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Adapting to the Impacts of Climate Change

Guidelines for Goulburn Murray Climate Alliance Councils

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A Marsden Jacob Report

Prepared for Goulburn Murray Climate Alliance
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Contents

Acronyms

AAD	Average annual damages
AAP	Adaptation action plan
BAU	Business as usual
BoM	Australian Bureau of Meteorology
CBA	Cost-benefit analysis
CEA	Cost effectiveness assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
MCA	Multi criteria analysis
NPV	Net Present Value
RCP	Representative concentration pathway
RDM	Robust decision-making
ROA	Real options analysis

Lessons

Drawing on the case studies undertaken with participating GMCA Councils, following are some useful overarching lessons for Councils that are considering undertaking an assessment of adaptation actions.

- Assessing climate change adaptation actions is an emerging area, likely to require an iterative process and significant 'learning by doing'.
- For this reason, and due to the inherent complexities of some of the issues being examined, assessing climate change adaptation actions can be a resource intensive exercise for the organisation, requiring significant inputs in terms of staff time, data and modelling (technical, financial). In some cases, external support may need to be sought.
- A climate change vulnerability assessment or risk assessment is a useful way of identifying priority issues that are more likely to warrant the resources and costs that could be involved.
- Even where Council has primary or even sole responsibility for an asset or service, it should still seek to engage other organisations or community members who have a stake in the outcome of the options assessment process.
- Where multiple objectives are relevant to an adaptation option(s), these should be prioritised for the purpose of designing the adaptation option(s).
- More than one climate change scenario should generally be considered when assessing climate-related hazards.
- Early in the assessment process it is important to understand and clearly define the no-adaptation option or 'Base Case' (sometimes also referred to as 'business-as-usual') against which adaptation options will be assessed.
- Comprehensive data of a range of types and from a range of sources will be needed to complete a robust assessment of adaptation options. Some of this data may already be generated through internal processes. Other data may need to be accessed through external sources and/or through technical modelling.
- Expert elicitation or judgement is a useful and valid process for generating some information requirements where empirical data is not available or may not be feasible to generate through other processes such as modelling.
- Due to the nature of the issues being assessed, uncertainties with climate change projections, and often long future timeframes over which costs are being assessed, results of an analysis of adaptation options (CBA or other) are likely to be subject to uncertainties.
- Nevertheless, lack of certainty need not preclude results of the analysis being used to assist a council in its planning processes. All decisions are made in the context of uncertainty.
- Use of techniques in the assessment process can help to quantify the uncertainties and/or guide decision making in the face of those uncertainties.

Introduction

The latest IPCC report states unequivocally that human influence has warmed the atmosphere, ocean and land, with widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere having occurred[1]. Local communities are bearing the brunt of climate change impacts in Australia, with studies indicating that climate change has made recent natural disasters such as the 2019-20 'black summer' bushfires and the 2022 floods more likely[2]. This highlights the need for Councils to factor the impacts of climate change into their decision making.

Why assess climate change adaptation options?

The area covered by the 17 Goulburn-Murray Climate Alliance (GMCA) member organisations is a large and diverse region of Victoria that has state significance for food security, biodiversity and tourism. In recent years, climate hazards and extreme weather events including drought, bushfires, floods and storms have severely impacted the region. Moreover, climate change projections indicate that the region will continue to become hotter, with associated increases in the frequency or severity of extreme events. It is important that Councils can make informed decisions on the value of investing in certain adaptation actions. Informed adaptation decision making will also help Councils engage with local communities on:

- the risks associated with climate change;
- the complexities and uncertainties involved in assessing those risks; and
- the adaptation options available for responding to those risks.

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[1] Intergovernmental Panel on Climate Change, 2021. *Climate Change 2021: The Physical Science Basis, Summary for Policy Makers,* Cambridge University Press, Cambridge, UK.

[2] CSIRO and BoM 2022. *State of the Climate 2022*. Australian Government, Canberra.

This document

The GMCA is keen to support member Councils to build climate change resilience and better plan for their futures. To that end, GMCA commissioned an asset vulnerability assessment (AVA) to provide a better understanding of how climate change and associated extreme weather events will impact key local government infrastructure of this participants in A Resilient Public Estate such as roads, buildings, open spaces and drainage assets. This document provides guidance to participating Councils of the GMCA on climate change adaptation decision making. Special focus in the guidelines is given to assessing adaptation actions through methods such as cost-benefit analysis (Box 1). The guidelines draw in part on the AVA as well as two adaptation case studies that were completed as part of the AVA study.

