Climate Systems

National Environmental Science Program

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A Guide to adapt the World Heritage Climate Change Toolkit to other Protected Areas in Australia

This guide is adapted from the Australian Government's Climate change toolkit for World Heritage properties in Australia[1] (the toolkit). The toolkit was developed to support climate change vulnerability assessment and adaptation planning for World Heritage properties in Australia.

It provides a 4-step method to scoping an approach, identifying climate change impacts, considering vulnerability and risk, and planning for adaptation. This method is suitable for managers of other heritage places and protected areas.

This guide can assist managers of other protected areas with assessing climate risks, by using a similar approach.

Background to the toolkit development and testing

To help respond to climate change, the Australian Government asked CSIRO to update a climate risk report published in 2009. The updated climate vulnerability assessment was published in 2022 along with a new climate change toolkit for World Heritage site managers.

The toolkit includes:

- A detailed handbook. The handbook supports managers in understanding climate change and creating adaptation plans. It offers step-by-step guidance to help managers identify, rank, and plan for climate risks. It also includes real-life examples (case studies) to demonstrate practical applications.
- A workbook. It includes a quick reference guide and templates for each step. This can be used during workshops.

World Heritage managers and Traditional Owners and Custodians across Australia tested and improved the toolkit. It includes case studies from various sites with natural and cultural heritage values, where Traditional Owners and Custodians were involved in workshops, including:

- Kakadu National Park (also a Ramsar Wetland)
- Willandra Lakes Region and
- Budj Bim Cultural Landscape

The Butchulla people of K'gari also piloted the toolkit to create their own Indigenous-led climate adaptation plan for K'gari.

These case studies along with the 20 assessments in the 2022 report demonstrate how the toolkit can be used in various tenures, protected areas including National Parks, Indigenous Protected Areas, Ramsar wetlands as well as private landholdings.

[1] Melbourne-Thomas, J., Lin, B., Hopkins, M., Hill, R., Sheppard, M., Meyers, J., Thomas, L., Visschers, L., Dunlop, M., McNeair, B., Syme, L., Grant, C., Pedrocchi, N., Oakley, P., Stevens, A., Rose, D., Rose, E., Gould, J., Locke, J., Maybanks, L., 2022. Climate Change Toolkit for World Heritage Properties in Australia: Handbook and Workbook. Department of Climate Change, Energy, the Environment and Water, Canberra. Available at. https://www.dcceew.gov.au/parks-heritage/heritage/publications/climate-change-toolkit-world-properties.

How this guide adds value to the Climate Change Toolkit

This short guide can be used by managers of other heritage places and protected areas, to help them use the toolkit and to incorporate their site's key values and relevant climate data [2] for their region. The reader will need to access the full toolkit for more detailed guidance.

The approach in the toolkit is particularly relevant for managing protected areas in a rapidly changing climate. It includes templates and examples from a World Heritage context and guidance for considering other values such as other Matters of National Environmental Significance, Ramsar wetland ecological character, threatened and migratory species, state or local protections and social or community values.

The World Heritage toolkit refers to key attributes that express the Outstanding Universal Value (OUV) for a property. To apply the toolkit outside of World Heritage areas, managers of other heritage places and protected areas can replace references to OUV with 'heritage significance', 'ecological character' for Ramsar sites or 'significance' - whatever listings and attributes are protected and make the area significant, as well as other values.

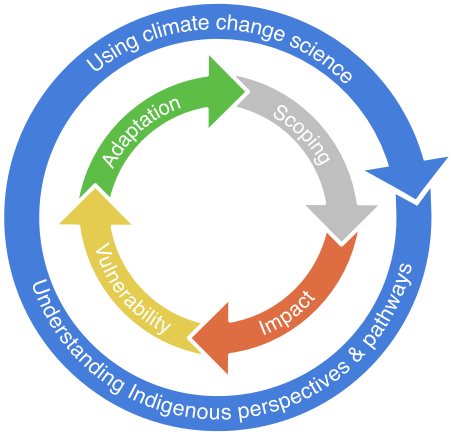
This guide focuses on protected areas and ecological communities more generally and their key ecological attributes and provides a protected area example in the text with accompanying tables on impact, vulnerability and possible future adaptation actions.

