPs and projected climate impacts at 2100. Selecting the right RCP for your situation is crucial to inform a realistic picture of future climate change impacts.

For the purpose of climate risk assessment, it is recommended that projections reflecting a moderate to high emissions scenario (e.g. RCP4.5 or RCP8.5) are consulted at a minimum. Low emissions scenarios (e.g. RCP 2.6) are not recommended to assess physical climate risks; but may be useful to assess transition risks as they represent corporate and government behaviour that is consistent with net zero emissions targets.

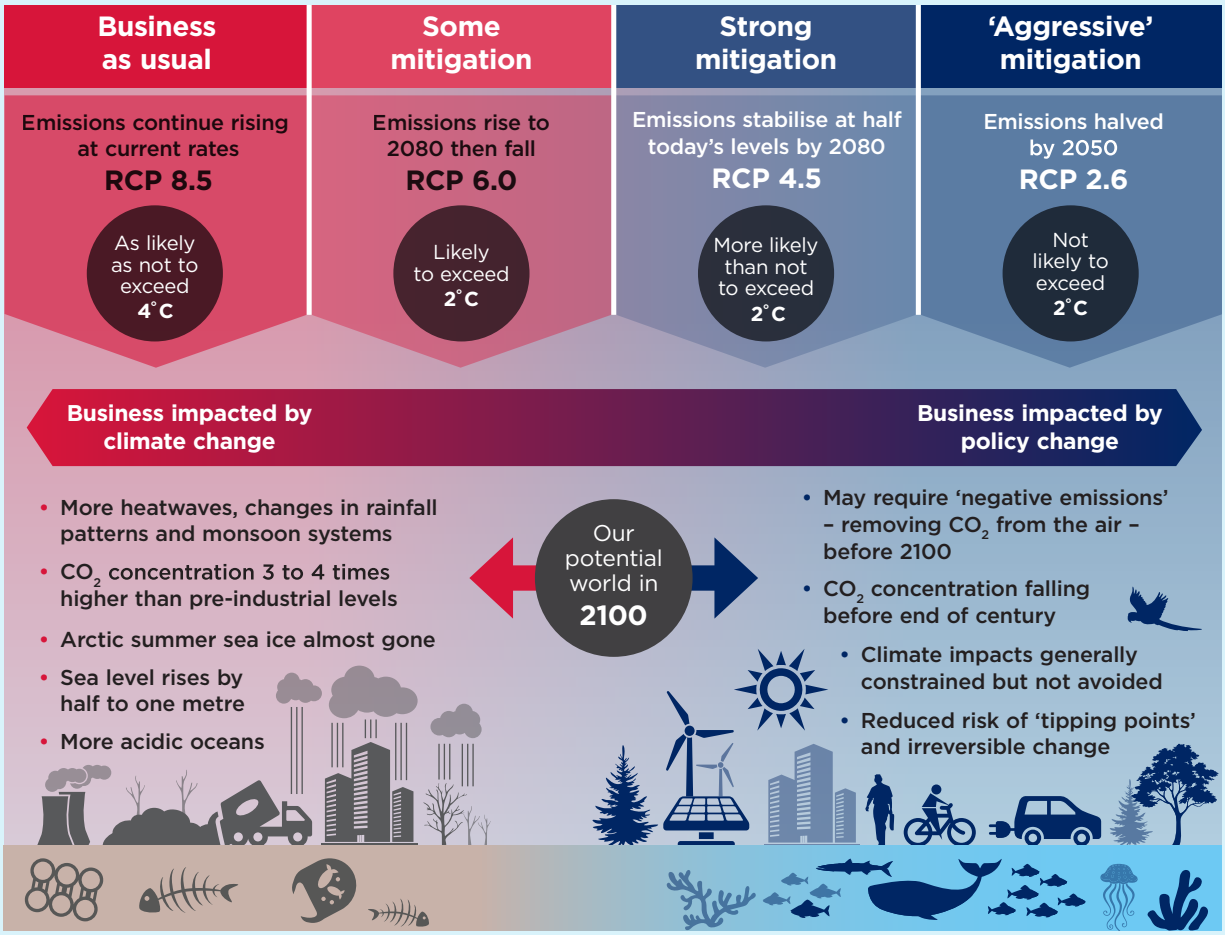


Figure 11: The four Representative Concentration Pathways project different scenarios for future climate change (University of Cambridge 2013)

Identify risks and opportunities

Identifying climate risks comprises identifying the source of the risk, the event/s that could trigger the risk, and potential impacts to your organisation. Risks should be documented in a way that is transparent and easy for others to understand, even if they were not involved in the risk assessment process and should state all assumptions underlying the assessment. This is particularly important so that information underlying highly aggregated risks (i.e. at the enterprise level) is transparent.

Identification of climate change risks should consider:

- **direct risks** such as damage or disruption to assets, health impacts to community and/or staff
- **direct opportunities** that can directly benefit the organisation
- **indirect risks or opportunities**, where there are secondary consequences of the initial risk such as impacts to supply chains or customers
- **interdependencies**, where infrastructure rely on each other for continued service provision.

To streamline the assessment process, pre-identified risks may be provided to stakeholders at a climate risk assessment workshop for them to validate and expand on.

Techniques identify climate risks include:

- desktop reviews of potential climate change impacts to your sector[1]
- group methods, such as brainstorming sessions or commissioned reviews
- risk assessment workshops
- checklists or questionnaires
- individual interviews
- review of audit findings.

Develop climate change risk statements

Climate risk statements contain key information about relevant climate variables and their potential impacts, to describe a potential risk. A proposed structure for these statements is outlined in Figure 12. The Climate Risk Assessment Tool in Appendix C provides example climate change risk statements.

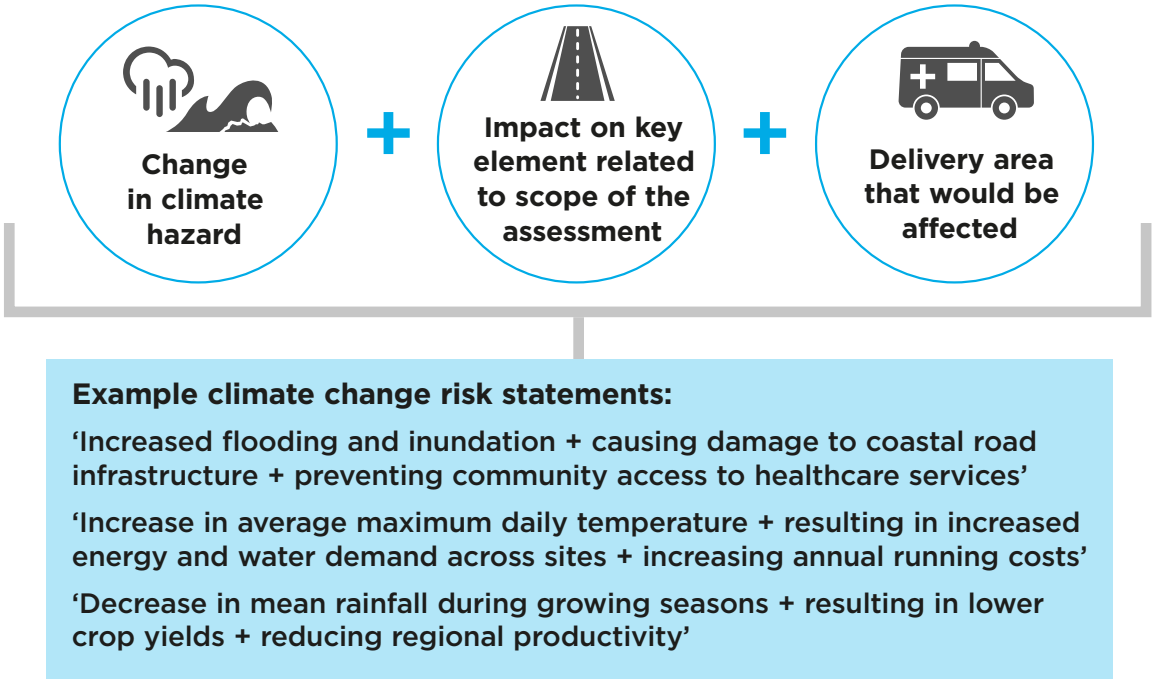


Figure 12: Developing climate change risk statements

1 Potential sources include the AdaptNSW and National Climate Change Adaptation Research Facility websites.

CASE STUDY

Studying disruption – data-driven approaches to risk assessment at Sydney Trains

With $39 billion in assets and infrastructure, many with lifespans of over 100 years, Sydney Trains has conducted enterprise climate change risk assessments since 2015. The rail services operator-maintainer took over 293 million patrons on 1.3 million passenger journeys in 2019.

Sydney Trains took an innovative approach to assessing potential climate-related risks to patronage and commuter behaviour. It analysed existing OPALTM card ticketing data during recorded extreme weather events and applied statistical tests to answer the question of whether commuters would consciously change their preferred mode of transport during various extreme weather conditions.

This world-first approach by a rail services operator-maintainer found that significant seasonal changes in patronage are likely as a result of increasing extreme weather events but, at present, there is no evidence that extreme weather is a primary driver for selection of transport mode; however, the availability and performance of infrastructure and services after extreme weather events is an important driver of customer choices.

Sydney Trains currently spends approximately 1–2% of its annual operational budget on infrastructure maintenance, repairs and injuries directly related to extreme weather events. This does not currently factor in costs of delays to customers, broader economic costs and indirect costs such as insurance. Sydney Trains expects to review these costs, and the findings of the climate change risk assessment, as the costs and effects of climate change increase.

For further information you can watch the Climate Change – Impacts on Rail Networks YouTube video.

The International Standard for Adaptation to climate change – *Guidelines on vulnerability, impacts and risk assessment* (ISO 14091) recommends using impact chains to document factors that influence a climate risk. Impact chains are a visual representation of a theory of change that can include important components of risk such as vulnerability, as well as indirect and interdependent risks. An example impact chain is provided below.

Impact chains are an effective collaboration and communication tool that can be used later in the process to help identify adaptation actions, and management triggers or thresholds. In this way, impact chains can support development of adaptation pathways (see page 57).