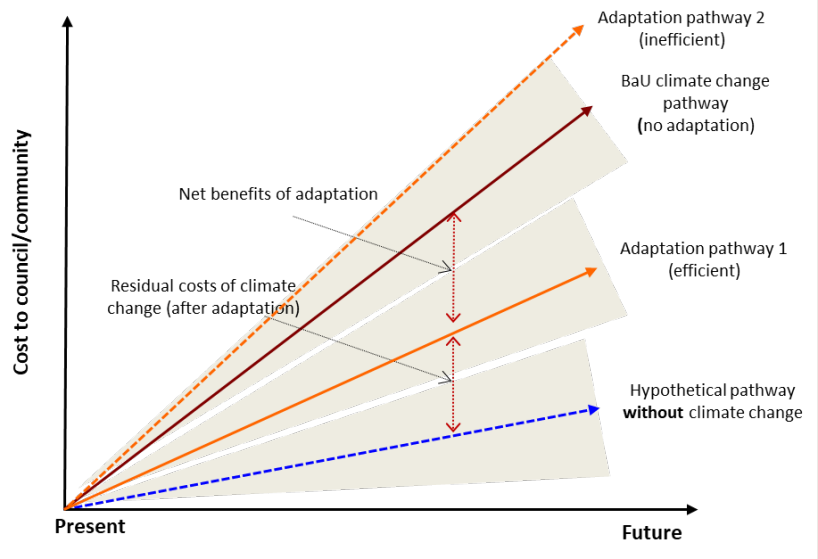
Box 1: Climate change adaptation

Climate change adaptation can be defined as *actions taken in response to actual or anticipated climate change impacts that lead to a reduction in risks or a realisation of benefits*.[3] Adaptation takes place in the context of interacting non-climatic (economic, social and ecological) changes and can range from short-term coping to intentional, planned response. The primary focus here is on intentional, planned adaptation.

Planned adaptation involves two main steps: first, making a decision on an action or actions to avoid or limit damage from climate change (or take advantage of opportunities); and second, putting actions into effect.

Adaptation actions need to balance the potential costs of actions with the likely impact of climate-related hazards and risks on economic, social and environmental values, considering potential trade-offs between those values. Due to uncertainties or a lack of data it may not always be possible to take a fully quantitative approach to assessing adaptation actions.

Figure 1: Benefits, costs and uncertainties of adaptation actions



[3] This is an abridged version of a definition provided by the IPCC.

Overview

A sound decision-making process provides the foundation for effective climate change adaptation. Figure 2 identifies the key steps involved in 'good practice' decision-making. These stages cover the entire decision-making process including:

Structuring the issue

- Step 1 – Identify priority climate impacts and define problem
- Step 2 - Clarify roles & responsibilities
- Step 3 - Establish the decision-making objectives
- Step 4 - Assess hazards