Getting started with the Assessment

The first tasks are to consider any relevant existing information and past or current engagement with stakeholders:

- Identify existing resources that can be drawn on (for example, Park Management Plans, Adaptation Plans, State of the Parks reports, research and monitoring reports).
- Assess understanding of climate change impacts on ecological attributes of the area.
- Assess understanding of natural, Indigenous, and historic heritage values, and cultural significance of the area.
- Ensure perspectives of Traditional Owners and Custodians are understood and integrated into management.
- Determine whether a vulnerability assessment has been undertaken and to what level.
- Review responses to recent changes and consider whether adaptation to future impacts has been addressed.
- Confirm that a broad stakeholder group has been engaged.
- Ensure engagement is culturally appropriate, including following cultural protocols for Traditional Owners and Custodians.

If this work has already been completed, it can be used during the assessment process.The toolkit provides a set of steps for identifying impacts, assessing vulnerability, and translating this assessment into climate change risk, outlined in Figure 1, which we follow in this guide.



The user follows an iterative or staged approach which is arranged around four modules to help address the complexities of climate change. The modules are summarised below. Refer to the toolkit guides for more detail if required.

Figure 1. Module breakdown showing core elements of using climate change science and understanding indigenous perspectives and pathways.

[2] Understanding data inputs for climate risk assessments

Module 1 – Scoping

Purpose: Identify what you need to know and who should be involved in developing an adaptation plan.

Steps:

1. Establish Project Team
   - Form the team
   - Determine project framing and scope

2. Identify Stakeholders and Experts
   - Advisory committee, First Nations, other stakeholders
   - Meet to:
     - » Define framing and scope (including geographic)
     - » Review existing management documents
     - » Clarify current management goals and establish a clear vision, goals and desired outcomes.

3. Compile Background and Context
   - Collect relevant information
   - Prepare a communication and engagement plan

4. Consider Risk Tolerance
   - Determine acceptable levels of loss or change
   - Example: Some local species extinctions may be acceptable, others not

Module 2 – Identifying climate change impacts (See Table 1 for Example)

Purpose: List key ecological attributes and other values, understand their sensitivity to climate change, and assess potential climate impacts.

Steps:

1. List Ecological Attributes and other values
   - Identify species, communities, habitats, other values to assess.
   - Define relationships (for example Ramsar site, listed ecological community, Indigenous significance etc).

2. Identify Relevant Climate Variables
   - Consider temperature, rainfall, humidity, sea level rise, fire weather.

3. Assess Sensitivities and Thresholds
   - Note known climate concerns and tolerance limits.
   - Highlight knowledge gaps for deeper stakeholder or expert consultation or further research.

4. Determine Potential Future Impacts
   - Use climate projections and modelling tools (for example Generalised dissimilarity modelling (GDM), Bioclimatic Ecosystem Resilience Index, Environmental niche modelling (ENM) – also known as species distribution modelling (SDM), Population demographics, climate velocity) or ecological information collected from the site.
   - Consider direct impacts (for example temperature, rainfall, sea level) and indirect impacts (for example drought, increased fire risk).
   - Identify where passive adaptation suffices versus where interventions are needed.
   - Use future climate scenarios (Shared Socio-economic Pathways (SSPs)) and Storylines to explore plausible futures.

5. Identify Knowledge Gaps
   - Highlight areas needing further research or stakeholder/expert input.

Module 3 – Vulnerability and Risk Assessment (See Tables 1 and 2 for Example)

This part of the guide provides a more granular risk rating suitable for ecological attributes. It can be used to supplement an assessment of all values in Module 3 of the toolkit.