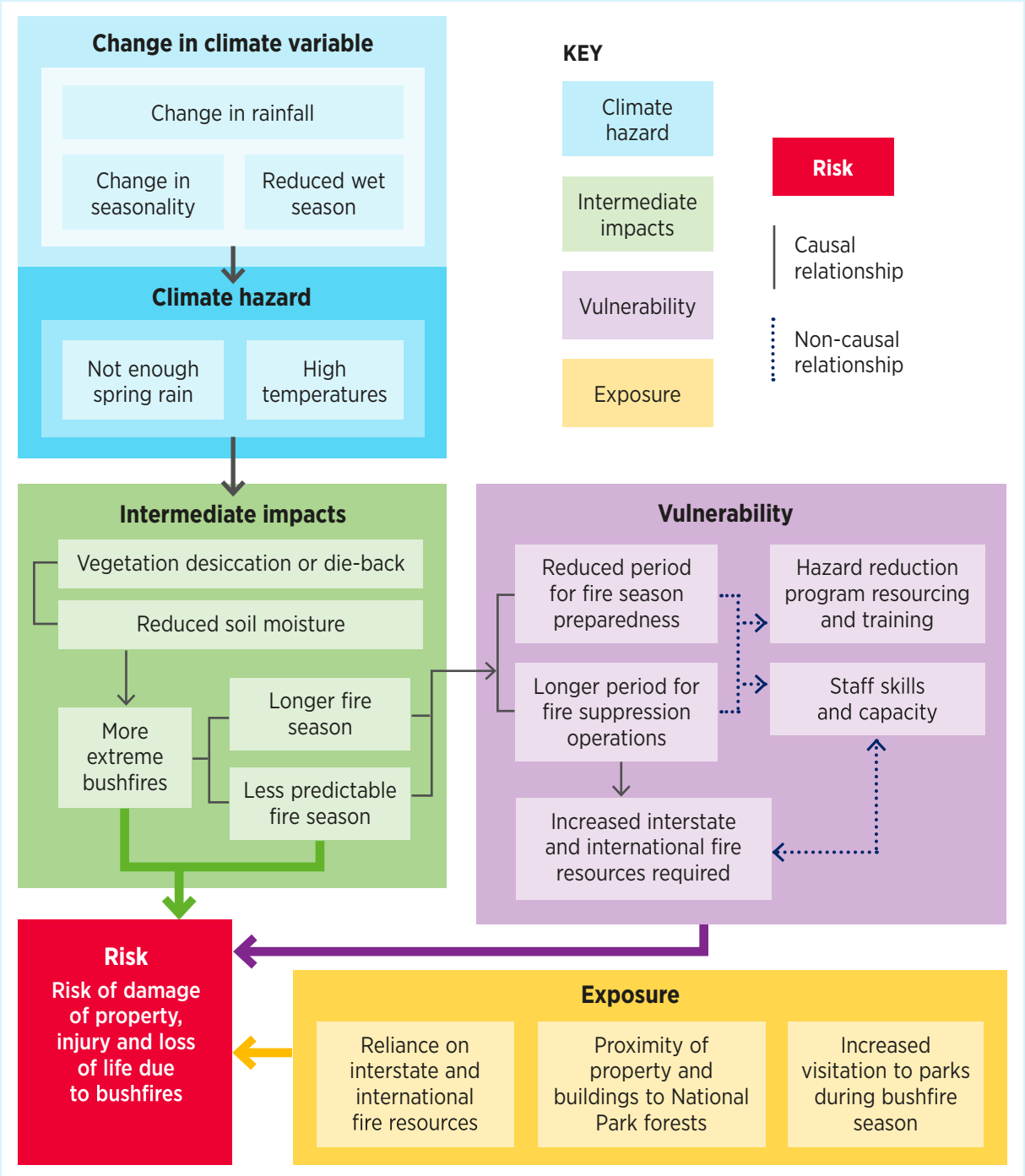


Figure 13: An example of an impact chain, adapted from an assessment undertaken to inform the NSW National Parks and Wildlife Climate Change Adaptation Strategy (see also page 58).

Analyse and evaluate risks

The Climate Risk Assessment Tool in **Appendix C**, or a similar tool, can be used to analyse the likelihood and consequence of your identified risks.

Analysis can be undertaken in a workshop with diverse stakeholders to:

- validate information about climate hazards
- review climate change risk statements
- validate the assigned likelihood and consequence ratings applied to each risk
- add relevant new risks
- help prioritiseclimate hazards and risks.

The workshop should involve the stakeholders identified in **Step 1**. Consulting external stakeholders may also be prudent to help identify interdependent and indirect risks.

At this stage it is not uncommon to find that weather-related risks have already been identified by the organisation under existing risk categories (such as work health and safety, or compliance); however, the impacts of climate change may not yet have been considered.

Using the Climate Risk Assessment Tool

The Climate Risk Assessment Tool (**Appendix C**) provides a template to analyse climate risks and to support ongoing identification of risk treatments and implementation of adaptation actions. It can be used where standard risk registers are not suitable.

The tool enables the rating of risks across future time horizons based on the NARCliM climate change projections. Example risks and adaptation actions are provided to assist users to complete first pass risk identification and adaptation planning.

For each risk you have identified you will need to:

- use your risk matrix to identify the consequence(s) – the impact, if the event occurs, on your organisation's objectives
- use your risk matrix to identify the likelihood – the chance of the event happening
- identify controls already in place or included in approved plans to prevent the event from occurring or limit its possible impact
- assess whether these controls are adequate
- update the risk rating of each risk to take into account existing controls.

Risk assessment criteria can be customised to align with the organisation's own risk assessment criteria Guidance is provided in the tool on how to work through the climate change risk assessment process.

The ISO 14091 – *Adaptation to climate change* suggests that an independent review of the climate risk assessment and may be helpful to validate findings or evaluate the most salient features of the risk assessment. This approach was used by the Sydney Opera House, outlined further on page 15.

Priority risks identifed at the workshop will form the basis of a climate change adaptation plan (or risk treatment plan, see **Step 3**). The assessment team may conduct a first pass prioritisation before the workshop, for participants to validate.

The following factors may be used to prioritise climate risks:

- **tolerance** – the organisation's toleration of climate risks
- **risk rating** – giving greater priority to extreme or high risks
- **qualitative assessment** – prioritising risks according to:
  - *materiality*, e.g. risks that have a significant impact on delivery of critical services; this may include lower rated risks
  - *scalability*, e.g. risks that affect multiple areas of the organisation
  - *geographic exposure*, e.g. locations subject to a large number of risks
  - *strategic importance*, e.g. risks that may have a lower rating but impact key areas
- **climate variable** – grouping risks by a specific climate variable or hazard
- **industry trends** – sectoral or socio-economic trends that may influence risks.

An example of priority physical risks grouped by climate variable is provided in Table 6. Confidence ratings may be attributed to priority risk statements to make the level of uncertainty clear to decision-makers.

Table 6: Example shortlist of priority climate change risks

Climate variable	Priority Risk Statements
Greater frequency and intensity of rainfall and storms	Service disruptions due to damage and flooding by rainfall and storm events.
Sea level rise and tidal intrusion	Operational disruptions, increased duration of repair and maintenance activities due to permanent sea level rise and/or cyclical tidal intrusion.
	Reduced land for future capacity and development due to permanent sea level rise and/or cyclical tidal intrusion.
Higher temperatures and more severe heatwaves	Increased health services demand due to heat exposure.
	Operational disruption due to power supply black outs and brown outs from to increased energy demand during heatwaves.

At the end of Step 2 you will have:

- Built a knowledge base and understanding of a plausible climate future and the potential climate risks that may affect your organisation
- Consulted with internal and external stakeholders to develop a list of priority risks with agreed risk ratings (based on consequence and likelihood criteria) that require further management action.

Step 3. Identify and plan risk treatments

Develop an adaptation plan to treat priority climate change risks and increase climate change risk maturity

Key messages

- Developing actions to treat priority climate risks forms the basis of an adaptation plan.
- An adaptation plan should include steps to improve climate risk maturity.
- Developing adaptation pathways supports implementation over time and can facilitate the most efficient use of resources.

Actions and outputs

Actions	Indicative timeframe	Outputs	Key resources
Identify and prioritise adaptation actions	3 weeks	• A resourced adaptation plan, including actions to improve climate risk maturity	• NSW Guide to Cost-Benefit Analysis (TPP17-03) • NSW Government Business Case Guidelines (TPP18-06)
Develop and implement an adaptation plan	4 weeks		

Recommended roles and responsibilities

Executive	Climate change risk officer	Assessment team
Commits resources to an adaptation plan Supports engagement with external stakeholders regarding treatment of shared and interdependent risks	Oversees development and implementation of the adaptation plan (enterprise scale) Leads integration of climate risk into existing risk frameworks	Leads development of the adaptation plan and economic appraisal of options where relevant Engages stakeholders in development of priority adaptation actions

Identify and prioritise adaptation actions

In this step you will develop adaptation actions in response to the priority climate risks selected in **Step 2, Identify, analyse and evaluate the risks**.

Identify adaptation actions

This step is best undertaken collaboratively with risk owners to avoid duplication or misalignment of adaptation efforts. External stakeholders should be involved where interdependent risks or risks to communities and customers have been identified.

Adaptation actions should be selected to reduce the likelihoods and/or consequences of priority risks, noting that it may not be possible to eliminate all risk relating to your organisation.

To build an adaptation plan you will need to:

- reflect on risk controls and measures that are already in place
- reflect on your organisation's current and target climate risk management maturity
- identify gaps in climate risk management maturity
- devise new actions or revise existing actions, with stakeholders and risk owners.

To address them a second workshop can be held with the same stakeholders that were involved in **Step 2** to identify existing controls for priority risks. For this workshop, a broader subsection of external stakeholders should be involved. It is important to be transparent and inclusive so value judgements applied to adaptation decisions are clear and accepted by stakeholders.

Leading practice adaptation may incorporate external partnerships with asset owners or communities into implementation plans, in addition to utilising internal delivery mechanisms.

Types of adaptation actions

Adaptation actions may range from incremental to transformational, and may include simple improvements to an organisation's adaptive capacity, to major infrastructure projects that require significant lead time for planning and design. Commonly used categories of adaptation actions include:

- **no/low regrets or win/win options** are low-risk responses that deliver economic benefits and should be implemented as a priority
- **accommodate** the risk by including provisions that reduce the consequence of impacts
- **retreat**, for example by relocating assets and people to safe areas
- **defend** existing and new structures against climate change affected hazards using largely structural measures, and
- **co-exist or adapt** through a combination of innovative measures including planning (Sinay and Carter 2020).