Analysis of adaptation options

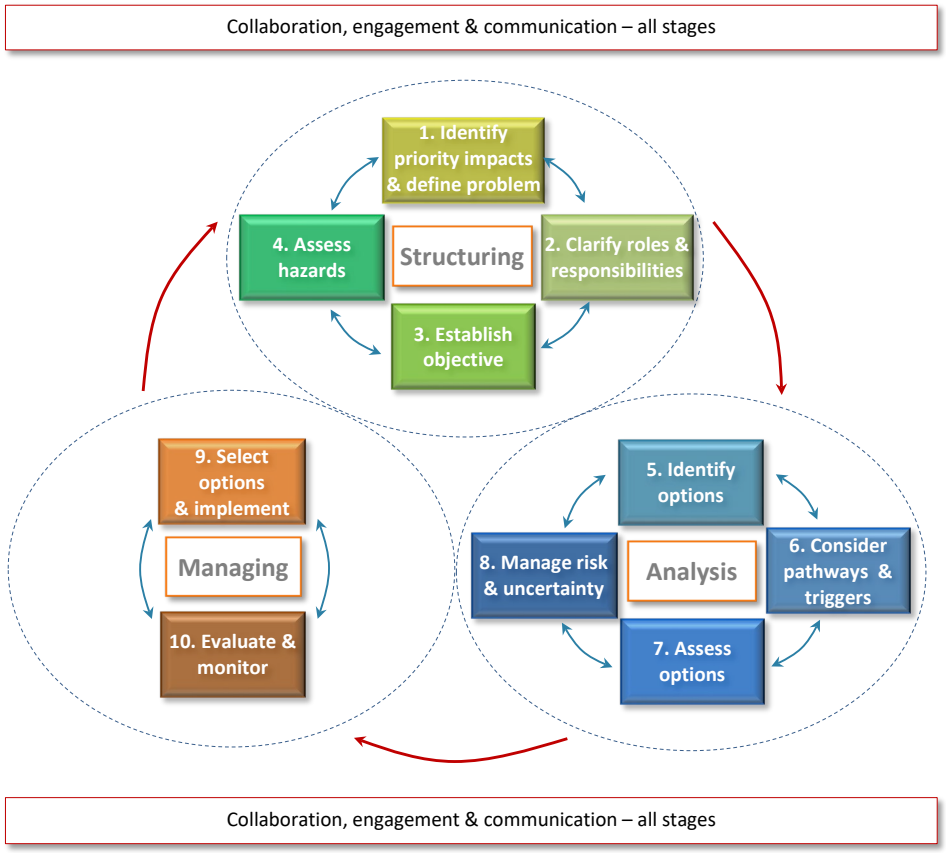
- Step 5 - Identify options and pathways
- Step 6 - Establish thresholds and triggers
- Step 7 - Assess options
- Step 8 - Manage risk and uncertainty in the assessment

Managing adaptation response

- Step 9 - Select and implement preferred options
- Step 10 - Monitor and evaluate outcomes.

Each of these steps are discussed in the guidelines, with particular attention being given to the analysis steps.

Figure 2: Stages and steps in the adaptation decision-making process



Box 2: Adaptation decision making principles

1. **Objective focused**: Decisions should be made with the purpose of meeting clear, measurable and prioritised objectives.
2. **Efficient use of resources**: Decision-makers should seek to achieve objectives cost effectively.
3. **Risk averse**: As a minimum, pursue strategies that will avoid catastrophic outcomes.
4. **Avoid maladaptation**: Avoid adaptation strategies that adversely impact or increase the vulnerability of other systems, sectors or social groups.
5. **Adaptive management**: Encourage adaptation strategies that are flexible, reversible and can achieve multiple objectives and synergies.
6. **Relevant**: Use data, methods, criteria and assumptions appropriate to the nature of the decision and that meet the expectations and requirements of stakeholders.
7. **Completeness**: Consider all potential implications of decisions - direct and indirect costs and winners and losers.
8. **Consistent**: Use data, methods, criteria and assumptions that allow for meaningful and valid comparisons with other decisions of a similar nature.
9. **Consultative**: Meaningful consultation and engagement should be undertaken to ensure that decisions reflect stakeholder and community values and preferences. The level of engagement should reflect the significance of the decision.
10. **Collaborative**: Decisions should be collaborative, involving close cooperation with other relevant decision-makers.
11. **Transparent**: Provide clear and sufficient information for reviewers to assess the credibility and reliability of the decision.
12. **Compliant**: Ensure decisions comply with relevant national and State legislation, policies and guidelines.

Structuring

Step 1. Identify priority climate change impacts and define problem
Step 2. Clarify roles & responsibilities
Step 3. Establish objectives
Step 4. Assess hazards

Lessons from case studies

- A climate change vulnerability assessment or risk assessment is a useful way of identifying priority issues that are more likely to warrant allocation of significant resources to identifying and assessing adaptation options.
- Even where Council has primary or even sole responsibility for an asset or service, it should still seek to engage other organisations or community members who have a stake in the outcome of the options assessment process.
- Where multiple objectives are relevant to an adaptation option(s), these should be prioritised for the purpose of designing the adaptation option(s).
- More than one climate change scenario should generally be considered when assessing climate-related hazards.