Purpose: Assess ecological attributes' vulnerability to climate change, translate into risk, and prioritise for adaptation planning.

Steps:

1. Assess Ecological Change and changes to other values
   - Will the attribute decline or persist? Within current distribution or within refugia, for example?

2. Evaluate Management Effectiveness
   - Are current management actions (e.g. prescribed burns and managing the impact of pests) effective?
     - » Yes: This can reduce vulnerability by reducing sensitivity or increasing adaptive capacity.
     - » No: Vulnerability likely to be High/Extreme

3. Convert Vulnerability to Risk
   - Vulnerability of an ecological attribute to future climate change risk is determined through a combination of sensitivity and adaptive capacity.
   - Understanding the vulnerability of the ecological attribute can help to understand the possible consequences of an impact, and the risks.
   - Risk is the potential for (likelihood) and consequences of an impact, it can be managed through adaptation planning and management actions.
   - A modified risk matrix can also incorporate vulnerability for a more granular rating of risk (Figure 2).
   - Once ratings have been assigned for likelihood, vulnerability and consequence, an overall level of risk can be determined. The Risk Matrix used in this process inputs the likelihood (X), vulnerability (Y) and consequence (Z) levels (each ranked 1-5) to output an overall risk severity rating (1-13).
   - The risk severity rating is then broken down across five levels of risk which range from very low (dark green in figure 2) to extreme (red in Figure 2).
   - Consider interactions with ecosystem integrity, keystone species, cultural values, and ecosystem services
   - For example, if a risk such as Blackbox community decline on the Riverland Ramsar site arising from hazards e.g. reduced inundation frequency and rainfall and increasing groundwater salinity, has a vulnerability rating 'extreme', a consequence rating of 'catastrophic' because Blackbox is considered a keystone species for the Ramsar site, and a likelihood rating of 'almost certain', then from figure 2 the risk has an 'extreme (E13)' rating. Tables 1 and 2 show a more detailed example of this process for Blackbox at the Riverland Ramsar site.

4. Prioritise Risks
   - Rank risks using consensus or stakeholder input
   - Focus first on high-priority risks for adaptation actions

Likelihood (X)		Rare (1)					Unlikely (2)					Possible (3)					Likely (4)					Almost Certain (5)				
Vulnerability (Y)		V. Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V. Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V. Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V. Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V. Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)
Consequence (z)	Insignificant (1)	VL1	VL2	VL3	L4	L5	VL2	VL3	L4	L5	L6	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9
	Minor (2)	VL2	VL3	L4	L5	L6	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10
	Moderate (3)	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11
	Major (4)	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11	M8	H9	H10	H11	E12
	Catastrophic (5)	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11	M8	H9	H10	H11	E12	H9	H10	H11	E12	E13

Figure 2. Inclusion of vulnerability along with likelihood and exposure can provide a more granular risk rating (adapted from https://www.health.qld.gov.au/system-governance/strategic-direction/plans/climate-change/climate-change-strategy-and-planning).

Module 4 – Adaptation Planning (See Table 2 for Example)

The toolkit can be used to create an adaptation pathway to analyse actions that may be effective in the face of sustained change. Adaptation pathways analysis aims to explore possible future actions and the enabling conditions (new values, rules or knowledge) before they could be planned and implemented, if and when needed in the future. The pathways tool is designed to help users consider possible adaptation pathways and actions. It does not prescribe the likelihood of any pathway or actions taken.

Purpose: Design flexible, long-term strategies ("adaptation pathways") to address ecological vulnerability and climate risks.