When developing specific adaptation actions you should consider:

- the organisation's risk tolerance
- the potential resources available
- existing controls and initiatives that may be leveraged
- the capacity for adaptive management as conditions change over time
- being equitable, in that they do not place a disproportionate share of costs or risk on a particular group
- being sustainable, by building local capacity to support long-term resilience
- being Specific, Measurable, Achievable, Realistic and Timely (SMART).

The longer the lead time for action, the more important it is to identify management thresholds and triggers for action. These thresholds and triggers should be included in annual implementation reviews.

Prioritise adaptation actions

Prioritising potential adaptation actions enables effective allocation of resources to those risks requiring the most urgent management. In selecting the most appropriate adaptation actions, or combination of actions, the potential costs and resource requirements should be balanced against likely benefits. This will include consideration of financial and non-financial costs and benefits. A high level cost–benefit analysis approach is recommended for assessing and comparing adaption options.

Cost–benefit analysis

Detailed guidance on undertaking cost–benefit analysis can be found in the NSW Guide to Cost–Benefit Analysis (TPP17-03). The guide recommends inclusion of a step to identify and develop a plan to manage potential risks as part of developing new investment proposals.

A win/win action: This section of Rainforest loop walk at Minnamurra Rainforest in Budderoo National Park is made more fire- and flood-resistant with its raised metal mesh boardwalk. Photo: Elinor Sheargold/DPIE

CASE STUDY

Creating safer school microclimates – NSW Department of Education

Children are more susceptible than adults to heat stress. The Cool Schools initiative recommends school design, building and maintenance guidelines to reduce the impacts. This could extend the time for outdoor learning and play in summer, boosting health and learning outcomes. Three strategies to develop heat smart schools are:

Avoid heat traps

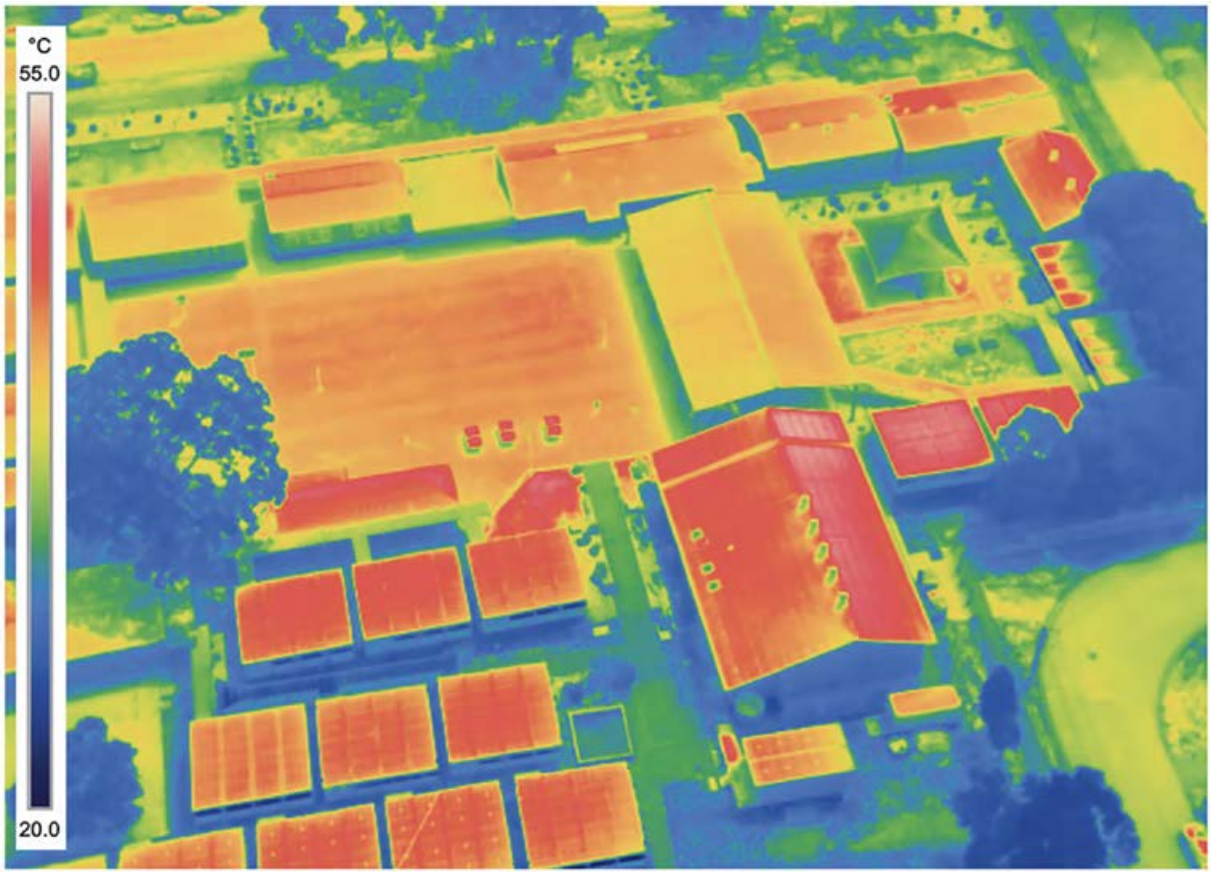
Reduce radiant heat by using materials that don't absorb heat well and reduce anthropogenic heat by installing vertical air-conditioning vents. Use highly reflective materials or coatings on roofs and establish low-intensity green roofs. Any shade materials should have highly reflective upper surfaces, encourage natural air flow and should feature over artificial grass and black asphalt.

Greening

Increase ground vegetation and tree canopy cover. Recommended trees include jacaranda, weeping lilly pilly, Queensland brush box and weeping bottlebrush.

Create heat management strategies

Microclimate maps can be developed for managers and teachers to identify hot and cool zones when children gather and play. Adaptation includes earlier recess times, equipment for chilled drinking water and increased shaded seating facilities in cool zones.



Aerial infrared image of the northern section of a school. This section contains all administrative buildings, classrooms and the main school yard, playground and assembly hall. *Image © S. Pfautsch, School Microclimates. Western Sydney University. Pfautsch S.,et al. (2020)*

Identifying adaptation themes

Grouping actions into themes may help you address multiple risks and secure greater co-benefits from adaptation. Themes may be based on climate variables or hazards, commitment by leadership, strategic planning, operations and assets, or interdependent systems.

Enhancing governance (or building internal capacity/ leadership) around climate risk management may be a fundamental theme to support effective adaptation. Redesigning governance systems to be more collaborative, flexible, integrated and able to deal with redundancies and complexity is essential to build resilience.

Develop and implement an adaptation plan

An adaptation plan provides a transparent approach to addressing climate risks over time. It will include steps that may be embedded in organisational or divisional adaptation strategies as well. Before commencing the plan, seek endorsement or approval of priority climate risks and proposed adaptation responses.

An adaptation plan will include at a minimum:

- a rationale for the actions/risk treatments selected and the residual risk
- designation of risk owners, accountabilities and responsibilities
- steps for implementation over time including milestones
- management thresholds and triggers for action to enable flexible management over time
- required budget and resources, including opportunities to leverage existing or secure new funding
- a process for monitoring and evaluation of implementation
- performance measures that are SMART (smart, measurable, ambitious, realistic and time-bound)

When developing the plan, consider potential roadblocks for implementation, potential gaps in capacity to deliver, and the role of stakeholders or partners in implementation. Allocated resources will build momentum and show commitment. Consider the potential for cost-sharing when treating shared or interdependent risks.

Further considerations when developing your adaptation plan may include:

- additional feasibility or technical studies that may be required
- securing regulatory or legislative approvals

Best practices in climate change adaptation planning

- Planning is underpinned by climate change risk assessment
- Climate change adaptation actions have been identified in master planning/ development plans/ strategic planning
- Adaptation actions are identified for short, medium and long-term planning horizons
- A corporate policy or strategy on climate change adaptation has been adopted (separate to climate change mitigation)
- Collaboration occurs with external stakeholders to validate risks and identify adaptation actions

- project specific risk management planning
- establishing project governance
- development of operational and maintenance plans.

Adaptation pathways

Adaptation pathways are an effective way for an organisation to document agreed thresholds and triggers for management across a suite of adaptation options. They support a management approach that is flexible enough to ensure risk exposure is being managed whilst avoiding path dependency and locked-in responses.

Pathway planning is a useful approach to guide adaptive management. They help address the inherent uncertainty in planning for, and responding to, climate change. Clear responsibilities and procedures for overseeing, managing and monitoring climate risk are required for this approach to be effective. The approach has been successfully applied in adaptation planning for infrastructure and water management projects, and broader cross-sector adaptation planning.

Pathway planning:

- enables investment in adaptation to be prioritised and staggered. Trigger points for decisions can be used along a time continuum to revisit decisions or actions (as shown in Figure 14)
- facilitates clear communication of risk and proposed adaptation approaches to stakeholders
- enables integrated risk management across adaptation themes
- helps prevent being "locked in" to actions that may not be the best solutions for managing uncertainty or a long-term problem.

Identifying management triggers and thresholds

Management thresholds and triggers are identified limits at which an unacceptable level of change to a key indicator occurs. For example, if water levels in a river are below a specified level for a certain period of time this may result in unacceptable threats to a local fishery, or to the river's ecological health. Alternatively, a management threshold may be reached when an increase in the frequency and scope of repairs to telecommunications assets results in unacceptable disruptions to customers, or prohibitive costs to the organisation.