1. Identify priority climate change impacts and define problem

Key points

- Prioritising climate change impacts will aid an efficient assessment process.
- A vulnerability assessment (when considering impacts to individual assets or groups of assets), or a risk assessment (when considering the broader impacts to services and operations) are suitable methods for identifying and prioritising impacts.
- It is important that a climate change vulnerability or risk assessment is integrated within broader strategic risk assessment and planning frameworks and are updated periodically.
- Once priority issues or risks have been identified, for each priority issue the problem should be clearly defined. Essentially, this involves asking the questions: "What is the nature of the problem we are seeking to address?"; and "Why does Council need to address the problem?".

Identify priority climate change impacts and issues

For Councils, assessing adaptation options has the potential to be a resource intensive exercise. Before undertaking any analysis therefore, Councils should undertake a process of identifying and prioritising climate change impacts on their assets and operations. A range of possible approaches are available for this task, but we suggest that one or both of two approaches can be used: (1) a **vulnerability assessment**, especially when considering impacts to council assets; and/or (2) a high-level **risk assessment**, especially when the broader impacts of climate change on the community and associated council services are being considered.

We note that an asset vulnerability assessment (AVA) has already been undertaken for GMCA Councils. Details of these AVAs, including methods and outputs, are provided elsewhere (see Spatial Vision 2024).

If a risk assessment is undertaken it should be completed in accordance with the International Standard for Risk Management, ISO 31000, and the International Standard for Adaptation to Climate Change, ISO 14091. However, elements need to be introduced into the risk assessment process that reflect the unique elements of climate change as a driver of risk (see Box 1). These include:

- the use of climate change scenarios to help identify and understand the hazards and associated impacts and risks posed by climate change; and
- assessing risks at different points in time.

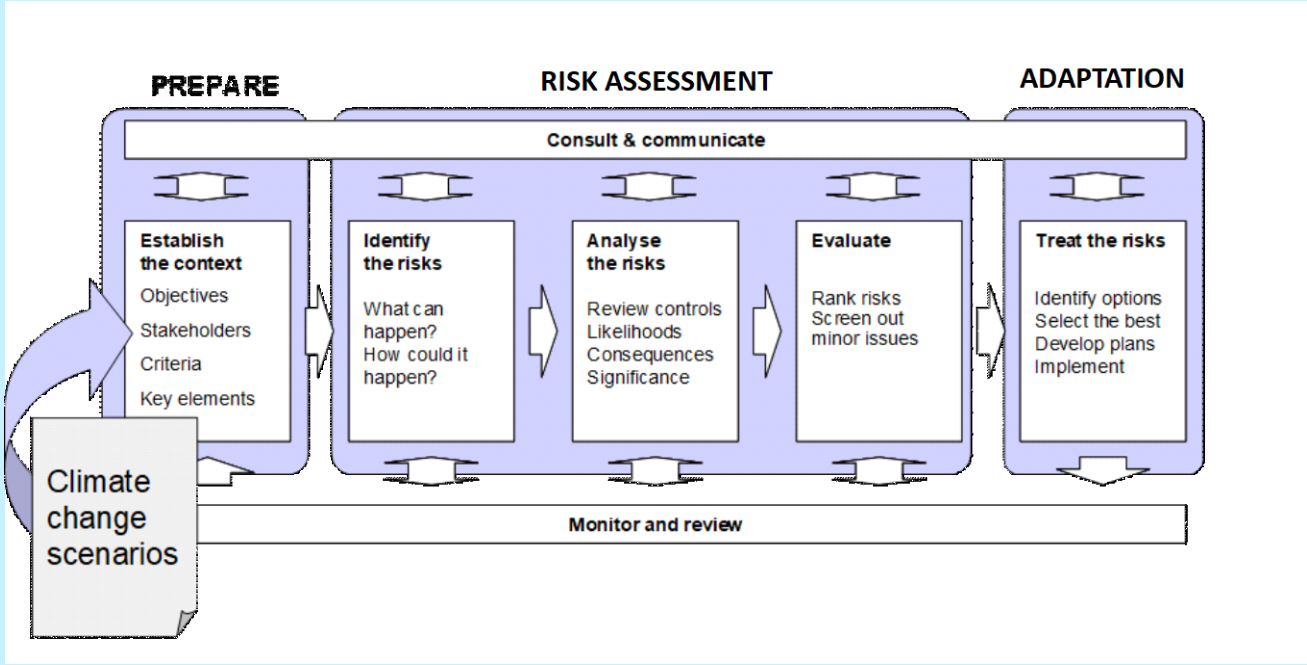
Outputs of the AVA and risk assessment will be used as a basis for selecting priority issues, that require further analysis. It is important that outputs of the AVA and climate change risk assessment are integrated within broader

organisational risk assessment and planning frameworks and are updated periodically.