Steps:

1. Identify New Actions
   - Brainstorm actions to reduce vulnerability and risk.
   - Focus on enhancing ecosystem resilience, for example:
     - » Support genetic diversity
     - » Reduce grazing pressure
     - » Protect climate refuges
     - » Increase connectivity
     - » Indigenous fire/land management
     - » Climate-ready restoration/revegetation
   - Include actions that may be needed in the future, even if not immediately feasible.
   - Adjust current management actions if already part of existing plans.
   - Document all the actions developed to reduce the vulnerability and/or risk for each ecological attribute

2. Determine Timing and Triggers
   - Identify current actions that remain effective.
   - Determine actions that need adjustment or replacement.
   - Develop future actions with clear objectives, monitoring, and evaluation.
   - Embed triggers and monitoring to guide when new actions should start.

3. Bundle and Sequence Actions
   - Develop a strategic plan (an adaptation pathway) to move from current actions through to new actions that will enable adaptation to the impacts of climate change as they arise.
   - Group together (or bundle) actions that are interdependent or complementary.
   - Once actions are bundled, identify when each action would need to be implemented.
   - Define triggers for when current risk controls are likely to become ineffective for example, sea-level rise reaches 50 cm, or heatwave conditions occur on more than 10 days a year.
   - Establish review points and update actions as conditions change. These should be documented in the adaptation plan.

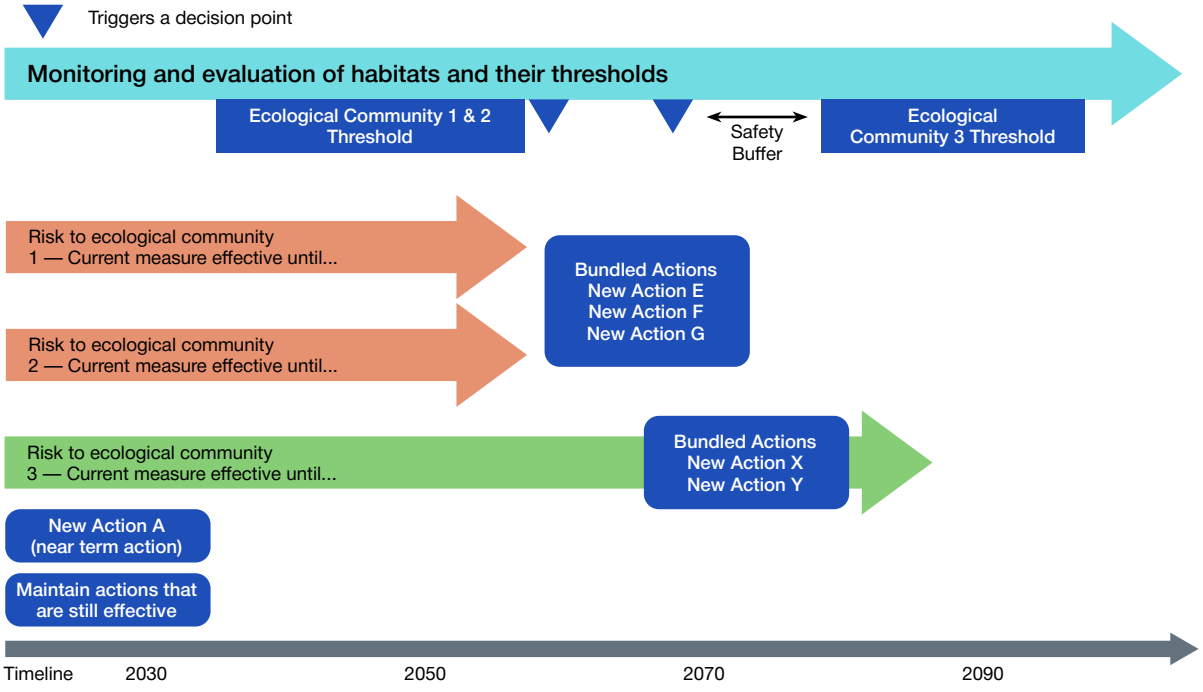


Figure 3. Adaptation pathways provide a framework for planning adaptation actions through time for the protected area. (Adapted from: Climate change toolkit for World Heritage properties in Australia: handbook for property managers p73)

4. Design Monitoring Strategy
    - Monitor ecological thresholds to guide triggers.
    - Ensure monitoring can inform decision-making when changes to risks are detected.