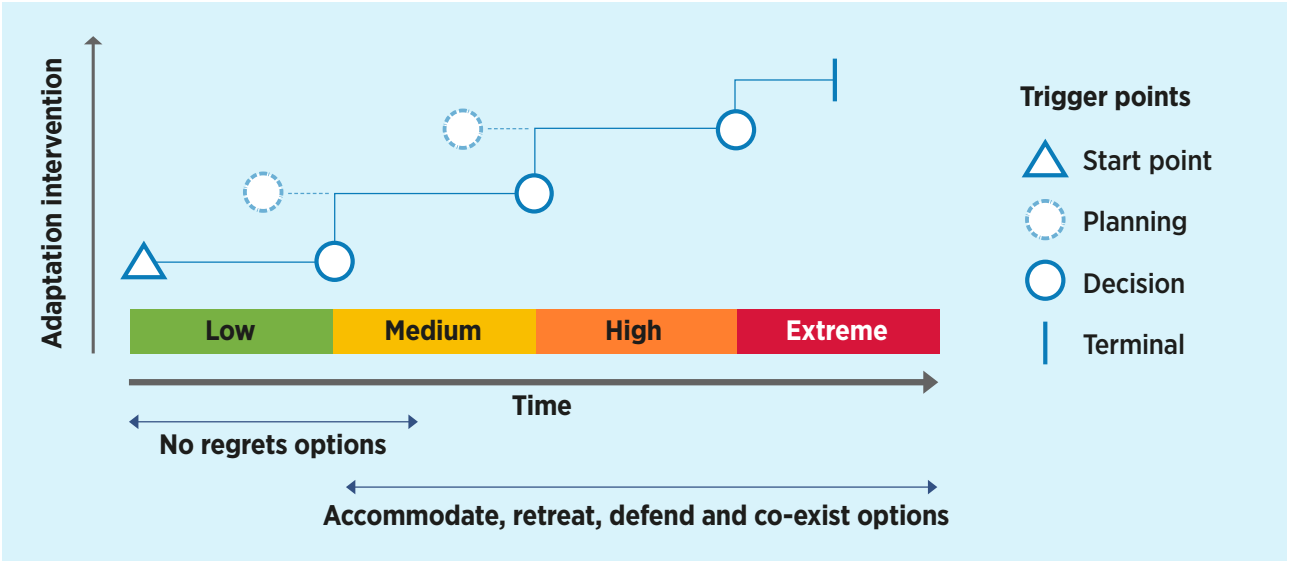


Figure 14: Adaptation pathways include management trigger points along a time and risk continuum (reproduced and adapted from Jacobs et al. 2018 and Haasnoot et al. 2013)

CASE STUDY

Developing the NSW National Parks Climate Change Adaptation Strategy

NSW National Parks and Wildlife Service (NPWS) developed a Climate Change Adaptation Strategy to identify climate risks to park assets and values, and management responses. Over 340 technical and operational staff were engaged to co-design the strategy with the Institute of Sustainable Futures at the University of Technology Sydney. Supported by NARCliM climate change projections, climate risks were identified for key park functions such as biodiversity protection, asset protection, and Aboriginal heritage management.

Adaptation pathways, like Figure 15 below, were then used to document management responses for each function. The pathways show staff what they can do now to protect park assets and values, what they need to plan for, and what will be challenging to protect if climate change reaches certain thresholds.

As part of strategy delivery, management pilots have been delivered through existing NPWS management and operational systems, such as their asset management system, for expansion in the future.

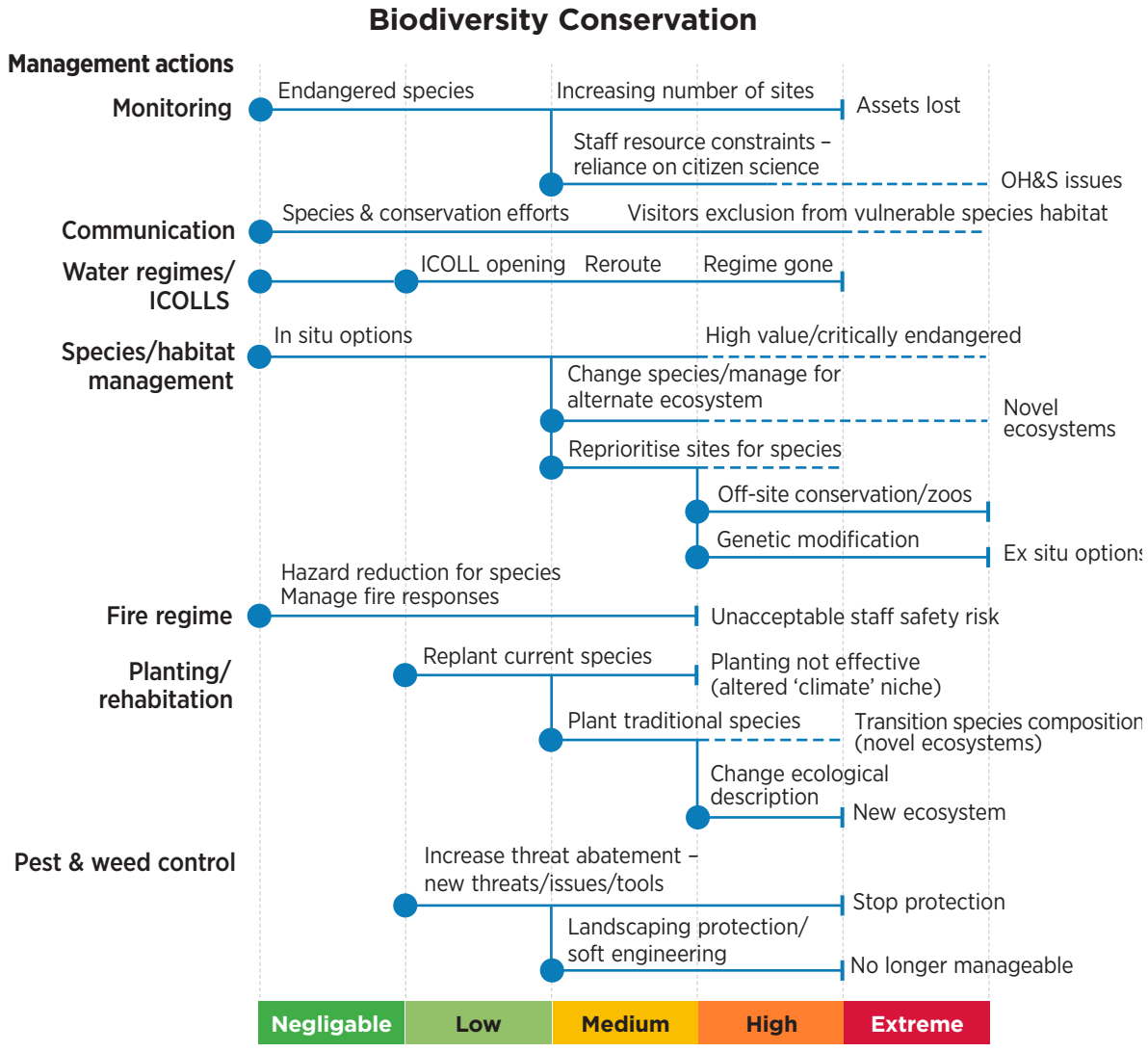


Figure 15: Biodiversity Conservation adaptation pathway developed to help manage climate risks to the NSW reserve system (Jacobs et al. 2018)

Coastal erosion may worsen due to more frequent extreme weather events, such as at Sandon River Campground in Yuraygir National Park. Photo: Kathy and John Mutch

Securing resources

Traditional economic decision support tools such as cost–benefit analysis should be used if seeking funding through NSW Government central budgeting processes. The NSW Guide to Cost–Benefit Analysis (TPP17-03) outlines proposed economic appraisal methods for public projects, programs and policies for the purpose of developing new proposals or business cases.

Establishing a 'do nothing' scenario (base case) can be useful to compare changes and to ascertain the difference that will be achieved by resourcing a particular adaptation response. It is also worth considering co-benefits that may be achieved through delivery of climate adaptation.

Accounting for the uncertainty inherent in climate change adaptation is a key challenge, and a range of decision support tools have been developed in recent years to respond to this. It is recommended that the use of decision support tools such as Real Options Analysis and Portfolio Analysis be considered on a case-by-case basis.

There are a range of NSW Government resources to support detailed project planning and design. Depending on the type and size of a project, different approval and management frameworks may be applied, including the NSW Government Gateway process, or organisation specific project management frameworks.

Accounting for the uncertainty inherent in climate change adaptation is a key challenge, and a range of decision support tools have been developed in recent years to respond to this.

CASE STUDY

A lesson in collaborative adaptation – XDI Sydney pilot project

Assets and critical infrastructure are often dependent on each other to operate effectively. In extreme weather events they can be damaged or disrupted. This creates flow-on disruptions to other critical services. To minimise the likelihood or impact of disruptions, organisations should understand how their assets and infrastructure depend on one another to continue to deliver public services. By understanding these 'interdependencies' organisations can identify opportunities for collaboration to minimise risks of disruption.

Cross-Dependency Initiative (XDI) Sydney was an international award-winning pilot project to trial technology that identifies and quantifies the transfer of risks between critical infrastructure. The project worked with public asset owners and operators including Sydney Water, Transport for NSW and City of Sydney to quantify extreme weather and climate risks. Using the XDI platform, the project showed asset owners which third-party risks will affect their own system and, equally, the consequences of their own failure risks to other critical infrastructure (an example is provided in Figure 16). Risks were quantified using financial and asset-based indicators, such as the cost of damage and number of customers affected by an outage.

The pilot enabled the project partners to identify opportunities to share the amount of risk transfer between interdependent assets, and to improve asset management and cost sharing. Through use of the XDI platform, project partners were equipped to make decisions on how to contribute to the costs of upgrading or replacing an asset, ensuring decision-making was informed by evidence and that opportunities for cost savings were explored, compared to individually adapting their own assets. This collaborative effort would benefit communities by increasing the resilience of the critical infrastructure and services that they rely on.