Box 3: Climate change risk assessment

Risk is defined as the likelihood and consequence of an outcome (in this case an impact driven by a climate related hazard). An initial assessment will typically be undertaken as a qualitative/ semi quantitative process that identifies, analyses and ranks and prioritises risks quickly (Figure 3). Risk treatment (identification and assessment of adaptation options and implementation of preferred option) will then be undertaken for priority risks. In some cases, additional, more detailed quantitative assessment of risks and hazards may be required to determine what form of treatment (adaptation) to adopt. That quantitative analysis could include hazard assessment (Step 4).

Figure 3: Climate change risk assessment process



Define the problem

Prior to undertaking an assessment of adaptation options, for each priority issue it is important to clearly define the nature of the issue or problem. Essentially, this involves asking the questions: “What is the nature of the problem we are seeking to address?”; and “Why does Council need to address the problem?”. The answer or answers to these questions will be important for framing other aspects of the decision-making process discussed in later sections.

Problem definition will typically involve describing in a reasonable level of detail:

- the nature of climate-related risk or impact of concern;
- the Council asset(s) or service(s) that will be affected;
- how they will be affected;
- how climate change will increase the risk;
- implications of the risk for the local community.

2. Clarify roles and responsibilities

Key points

- Early in the decision-making process it is important that Councils and other decision makers clarify roles and responsibilities for addressing the priority issue or problem.
- If Council has primary responsibility for the issue, then it should ensure that there is appropriate internal resourcing to address the issue.

Early in the decision-making process it is important that Councils and other decisions makers clarify roles and responsibilities for addressing the priority issue or problem. This entails deciding on whether primary responsibility for the issue belongs to council, to other agencies, or whether responsibilities can and should be shared. The process of clarifying roles and responsibilities is important for various reasons:

- It will give greater surety to the assessment process.
- It will help to resolve issues around resourcing (of the process) and cost sharing (of preferred options).
- If responsibilities are shared (as they frequently are), clarifying roles and responsibilities will open the way for collaborative decision-making, adding credibility to the process and outcomes.

On the other hand, lack of clarity can and already does present a significant barrier to effective decision-making on adaptation.

If Council determines that it has primary responsibility for the issue, there are a number of subsequent steps that it should seek to follow:

- Establish the constraints and conditions imposed on its role by legislation and planning frameworks;
- Allocate roles and responsibilities internally.
- Ensure that there are adequate resources and support for the relevant areas to fulfil their responsibilities; and
- Engage with relevant stakeholders.

In many instances, responsibilities for adaptation actions will be shared between Council and other agencies. In these cases, it is important that decision-makers map and agree on responsibilities for each aspect of the issue, identify constraints and conditions on roles & responsibilities and, as far as practical establish a collaborative decision-making process.

In some cases, it will be clear that an agency other than Council has primary responsibility for the adaptation action. In these situations, Council should essentially seek to stay informed of the decision-making process being undertaken by the primary agency, paying attention to its impact on council and council processes and plans.

3. Establish objectives

Key points

- It is important that Councils have a clear understanding of the objective or objectives against which options will be assessed before undertaking the assessment.
- If there are multiple objectives these should be aligned, with competing objectives being prioritised.