5. Implement and Evaluate Pathway
    - Develop strategy and implementation plan and seek endorsement.
    - Implement actions and monitor outcomes.
    - Evaluate:
        - » Individual treatments/projects
        - » Overall adaptation pathway to ensure effectiveness and flexibility
    - Use thresholds and triggers to adjust actions as needed.

Your organisation's monitoring and evaluation framework may be sufficient to evaluate the actions to address climate risk but will need to be augmented to allow for evaluation of the adaptation pathway.

Final thoughts

It is important to note that climate risk assessment and adaptation is intended to be an iterative and cyclical process revisited on a regular basis in the future. The protected area manager may decide to revisit a high-level assessment of the protected area every 3 to 5 years, or as part of regular reviews of management plans and operational plans.

This assessment should not be seen as a one-time process, rather something that is built into the strategic planning and decision-making of the protected area. How often these iterations occur and the level of detail involved, maybe different depending on the governance structure of the protected area, but a discussion will be required to determine how to include climate risk into management plans.

Glossary

Adaptive Capacity: Ability of a species or system to adjust to climate change and cope with impacts.

Adaptation Pathways: Sequenced management actions with triggers that guide when to shift to new actions as conditions change.

Attributes: Key ecological or heritage features that express the value of a place and help assess sensitivity and integrity.

Climate Adaptation: Actions taken to adjust to actual or expected climate risks.

Climate Risks: Potential impacts of climate change, including physical, transition, and liability risks.

Consequence Rating: How severe the impact would be if a climate hazard occurs.

Ecological Attribute: A key feature of a species, habitat, or community used to assess climate sensitivity.

Exposure: The degree to which an ecological attribute is subjected to climate hazards.

Hazard: A climate related event or trend that can cause harm.

Impact: The effect of climate hazards on ecological or cultural values.

Inundation Frequency: How often floodplain areas receive water; a key threshold for some species.

Keystone Species: A species with a critical ecological role.

Likelihood Rating: How probable a climate impact is.

Maladaptation: An action that reduces risk in one area but increases it elsewhere or later.

Management Effectiveness: How well current actions reduce vulnerability or risk.

Outstanding Universal Value (OUV): Exceptional natural or cultural significance recognised under the World Heritage Convention.

Passive Adaptation: Natural ecological adjustment without intervention.

Projected Impacts: Expected ecological changes based on climate projections and known sensitivities.

Resilience: The ability of a system to absorb change while maintaining function.

Risk: Combination of likelihood, vulnerability, and consequence.

Risk Matrix: Tool used to assign a risk severity rating.

Risk Treatments: Actions taken to manage climate risks.

Risk Tolerance: The level of change or loss considered acceptable.

Sensitivity: How strongly an ecological attribute is affected by climate variables.

Threshold: A point at which goals or outcomes can no longer be achieved without changing management.

Traditional Owners and Custodians: First Nations peoples with cultural authority and knowledge for Country.

Trigger / Decision Trigger: A monitored condition indicating when management intervention is required.

Vulnerability: A measure combining sensitivity and adaptive capacity.

Useful Links

- Climate change toolkit for World Heritage properties in Australia
- National Environmental Science Program Climate Systems Hub
- Adapt Land&Sea - A biodiversity adaptation knowledge and guidance platform by the National Environmental Science Program
- Navigating Climate Portals - Provides an index to different places to find climate information.
- AdaptNRM: Supports NRM groups with climate change adaptation tools and resources
- CoastAdapt: An information delivery and decision support framework.
- Understanding data inputs for climate risk assessments
- CSIRO Australia's National Science Agency MDB Ramsar wetland Climate Change Vulnerability and Adaptation Pathways: Early Insights Report (2025)
- Dunlop M and N Grigg (2019) Methodology for analysing the vulnerability to climate change of Ramsar wetlands sites. CSIRO.
- National Climate Change Adaptation Research Facility (NCCARF)
- Moran, C. and Boulter, S. (2018). Biodiversity and Ecosystems Climate Adaptation Plan. Brisbane, Australia.
- Climate-Ready Conservation – Enabling Adaptation Pathways
- Reef Adapt
- Habitat Restoration Planning Guide for Natural Resource Managers
- AdaptLog: An online, searchable repository of conservation interventions for climate adaptation.
- The Australian Adaptation Database: Helping to understand Australia's progress toward climate change adaptation.