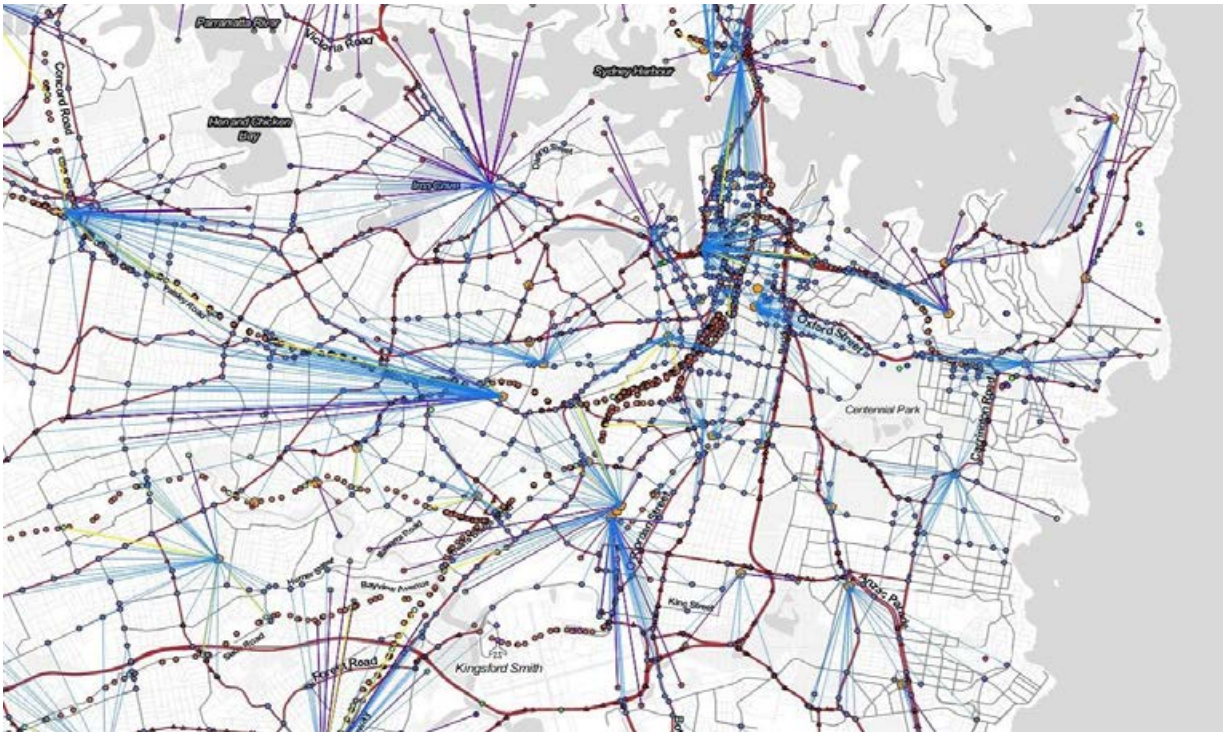


Figure 16: Image capture of dependent assets as displayed in the XDI platform

Blue, yellow and red lines are different sector connections. Circles are different assets.

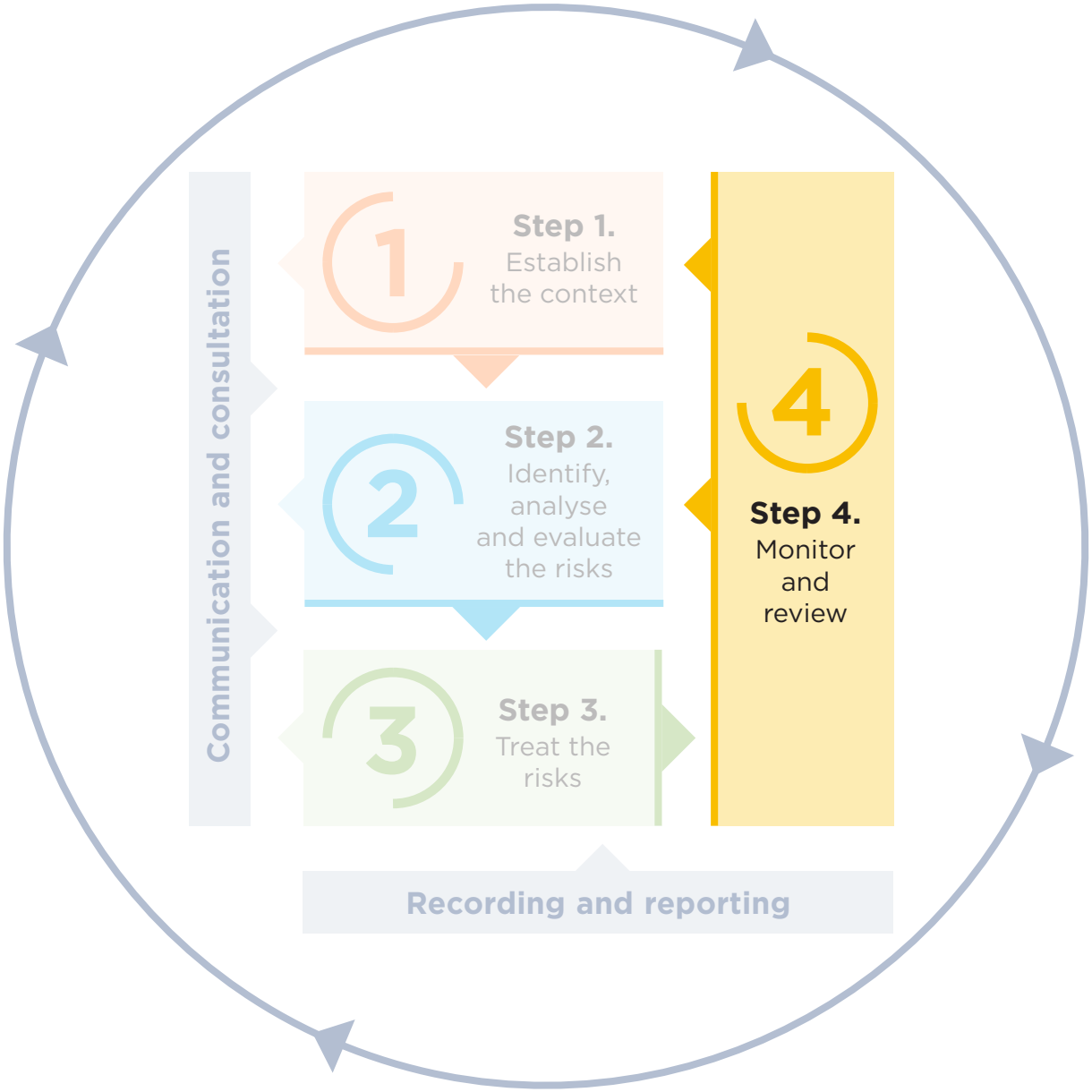
At the end of Step 3 you will have:

- Identified the most important actions to start taking to treat your priority climate risks, and triggers for action over time
- Developed and communicated an adaptation plan with risk owners and key stakeholders in your organisation
- Undertaken economic appraisal of adaptation options, and other relevant studies, including consideration of required resources.

A pilot's view of the 2014 Murrumbucca fire near Cooma. Photo: Sean Parry/DPIE

Step 4.
Monitor and review

Monitor implementation of adaptation plans, climate change impacts and embed reviews in existing procedures and systems



Key messages

- The nature of climate change requires a strong emphasis on embedding monitoring and evaluation as a continuous and flexible part of the risk management process.
- Implementation of adaptation plans should be reviewed annually.
- Monitoring of adaptation actions should be embedded in existing relevant frameworks and processes where possible.
- It is recommended that climate change risk maturity is reassessed every 2–3 years.

Actions and outputs

Actions	Indicative timeframe	Outputs	Key resources
Develop a monitoring and evaluation plan	2 weeks	• A plan to track adaptation implementation, and monitor climate risks	• NSW Department of Premier and Cabinet's Evaluation Toolkit website • Better Evaluation website
Integrate monitoring, review and learning into existing systems	4 weeks	• An updated risk register	

Recommended roles and responsibilities

Executive	Climate change risk officer	Assessment team
Approves action to be taken when management triggers or thresholds are reached Uses adaptation reviews and priority risk monitoring to inform decisions about climate risk management	Monitors and reports on adaptation progress and climate risks and escalates action when required Oversees maintenance of monitoring and evaluation procedures	Develops monitoring and evaluation plans, and establishes baselines where appropriate

Develop a monitoring and evaluation plan

Monitoring and evaluating climate change adaptation and risk management practices is necessary to support a flexible response and reduce the risk of inefficient use of resources. This is particularly true for adaptation, giving the inherent uncertainty of responding to climate change, and the complex and long-term nature of managing climate risks.

Monitoring and evaluation can help achieve different objectives, depending on the scale of climate risk assessment conducted and the objectives of the organisation. These include:

- to assess progress of adaptation actions
- to track risk exposure at enterprise or program level, or provide input into enterprise risk and financial risk reporting
- to identify and integrate new knowledge about climate change impacts and climate projections as they arise
- to track management thresholds and triggers
- to inform improvements and realignment of action in response to changing context or impacts
- to provide progress updates to stakeholders or adaptation delivery partners
- to inform reporting to meet legislative or regulatory obligations.

It is recommended that enterprise risk management reviews of climate change risks are undertaken every 5 years at a minimum. This should include a review of confidence ratings attributed to priority climate risks.

Monitoring and evaluation activities should be embedded in organisational processes. Its recommended that a climate risk officer is allocated to maintain focus on priority climate risks over time.

As described in **Step 3**, adaptation pathways may be a useful way to represent when adaptation steps are required to occur. These pathways may form the basis of a monitoring and evaluation plan to monitor progress and identify when management triggers have been reached.

Monitoring and evaluation activities should be embedded and ideally a climate risk officer will be allocated to maintain focus on priority climate risks over time.

A monitoring and evaluation plan should consider the following components at a minimum:

- **time period** – an agreed period for ongoing monitoring
- **lifecycle** – an agreed decision lifecycle for adaptation interventions
- **responsibility** for data collection, reviews and reports
- clear articulation of long-term and intermediate **outcomes**
- **performance** indicators and management triggers
- **metrics** – agreed measures that will indicate change, and baselines where appropriate
- **targets** that will demonstrate success
- **review or trigger points** to guide changes as new knowledge is gained.

It may be necessary to establish baseline conditions to ensure targets are realistic and achievable, and that progress can be tracked over time to help tell a story of how adaptation actions helped build resilience or achieve their ultimate goal.

Understanding management thresholds and triggers will support timely implementation of adaptation actions. *Photo: DPIE*

CASE STUDY

Climate risk assessment – an integral part of asset stewardship at NPWS

The NSW National Parks & Wildlife Services (NPWS) asset management plan reflects the 10-year forward estimate that is foundational to the budget cycle. Climate risks are treated no differently to other risks and must be considered as part of existing asset revaluation and performance assessment processes. Responses to climate risks are then operationalised through asset management plans.

The NPWS adopted an Asset Stewardship Strategy in 2015 to better define the relationship between its built asset portfolio and the services it delivers. This relationship supports organisational drivers of outcomes-based budgeting, and alignment to the NSW Treasury Asset Management Policy for the NSW Public Sector. To prioritise assets for investment, NPWS assesses the relevance and performance of all major assets across its portfolio. Figure 17 outlines the stewardship approach, including measures used to assess asset relevance and performance.

The objectives for achieving sustainable asset management outlined in the NPWS Asset Stewardship Strategy are:

- **stewardship** to ensure the responsible management of assets for current and future generations
- **optimisation** to ensure the asset portfolio maximises social, environmental and economic outcomes for the community at least cost, risk and impact within a sound decision-making framework
- **relevance** to continuously improve the contribution of our assets to our services, through a customer centric approach, and maintain the relevance of assets as service demands change.