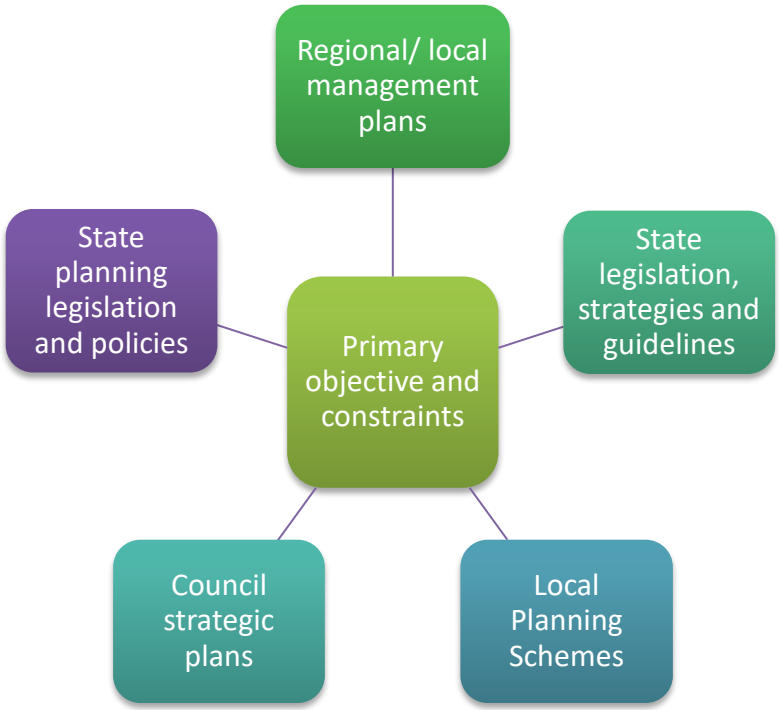
It is important that Councils have a clear understanding of the intergovernmental policy objective or objectives against which options will be assessed before undertaking the assessment. Clearly defined objectives will be critical to identifying the 'decision rule' for selecting the preferred option or set of options (see Step 9). The objective is also important for assisting with the process of identifying, filtering and assessing options (Steps 5-8).

To clarify its objectives, Council should seek to:

- identify its policy objectives, as set out in relevant Council strategies and plans;
- identify relevant Federal and State government objectives, especially those established through legislation;
- align and, if necessary prioritise competing objectives; and
- set a primary objective and constraints or conditions (if any) that should apply to the primary objective.

(see Figure 4)

Figure 4: Alignment of objectives



4. Assess climate changes, hazards and associated costs

Key points

- Analysis of adaptation options should be underpinned by a sound understanding of climate changes and the relevant hazards costs associated with the changes.
- There are three main types of information required: climate change data; hazard assessment information; and information relating to adaptation options.
- Compiling this information can be resource intensive.

Analysis of adaptation options should be underpinned by a sound understanding of climate changes projected for the region, the hazards with those changes, as well as the costs associated with the hazards. Compiling this information is likely to be the most resource intensive aspect of the analysis. Unless ''off the shelf'' data is readily at hand, a significant amount of time will be required to generate this information.

Table 1 provides an overview of the types and potential sources of information that will need to be compiled or generated for an analysis. Data generation falls into three main types:

- climate data, including current climate and climate projections;
- hazard or vulnerability analysis to assess the magnitude and frequency of climate impacts; and
- information on adaptation options including their effectiveness and capital, operating and other costs associated with different options.

Relevant climate data and projections are readily available now through the CSIRO and BoM. Additionally, data compiled for the asset vulnerability assessment (AVA) includes some data that is useful for hazard assessments including climate related exposure and activity data. Depending on the type and level of detail of the analysis however (see section 7), this data may need to be reworked (e.g. involving sorting, reformatting) or further specialised modelling may be needed to assess the magnitude and frequency of climate hazards and their associated impacts.

Further discussion of climate and hazard assessment information requirements is provided in sections below. Further discussion of information requirements relating to adaptation options is provided in section 7.

Table 1. Types and potential sources of information likely to be required for analysis of adaptation options

Information/ analysis type	Description	Examples	Potential source(s)	Comment
Climate data - current climate	Recent historic data on relevant climate hazards and variables.	Average temperatures, maximum/minimum temperatures, frequency of extreme temperatures, average rainfall, extreme rainfall, time in drought, bushfire weather	Bureau of Meteorology (BoM)	Data for BoM weather sites relevant to a number of climate variables are available free online. More specialised data can be purchased from BoM
Climate change projections	Projected changes to climate hazards/ variables with climate change	Average temperatures, maximum/minimum temperatures, frequency of extreme temperatures, average rainfall, extreme rainfall, time in drought, bushfire weather	AVA, Victoria's Climate Futures, DELWP 2016	Further discussion below
Exposure data	Assets and services exposed to climate hazards	Council infrastructure and other assets	AVA, Council records & analysis	See AVA reports and databases
Activity data	Activities impacted by climate hazards	Council services, especially those linked to Council assets	AVA, Council records & analysis	Input to impact assessment
Hazard assessment	Frequency and/or intensity of climate hazards impacting Council assets and services	Changes in extreme rainfall on flood return intervals, bushfire behaviour and impacts, impacts of extreme temperatures and heatwaves on community health	Council records & analysis, CMA analysis, ARR 2019, State government studies, academic studies	Will often require specialist technical analysis/ modelling or expert elicitation. Further discussion below
Impacts of adaptation options	Effectiveness of adaptation options in reducing climate hazards	Effectiveness of new/ upgraded infrastructure in reducing flood/ bushfire risk. Effectiveness of		Could be reactive or strategic expenditure, short or long run costs. See section 7 for further discussion.
Costs of adaptation options	Data on costs relevant to adaptation options	Maintenance costs, cost of capital replacement/ upgrade, ongoing cost of new/ upgraded service	Council records & analysis	