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Department of Climate Change, Energy, the Environment and Water

Table 1: Impact and vulnerability assessment example for Black Box woodland - Riverland Ramsar Site [3]

Ecological communities	Sensitivities - What physical variables is this community sensitive to?	Thresholds - Are there key thresholds for physical variables that determine viability/persistence of the community?	Climate change data - What data on climate change projections are available to identify impacts on communities?	Projected impacts - What do available climate data tell you about impacts on values, given thresholds and sensitivities?	Knowledge gaps - Are there key knowledge gaps with respect to sensitivities and/or threshold for this community?	Management - what management actions are currently available and what is their effectiveness?	Vulnerability - On this basis, how would you rate the vulnerability of this to climate change?
Black Box *(Eucalyptus largiflorens)* woodland Riverland Ramsar	Reduced inundation frequency Reduced rainfall.	Inundation frequency >5- 7 years depending on floodplain elevation. If inundation threshold not met, then minimal change in the regional precipitation regime is required. For instance, greater than average annual precipitation volumes, similar seasonal distribution (i.e. greater cool-season versus warm-season rainfall), and comparable frequency, intensity and duration of precipitation events.	Projections for average rainfall change to a certain defined time frame (e.g 2030/2050/2070/2090)	Habitat decline with reduced inundation and rainfall (2050-2090).	Are some provenances of Blackbox more tolerant of drying than others?	Current managed inundation - pumping Controlling pest animals and plants Regulation of total grazing pressure	Extreme
Black Box *(Eucalyptus largiflorens)* woodland Riverland Ramsar	Increasing groundwater salinity	Groundwater EC >32,000 uS/cm (within 1 metre of the water table).	Projections for average rainfall change to a certain defined time frame (e.g. 2030/2050/2070/2090)	Habitat decline with increasing groundwater salinity (2050-2090).	Are some provenances of Blackbox more tolerant of salinity than others?	Monitoring groundwater salinity. Controlling pest animals and plants Regulation of total grazing pressure	Extreme

[3] Adapted from: MDB Ramsar wetland Climate Change Vulnerability and Adaptation Pathways: Early Insights Report

Table 2: Adaptation planning example for Black Box woodland - Riverland Ramsar Site

Ecological community	Projected impacts - What do available climate data tell you about impacts on values, given thresholds and sensitivities?	Management - What management actions are currently available and what is their effectiveness?	Vulnerability - On this basis, how would you rate the vulnerability of this community?	Risk - Risk rating (for vulnerability expressed as risk)	Priority rating of risk	New management actions - What new management actions might be needed to address risks?	Plan - When will new actions need to be implemented?
Black Box *(Eucalyptus largiflorens)* woodland Riverland Ramsar	Habitat decline with reduced inundation and rainfall (2050-2090). Habitat decline with increasing groundwater salinity (2050-2090).	Current managed inundation - pumping Controlling pest animals and plants Regulation of total grazing pressure Monitoring groundwater salinity.	Extreme	Extreme	High priority – need to plan for decline of habitat due to reduced inundation, alterations to precipitation regime, and increasing groundwater salinity.	Grazing management and exclusion. Install additional pumps to target discrete, localised patches of higher elevation Black Box floodplain woodlands. Indigenous land management	Continue current management actions and plan for additional pumping, grazing management and exclusion. Consult traditional owners on management options to enhance biodiversity.