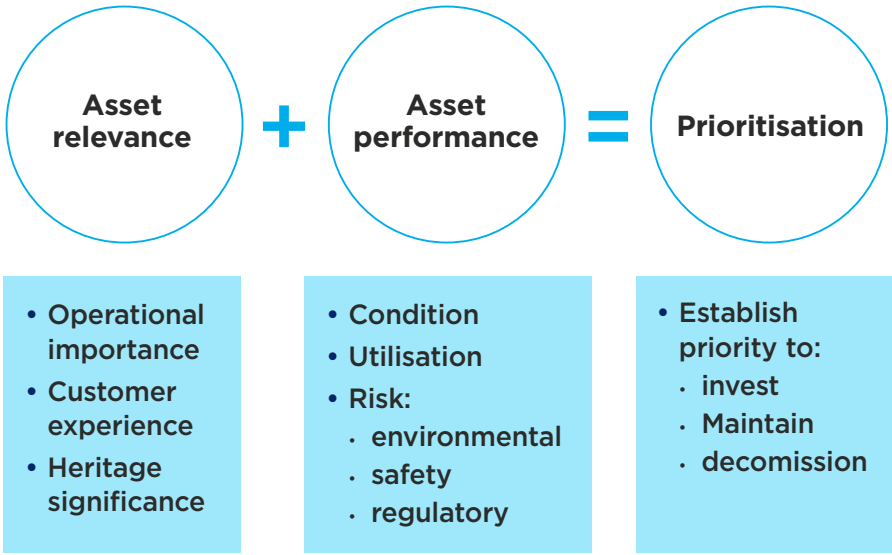


Figure 17: Asset stewardship approach adopted by NPWS

Dealing with uncertainty

Developing a theory of change may be useful to clearly articulate how change, such as adaptation progress, is expected to happen over time. This will build on an adaptation pathway by documenting assumptions that underpin your anticipated path to success. For example, there may be assumptions about how climate change impacts may develop, or how community or business stakeholders may respond to interventions.

A theory of change will typically document elements such as:

- **long-term and intermediate outcomes** – the changes that are expected to occur in the short, medium or long-term as a result of your work activities (Funnell and Rogers 2011)
- **benefit(s)** – the measurable improvement resulting from an outcome perceived as an advantage by one or more stakeholders
- **outputs** – the physical goods, services or products that will be produced through project activities, and will help result in change
- **assumptions** – the beliefs or premise that underlie your theory of how change will occur (preferably based on some prior knowledge or evidence).

For each outcome outlined in a theory of change, performance measures and indicators should be identified to measure ultimate impact. In some instances, proxy indicators may be needed to demonstrate indirect change, and process indicators may be useful to measure the success of actions over long periods of time (where outcomes cannot yet be measured). SMART targets may also be included.

Further resources:

A range of resources can be consulted that provide guidance on monitoring and evaluation of climate change adaptation:

- AdaptME Toolkit (PDF 3.8MB) (Pringle 2011)
- Better Evaluation website, including their working paper series on monitoring and evaluation and adaptive management
- NSW Department of Premier and Cabinet's Evaluation Toolkit.

Integrate monitoring, review and learning into existing systems

Reviewing progress and implementing learning is a fundamental aspect of adaptive management. Monitoring and reviews of adaptation plans should occur annually and be integrated with existing frameworks or systems such as business continuity, asset management, and program governance. At an enterprise level, this may include strategic and business planning and outcomes reporting requirements, including those aligned to the NSW Government's outcome budgeting commitments.

Reviews of climate risk management practices may be undertaken less frequently, in line with the frequency of the organisation's enterprise risk framework reviews. This may include a review of how the organisation is using climate change projections, datasets or assumptions, or how information about recent climate impacts is being captured. It is recommended that climate risk maturity is reassessed every 2–3 years using the Health Check Tool, or similar.

Increasingly, agencies may consider aligning their monitoring and evaluation to the recommendations of the TFCD, to inform public transparency. Figure 18 outlines core elements of climate-related financial disclosures as recommended under the TCFD framework.

Governance

The organisation's governance around climate change risks and opportunities

Strategy

The actual and potential impacts of climate-related risks and opportunities on the organisation's business, strategy, and financial planning

Risk management

The process used by the organisation to identify, assess, and manage climate-related risks

Metrics and targets

The metrics and targets used to assess and manage relevant climate-related risks and opportunities

Figure 18: Core elements of climate-related financial disclosures (TCFD 2017)

When reviewing progress, the roles and responsibilities for implementation may have changed and may sit with contractors. In this case you may wish to clarify their roles in supporting adaptation at a strategic or operational level. As an example, Sydney Metro has identified specific climate adaptation actions it remains responsible for, irrespective of the stage of design or construction of the Sydney Metro component. This ensures central oversight of material climate risks across the project.

When seeking data from external parties such as local government or community groups, consider the need for capacity building and provide clear tools and templates to reduce the administrative burden on these groups. Digital platforms may also be used to efficiently track progress and collate data. It may be possible to consult existing monitoring programs to track performance measures and indicators; for example, air quality, water levels, vegetation cover, and socioeconomic patterns. These may be sources you already consulted in **Step 1** of the Guide.

At the end of Step 4 you will have:

- Developed a monitoring and evaluation plan that draws on adaptation action plans and adaptation pathways, and outlines performance measures and indicators that can be monitored over time
- Allocated responsibility to an internal lead or climate risk officer to monitor and report on climatic changes over time
- Identified where monitoring and evaluation can be operationalised through use of existing procedures and systems
- Established regular reporting cycles and a group or governance with oversight of implementation progress.

Glossary

Acute climate change risk	Event-driven physical risk, including increased severity of extreme weather events such as heatwaves, floods or storms (TCFD 2017).
Adaptation	Actions undertaken to manage or reduce the adverse consequences of climate change, as well as to harness any benefits or opportunities (AdaptNSW n.d.a).
Adaptive capacity	The sum of attributes that an organisation has that enables them to successfully manage risks and maximise opportunities from climate change. Attributes include resources, skills, knowledge, leadership and adaptive management maturity (ClimateADAPT n.d.).
AdaptNSW website	A NSW Government website providing NSW specific information on climate change and access to the NARCliM climate change projections (see NARCliM).
Audit and risk committee (ARC)	A committee established to monitor, review and provide assurance and advice about the organisation's governance processes, risk management and internal control frameworks and external accountability obligations (NSW Treasury 2015).
Chronic climate change risks	Risks resulting from longer-term and cumulative changes in weather patterns, and climate-related trends. Chronic risks can amplify acute risks (event-based risks) and can relate to changes to the average of a climate variable over time.
Climate	The average weather that a location experiences over many years, even thousands of years. Key variables include temperature, rainfall and wind (CSIRO 2018).
Climate change	Persistent change in the average weather for an extended period of time, typically decades or longer. This change occurs on top of variability from year-to-year (CSIRO 2018).
Climate change risk/Climate risk	The effect of uncertainty on organisational objectives from acute and chronic climatic change. This includes physical, transition and liability risks. Physical risks are associated with direct impacts from rising aggregate global temperatures. Transition risks may result from activities undertaken to adjust towards a lower-carbon economy. Liability risks arise when a person or entity is held responsible for not acting sufficiently on physical or transition risks, causing damage to others (adapted from CSIRO (2016)). The terms climate change risk and climate risk are used interchangeably in this guide.
Climate change scenario	A coherent, plausible but often simplified description of a possible future state of the climate as influenced by climate change. It is not a prediction about the future, but rather it provides a means of understanding the potential impacts of climate change (CSIRO 2016).

Climate forcing	A physical process that affects the climate, specifically through changes to the energy flow in Earth's atmosphere caused by human (e.g. greenhouse gas concentrations) or natural drivers (e.g. solar radiation, volcanic eruptions) (adapted from IPCC 2014). The concept is used in simple climate models.
Climate projection	The response of the climate system over the coming decades to an emissions scenario as simulated by a climate model to obtain a sense of the range of future climate conditions that may emerge, for which we must plan. A true climate prediction or forecast is not currently possible beyond a few months (CSIRO 2018).
Climate-related opportunity	The potential positive impacts for an organisation related to climate change. Efforts to mitigate and adapt to climate change create the potential for organisations to benefit. Benefits may include resource efficiency and cost savings, utilising low emission energy sources, developing new products and services, and building robust supply chains (TCFD 2017).
Climate resilience	The ability to anticipate, prepare for, respond to and adapt to incremental change and sudden disruptions associated with climate change, so as to continue the delivery of products and services and meet customer expectations.
Climate risk officer	A person with ongoing, designated responsibility for the oversight of climate change risk within the organisation and who establishes and/or maintains the organisation's context for climate change risk management. The climate risk officer champions the climate risk assessment process within the organisation and seeks its integration into existing risk frameworks.
Consequence	Certain or uncertain outcome of an event affecting objectives directly or indirectly. It can be expressed qualitatively or quantitatively. Any consequence can escalate through cascading and cumulative effects (ISO 2018).
Critical infrastructure	The assets, systems and networks required to maintain security, health and safety, as well as social and economic prosperity. These are underpinned by supporting organisations and people (Department of Justice 2018).
Emissions scenario	Emissions scenarios are a tool with which to analyse how driving forces may influence future greenhouse gas emission outcomes and to assess the associated uncertainties. They are used in climate change analysis, including climate modelling and the assessment of impacts, adaptation and mitigation (IPCC 2000)
Interdependency	When multiple critical infrastructures rely on each other for continued service provision, or where interconnections associated with the supply or receipt of a service (e.g. water) on which the receiving sector is reliant and an impact on this supply could be critical (Department of Justice 2018).
Likelihood	The chance that a hazard will cause harm under a given scenario.