Climate change scenarios

Because there are uncertainties associated with future climate changes, assessment of adaptation actions will, in most cases, need to be undertaken reflecting potential different climate futures, referred to as climate change scenarios. Typically, we suggest the use of at least two climate change scenarios for any assessment based on medium and high emissions scenarios. These scenarios can draw on local and regional scale climate change projections developed for Victoria by the CSIRO through Victoria's Future Climate Tool. Regional summaries are also available for 10 Natural Resource Management (NRM) regions in Victoria, with the Goulburn, Ovens Murray and part of the Central Highlands being relevant to the areas covered by GMCA Councils (see https://www.climatechange.vic.gov.au/victorias-changing-climate). The regional summaries provide climate change medium and high emission projections for:

- Numerous climate variables including - Temperature, Maximum Temperature, Minimum Temperature, Mean rainfall, Extreme rainfall (1-in-20 year daily maximum), Solar radiation, Mean wind-speed, Strong wind (99th percentile), Relative humidity, Evapotranspiration, Evaporation, Time in drought, Sea surface temperature (mean).
- Three time periods – 2020-2039 (2030), 2040-2059 (2050) and 2080-2099 (2090).

Linear interpolation can generally be used to estimate changes to the climate variables for years between the time periods provided. For purposes of sensitivity analysis however (see Step 5), it is also reasonable to introduce a scenario that applies step changes to the relevant climate variables.

Although projections are now provided for an extensive range of climate hazards/variables, in some instances these will still not be available for the climate change impact being assessed, at least not in the exact form required. Three options are available to councils in this situation:

- If data is provided for a climate variable/ hazard that is similar, but not identical to the hazard being assessed (e.g. data is available for extreme 24 hour rainfall, but the hazard of interest is 72 hour rainfall), consideration could be given to whether the available data can be adapted for use in the assessment. CSIRO should be consulted on the validity of this approach before embarking on it[4].
- Many technical guidelines now provide information on how to incorporate climate change information into hazard assessment. For example, the Australian Rainfall and Runoff (ARR) Guidelines (Ball et al. 2019) provide climate change information relating to extreme rainfall and flooding.
- It is possible that projections are available for the hazard in question but, for various reasons, have not been included in the published material. Once again, CSIRO will need to be consulted on whether this is the case.

An approach could be made to CSIRO or other climate modellers to undertake purpose specific modelling to produce projections for the relevant climate hazard. Councils will need to consider whether the time and expense involved in doing this can be justified.

[4] Refer https://www.csiro.au/en/Contact

Hazard assessment

In many (but not all cases) a hazard assessment will be required to provide the information for a detailed quantitative analysis of adaptation options. Hazard assessments will seek to quantify the likelihood (or probability) of climate related hazards under different climate change scenarios (such as floods, bushfires and extreme heat) on the land, waterways, ecosystems, settlements, infrastructure and communities exposed to the hazards. They may also assess the underlying environmental and social conditions that can provide an understanding of the sensitivity of systems to the hazards and, by extension, the consequences of the hazards.