Materiality	When a climate change risk is material, it results in significant deviation from the organisation's strategic, financial or non-financial performance outcomes (Natural Capital Coalition 2016).
Mitigation	Climate change mitigation includes actions we take globally, nationally and individually to limit changes caused in the global climate by human activities. Mitigation activities are designed to reduce greenhouse emissions and/or increase the amounts of greenhouse gases removed from the atmosphere by greenhouse sinks (AdaptNSW n.d.,b).
NARCliM	The NSW and ACT Regional Climate Modelling (NARCliM) initiative provides an ensemble of robust regional climate projections for south-eastern Australia that can be used by the NSW and ACT community to plan for the range of likely future changes in climate. It can be accessed via the AdaptNSW website.
Natural hazards	A natural or human-induced situation or condition that could harm people or damage property or the environment. Natural hazards include heatwaves, flooding and tidal inundation, storms such as east coast lows, landslides and bushfire (Resilience NSW).
Resilient infrastructure	New and existing physical facilities that support our society (e.g. roads, water pipes, power stations and communication systems) that are able to withstand climate variations over the decades of their use. To be climate resilient, new assets are located, designed, built and operated with the current and future climate in mind, and existing infrastructure and maintenance regimes should incorporate resilience to the impacts of climate change over an asset's lifetime (UK DEFRA 2011).
Risk	The effect of uncertainty on objectives, noting that effect is a deviation from the expected and may be positive and/or negative (ISO 2018).
Risk management framework	The set of components for integrating, designing, implementing, evaluating and improving risk management throughout an organisation (NSW Treasury 2015).
Risk management process	The systematic application of policies, procedures and practices to the tasks of communication, consultation, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risk (NSW Treasury 2015).
Risk treatment	A process to modify risk (NSW Treasury 2015).
Vulnerability	The extent to which a system or organisation can cope with the negative impacts of climate change, variability and extremes. Vulnerability is a function of risk and adaptive capacity (AGO 2006).
Weather	The atmospheric conditions over defined short periods of time, such as hours or days (AdaptNSW n.d.).

Appendix A: Related NSW legislation, policies and guidelines

The *Government Sector Finance Act 2018* sets out financial management obligations for the NSW Government sector, including accountability for establishing and maintaining effective systems for risk management (s.3.6(1)(b)(i)), and preparing annual financial statements in accordance with the Australian Accounting Standards (AAS) (s.7.6(3)(a)). In April 2019 the AAS Board (AASB) released updated guidance on assessing the materiality of climate-related financial risks for the purpose of disclosure in financial statements.

Assessing climate risks during planning and design of new assets supports fulfilment of asset management principles under Core Requirement 1 of NSW Treasury's Asset Management Policy for the NSW Public Sector (TPP19-07). Integrating management of climate risk into asset management frameworks will support consideration and action on material climate risks throughout the asset lifecycle. This supports Core Requirement 2 of TPP19-07.

For capital, ICT and major recurrent projects, NSW Government organisations are required to follow the *Gateway project assurance process* (TPP17-01), a risk-based approach to providing independent assurance to investors and delivery agencies of the project's preparedness for success. Whilst climate risks are not explicitly considered under Treasury's Recurrent Expenditure Assurance Framework (TPP19-03), considering climate risks through an assessment may help inform project risk assessment requirements for recurrent major projects, particularly relating to Criticality of Service.

Nationally adopted industry standards developed by the Infrastructure Sustainability Council of Australia (ISCA) and the Green Building Council of Australia (GBCA) both include performance credits to encourage building facilities management and operations teams to address climate risk in the delivery of assets and infrastructure.

The NSW Government's Standard Secretary's Environmental Assessment Requirements (SEARs) also require that State Significant Infrastructure is designed, constructed and operated to be resilient to the future impacts of climate change.

Considering climate risks through an assessment may help inform project risk assessment requirements for recurrent major projects.

Appendix B: Climate Risk Maturity Health Check Tool

The **Health Check Tool** is designed to help organisations in the NSW Government sector to assess their existing climate risk management capacity. The Tool builds upon the recommended general risk management maturity advice provided in the Treasury Risk Maturity Assessment Tool Guidance Paper (TPP20-06).

The Tool can be used by organisations to target an increased climate risk management maturity level and /or identify areas of focus to build capacity. Organisations using the tool may range from those just beginning their journey to understand climate risk (Fundamental risk management maturity), to those who are already demonstrating leading practice (Systematic risk maturity and above).

It is recommended that NSW Government organisations seek to meet a **Systematic** level of climate risk management maturity. At an enterprise level, Systematic maturity is distinguished by standard, consistent processes.

The Health Check Tool can be accessed on the AdaptNSW website.

Climate Risk Maturity Health Check Tool

			Rating	Legend
Assessed by:	Current practice:	Organisation's current practice	0 = No	You have not started or cor
Date:	Target:	Organisation's target for climate risk maturity	1 = Partly	Some initial efforts have be
Notes:			2 = Yes	Your organisation has estal

Stage	Fundamental		Current practice	Target	Repeatable		Current practice	Target	Systematic	
3 - Treat the risks	3.1.1	Are there any existing controls to manage natural hazards (e.g. emergency management procedures)?	2	2	3.2.1	Have adaptation actions been identified to treat priority climate risks (e.g. high and extreme risks) in consultation with relevant internal stakeholders?	0	2	3.3.1	Have roles and resp implementation of act clearly defined?
	3.1.2	Have measures to respond to climate change at a high level been identified?	0	2	3.2.2	Have adaptation actions been identified for implementation over short, medium and long-term timeframes?	0	2	3.3.2	Have adaptation acti identified in consultat relevant external stal
lonitor and review	4.1.1	Are records of historical performance for climate-related issues available to allow trend analysis?	0	1	4.2.1	Is there a process for internally communicating and disseminating information about climate-related risks and adaptation activities?	0	1	4.3.1	Have there been res allocated to monitor r information regarding change impacts and
					4.2.2	Is there a commitment to periodically review climate adaptation (risk treatment) plans?	0	2	4.3.2	Have metrics been ic measure and manag climate risks?

Appendix C:
Climate Risk Assessment Tool

The **Climate Risk Assessment Tool** has been developed as a template to support organisations in completing a climate risk assessment, ongoing identification of risk treatments and implementation of adaptation actions. It can be used where the user's standard risk registers are not suitable for the purposes of climate risk assessment.

The Tool assists users to structure their climate risks. It enables the rating of risks across multiple future time horizons for organisations to consider how they are likely to be affected by climate change in the long term. These time horizons (near-future to 2030 and far-future to 2070) have been selected based on the NSW Government's NARCliM climate change projections. Example risks and adaptation actions are provided to assist users in their first pass of risk identification and adaptation planning.

Risk assessment criteria have been provided in an editable form in the Tool to allow users to customise the template with the risk assessment criteria outlined in an organisation's existing enterprise risk management framework/guidance if desired.

The Climate Risk Assessment Tool can be accessed on the AdaptNSW website.

					Natural hazards (climate related)							
Risk ID	Risk description	Business area/Risk owner	Date last assessed DD/MM/YY	Risk category	Sea level rise & coastal floodin	Mean temperature	Heatwaves/extreme heat days	Relative humidity	Bushfires	Extreme rainfall and flooding	Extreme storms (incl wind & h	Droughts
Unique identifier	*Refer to Guidance for advice on developing a climate risk statement, or refer to the Example Risks tab*	*Who is responsible for managing the risk*		*e.g. financial, service delivery, work health and safety*	*e.g. map against natural hazards to help understand how many risks relate to specific natural hazards and/or identify any gaps*							
1	***EXAMPLE*** Increased number of health issues related to heat stress in the workplace due to higher temperatures and increased severity of heatwaves.	Operations	20/09/19			✓	✓	✓				
2	*User input*	*User input*	*DD/MM/YY*									
3	*User input*	*User input*	*DD/MM/YY*									
4	*User input*	*User input*	*DD/MM/YY*									

Appendix D: Improving climate change risk management maturity

Table 7: What success may look like in terms of outcomes and level of stakeholder engagement over time under different maturity levels

Maturity level	Timeframe		
	0 – 6 months	**6 months – 1 year**	**1+ years**
Fundamental	**Outcome:** Scope for initial climate risk assessment for a specific area of the organisation.	**Outcome:** Risk register updated to incorporate climate risk for a specific area.	**Outcome:** Low cost adaptation actions identified and implemented.
INCREASING MATURITY	**Engagement:** Stakeholders and assessment team identified.	**Engagement:** Climate risk owners are identified.	**Engagement:** Existing risk governance reviews adaptation actions in a specific area of the organisation annually.
Repeatable	**Outcome:** Existing risk assessment matrices reviewed and enhanced to capture physical climate risks.	**Outcome:** Policy for how and when climate risk assessments are required within the organisation.	**Outcome:** A climate risk assessment policy is being implemented.
	Engagement: Key internal stakeholders informed of physical climate risks.	**Engagement:** The policy has been endorsed by internal stakeholders.	**Engagement:** Resources for implementation have been committed (financial, intellectual, monitoring).
Systematic	**Outcome:** Physical climate risks to the organisation have been prioritised for adaptation planning. A climate risk officer is formally identified.	**Outcome:** Enterprise risk register and procedures updated to incorporate climate risk. Economic assessment of priority adaptation actions and resourcing identified.	**Outcome:** Risk assessments are revised at pre-determined intervals. Adaptation implementation is reviewed annually.
	Engagement: Climate risk to delivery of services are understood by delivery teams.	**Engagement:** Climate risk owners are identified. Building staff capability in climate risk management.	**Engagement:** A cross-agency climate risk management subcommittee is established.
Embedded	**Outcome:** Specific climate hazard, such as heat, is identified as a priority organisation-wide risk.	**Outcome:** Heat adaptation plan established. Organisation-specific climate risk assessment policy established.	**Outcome:** Funding for adaptation actions reviewed and renewed.
	Engagement: External stakeholders engaged in risk assessment.	**Engagement:** Practitioner champions group established to build internal capability.	**Engagement:** Vulnerable communities or stakeholders identified and a plan is established to them on potential climate risks.
Advanced	**Outcome:** Social, economic and environment climate-related risks identified.	**Outcome:** Interdependent risks between critical assets are identified.	**Outcome:** Gateways or triggers for management of climate risks are identified for the organisation.
	Engagement: Critical asset owners are involved in risk assessments and scenario testing.	**Engagement:** Community risk assessments undertaken.	**Engagement:** Adaptation actions are co-designed with external stakeholders. Lessons learned from implementing adaptation actions are shared internally.

References

AdaptNSW n.d.,a, *Adaptation planning*, climatechange.environment.nsw.gov.au/Adapting-to-climate-change/Local-government/Adaptation-planning.

AdaptNSW n.d.,b, *Climate change mitigation*, climatechange.environment.nsw.gov.au/About-climate-change-in-NSW/NSW-Government-action-on-climate-change/Climate-change-mitigation.

AdaptNSW n.d.,c, *Understand climate change*, climatechange.environment.nsw.gov.au/About-climate-change-in-NSW/Understand-climate-change.

Australian Greenhouse Office (AGO) 2006, *Climate change impact and risk management: A guide for business and government*, Australian Greenhouse Office, Department of the Environment and Heritage, Canberra, ACT.

Australian Business Roundtable (ABR) for Disaster Resilience & Safer Communities 2017, *Building resilience to natural disasters in our states and territories*, Deloitte Access Economics for the Australian Business Roundtable for Disaster Resilience & Safer Communities, http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf (PDF 37MB).

Australian National University, 2020. Measuring the economic impact of early bushfire detection https://csrm.cass.anu.edu.au/sites/default/files/docs/2020/9/Measuring_the_economic_impact_of_early_bushfire_detection.pdf

Climate Change Authority, 2020. *Prospering in a low Emissions World: An updated climate policy toolkit for Australia*, Australian Government, Canberra, www.climatechangeauthority.gov.au/sites/default/files/2020-06/toolkit-2020/Prospering%20in%20a%20low-emissions%20world.pdf (PDF 3.1MB).

Bank of England 2020, *Climate change: what are the risks to financial stability?* Bank of England, London, UK, www.bankofengland.co.uk/knowledgebank/climate-change-what-are-the-risks-to-financial-stability.

BoM 2020, *NSW Climate Statistics*, decadal averages, Bureau of Meteorology, www.bom.gov.au/web01/ncc/www/cli_chg/timeseries/tmean/0112/nsw/latest.txt.

Brigadier Darren Naumann AM 2015, *Recovery Coordinators Summary Report: East Coast Storm and Flood – April 2015*, Regional Recovery Committee, NSW Government, www.emergency.nsw.gov.au/Documents/publications/Report-East-Coast-Storm-and-Flood_April2015-Recovery-Coordinators.pdf (PDF 3.9MB).

Business SA n.d., *Blackout Survey Results: Understanding the effects of South Australia's State-wide blackout on Wednesday 28 September 2016*, Business SA, Chamber of Commerce and Industry South Australia.

ClimateADAPT n.d., *The Adaptation Support Tool – Getting started*, European Climate Adaptation Platform, https://climate-adapt.eea.europa.eu/knowledge/tools/adaptation-support-tool.

Climate Council 2020, Summer of Crisis https://www.climatecouncil.org.au/resources/summer-of-crisis/

CoastAdapt 2017, *Working with consultants*, CoastAdapt, coastadapt.com.au/how-to-pages/working-with-consultants.

Collins M, Knutti R, Arblaster J, Dufresne J-L, Fichefet T, Friedlingstein P, Gao X, Gutowski WJ, Johns T, Krinner G, Shongwe M, Tebaldi C, Weaver AJ and Wehner M 2013, 'Long-term Climate Change: Projections, Commitments and Irreversibility', in TF Stocker, D Qin, G-K Plattner, M Tignor, SK Allen, J Boschung, A Nauels, Y Xia, V Bex and PM Midgley (eds), *Climate Change 2013: The Physical Science Basis*, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA, www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter12_FINAL.pdf (PDF 35MB).

CSIRO 2016, *Climate Change in Australia: Projections for Australia's NRM regions – Glossary*, CSIRO, Australia, www.climatechangeinaustralia.gov.au/en/climate-campus/glossary.

CSIRO 2018, *Climate Compass: A climate risk management framework for Commonwealth agencies*, CSIRO, Australia, www.environment.gov.au/climate-change/adaptation/publications/climate-compass-climate-risk-management-framework.

Deloitte Access Economics 2020, *A new choice: Australia's climate for growth*, www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-dae-new-choice-climate-growth-051120.pdf?nc=

Department of Justice 2018, *NSW Critical Infrastructure Resilience Strategy: Partner, Prepare, Provide*, NSW Department of Justice and Office of Emergency Management, www.emergency.nsw.gov.au/criticalinfrastructure.

Department of Planning, Industry and Environment (DPIE) n.d., *Climate projections for NSW*, NSW Department of Planning, Industry and Environment, Sydney, climatechange.environment.nsw.gov.au/Climate-projections-for-NSW.

Funnell SC and Rogers PJ 2011, *Purposeful Program Theory*, John Wiley & Sons.

Haasnoot M, Kwakkel JH, Walker WE and ter Matt J 2013, Dynamic adaptive policy pathways: a method for crafting robust decisions for a deeply uncertain world, *Global Environmental Change*, vol.23, no.2, pp.485–498.

IAP2 2015, *Quality Assurance Standard for Community and Stakeholder Engagement*, International Association for Public Participation – Australasia, iap2.org.au/wp-content/uploads/2019/07/IAP2_Quality_Assurance_Standard_2015.pdf (PDF 730KB).

IPCC 2014, *Climate Change 2014: Impacts, Adaptation, and Vulnerability Part A*, Contribution of Working Group II to the Fifth Assessment Report of the IPCC, Cambridge University Press

IPCC 2014, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], IPCC, Geneva, Switzerland.

IPCC 2000, *Emissions Scenarios*, N Nakicenovic and R Swart (eds), Cambridge University Press, Cambridge, UK, www.ipcc.ch/report/emissions-scenarios.

International Organization for Standardization (ISO) 2018, *ISO 31000:2018(en): Risk management – Guidelines*, International Organization for Standardization, Geneva, Switzerland, www.iso.org/obp/ui#iso:std:iso:31000:ed-2:v1:en.

Jacobs B, Boronyak L, Mitchell P, Vandenberg M and Batten B 2018, Towards a climate change adaptation strategy for national parks: Adaptive management pathways under dynamic risk, *Environmental Science and Policy*, vol.89, pp.206–215.

National Institute of Building Sciences 2018, *National Institute of Building Sciences Issues New Report on the Value of Mitigation*, press release issued 11 January 2018, https://www.nibs.org/news/381874/National-Institute-of-Building-Sciences-Issues-New-Report-on-the-Value-of-Mitigation.htm.

Natural Capital Coalition 2016, *Statement of Common Principles of Materiality of the Corporate Reporting Dialogue*, Natural Capital Coalition, https://naturalcapitalcoalition.org/statement-of-common-principles-of-materiality-of-the-corporate-reporting-dialogue.

Nicholls N, Bi P, Handmer J, Bennett C, Hansen A, Cowan T, Forrest S, Guo Y, Harris R, Huang C, Law T, Lewis S, Loughnan M, Wyrwoll C and Zhang Y 2015, 'Group 1: Temperature and extreme weather events', in Australian Academy of Science, *Climate change challenges to health: Risks and opportunities – Recommendations from the 2014 Theo Murphy High Flyers Think Tank*.

NSW Government 2018, *Benefits Realisation Management Framework Parts 1–5*, www.finance.nsw.gov.au/publication-and-resources/benefits-realisation-management-framework.

NSW Treasury 2012, *Risk Management Toolkit for NSW Public Sector Agencies (TPP12-03)*, NSW Treasury, Sydney, www.treasury.nsw.gov.au/information-public-entities/governance-risk-and-assurance/internal-audit-and-risk-management/risk.

NSW Treasury 2015, *Internal Audit and Risk Management Policy for the NSW Public Sector (TPP15-03)*, NSW Treasury, Sydney, https://arp.nsw.gov.au/tpp15-03-internal-audit-and-risk-management-policy-nsw-public-sector.

NSW Treasury 2017a, *NSW Gateway Policy (TPP17-01)*, NSW Treasury, Sydney, https://arp.nsw.gov.au/tpp17-01-nsw-gateway-policy.

NSW Treasury 2017b, *NSW Government Guide to Cost–Benefit Analysis (TPP17-03)*, NSW Treasury, Sydney, https://arp.nsw.gov.au/tpp17-03-nsw-government-guide-cost-benefit-analysis.

NSW Treasury 2018, *NSW Government Business Case Guidelines (TPP18-06)*, NSW Treasury, Sydney, www.treasury.nsw.gov.au/information-public-entities/business-cases.

NSW Treasury 2019a, *Asset Management Policy for the NSW Public Sector (TPP19-07)*, NSW Treasury, Sydney, www.treasury.nsw.gov.au/finance-resource/asset-management-policy.

NSW Treasury 2019b, *Recurrent Expenditure Assurance Framework (TPP19-03)*, NSW Treasury, Sydney, https://arp.nsw.gov.au/tpp19-03-recurrent-expenditure-assurance-framework.

NSW Treasury 2020a, *Internal Audit and Risk Management Policy for the General Government Sector (TPP20-08)*, NSW Treasury, Sydney.

NSW Treasury 2020b, *Treasury Risk Maturity Assessment Tool*, NSW Treasury, Sydney, www.treasury.nsw.gov.au/information-public-entities/governance-risk-and-assurance/treasury-risk-maturity-assessment-tool.

Pringle P 2011, AdaptME: Adaptation monitoring and evaluation, UKCIP, Oxford, UK.

Resilience NSW 2017, *Definitions*, Resilience NSW, www.emergency.nsw.gov.au/Pages/for-the-community/community-service-workers/resources/definitions.aspx.

Schaffer A, Muscatello DJ, Broome R and Corbett S 2012, Emergency department visits, ambulance calls, and mortality associated with an exceptional heat wave in Sydney, Australia 2011: a time-series analysis, *Environmental Health*, vol.11, p.3.

Senate Economic References Committee, Parliament of Australia, 2017, *Carbon risk: a burning issue*.

Sinay L and Carter RW 2020, Climate Change Adaptation Options for Coastal Communities and Local Governments, *Climate*, 2020, 8, 7.

Task Force on Climate-related Financial Disclosures (TCFD) 2017, *Recommendations of the Task Force on Climate-related Financial Disclosures*, Final Report, Task Force on Climate-related Financial Disclosures, www.fsb-tcfd.org/recommendations.

Tonmoy FN, Rissik D and Palutikof J 2019, A three-tier risk assessment process for climate change adaptation at a local scale, *Climatic Change*, vol.153, no.4, 10.1007/s10584-019-02367-z.

Transport for NSW 2016, *TfNSW Climate Risk Assessment Guidelines*, Transport for NSW, Sydney, www.transport.nsw.gov.au/sites/default/files/media/documents/2017/tfnsw-climate-risk-assessment-guideline-9tp-sd-081-1.pdf (PDF 1.6MB).

University of Cambridge 2013, *Climate change: action, trends and implications for business - the IPCC's Fifth Assessment Report, Working Group 1,* Cambridge Judge Business School with the Cambridge Programme for Sustainability Leadership and European Climate Foundation.

UK Department for Environment, Food & Rural Affairs (DEFRA) 2011, *Climate Resilient Infrastructure: Preparing for a Changing Climate*, www.gov.uk/government/collections/climate-change-guidance.