When undertaking a hazard assessment, important considerations that Councils and other decision-makers will need to address are:

- Hazard assessment planning and design including:
  - the underlying premise for and scale of the assessment;
  - the types of hazards and risks to be assessed and how they will be assessed; and
  - parameters to be used in the assessment.
  -
- Review processes, including sensitivity analysis and expert review.
- The need to assess the hazard (likelihood and/or consequence) under different climate change scenarios.
- Whether the assessment will often need to be supported with specialist technical modelling or, if that is not feasible, expert elicitation.
- Whether the assessment involves short term, random hazards or long term, ongoing hazards. For example:
  - If the impacts involve short term, random events (e.g. floods, bushfires, heatwaves), the technical modelling or elicitation process will be on understanding the average recurrence intervals (ARIs) of hazards of different scales at different time periods in the future (e.g. 2030, 2050, 2070).
  - Where the focus is on the impacts of long term reduced rainfall and runoff on the viability of local industries, analysis might be needed to assess rainfall thresholds at which an industry is no longer viable and the likely timing of the threshold being met under different climate scenarios.

Analysis of adaptation options

Step 5. Identify options and pathways
Step 6. Consider triggers
Step 7. Assess options
Step 8. Deal with risk and uncertainty

Lessons from case studies

- Early in the assessment process it is important to understand and clearly define the no-adaptation option or 'Base Case' (sometimes also referred to as 'business-as-usual') against which adaptation options will be assessed.
- Comprehensive data of a range of types and from a range of sources will be needed to complete a robust assessment of adaptation options. Some of this data may already be generated through internal processes. Other data may need to be accessed through external sources and/or through technical modelling.
- Expert elicitation or judgement is a useful and valid process for generating some information requirements where empirical data is not available or may not be feasible to generate through other processes such as modelling.
- Due to the nature of the issues being assessed, uncertainties with climate change projections, and often long future timeframes over which costs are being assessed, results of an analysis of adaptation options (through cost-benefit analysis or other assessment process) are likely to be subject to uncertainties.
- Nevertheless, lack of certainty need not preclude results of the analysis being used to assist a council in its planning processes. All decisions are made in the context of uncertainty.
- Use of techniques in the assessment process can help to quantify the uncertainties and/or guide decision making in the face of those uncertainties.

5. Identify options

Key points

- Councils should engage in a process of systematically identifying adaptation options prior to undertaking a detailed analysis of options.
- Consideration of as broad range of options will be useful in the early stages of option identification and analysis.
- Once adaptation options have been identified, it may be necessary to undertake a process to derive a shortlist of options that warrant detailed analysis.
- Multi-criteria analysis (MCA) is a useful tool to apply to the shortlisting process.

Councils and other decision-makers may already be familiar with the range of options available to them to assist with adapting to climate change identified. This awareness may derive from a sound understanding of the issue at hand (Step 1) or from the hazard assessment undertaken at Step 4. Nevertheless, it is important that Councils engage in a process of systematically identifying adaptation options prior to undertaking a detailed analysis of options. If a significant number of options (or variations of options) are identified (e.g. > 3 or 4), then a shortlisting process could be useful to reduce the list down to a manageable set of options for analysis.

Types of adaptation options

Options relating to established land uses, assets and infrastructure essentially fall into three general strategies:

- 'Protect' – defensive structures aimed at protecting public and private infrastructure or natural assets from a hazard.
- 'Accommodate' – redesign or other changes to reduce sensitivity of assets or people to the hazard.
- 'Retreat' – move or enable the asset or people to retreat to an area less exposed to the hazard.

Options relating to new developments also fall into three general strategies:

- 'Avoid' – refuse new developments or land uses in areas exposed to a hazard.

- 'Adapt' – permit developments or land uses but with conditions of consent that reduce exposure or sensitivity of people and assets to the hazard.
- 'Accept' – permit developments under established conditions of consent.

There are a variety of specific options available to decision-makers under these general strategies (Table 2). Consideration of a broad range of these options will be useful, at least in the early stages of option identification and analysis.

This will provide the best basis for selecting the most suitable option or suite of options. The selection of options, as well as the timing and scale of those options, will be influenced by many factors including the type of hazard and level of risk for assets and services associated with the hazard, improved information about climate changes and associated hazards, societal perspectives and appetite for risk, and new technologies.

This highlights the importance of a flexible and adaptive approach and the benefits of considering pathways and triggers when developing options (see Step 6).

Table 2. Types of adaptation options

Category	Description and examples
Structural works, design	Prevent effects through engineering solutions and changed practices: • Scale up infrastructure protection measures. • Change design of infrastructure to increase resilience. • Environmental protection or remediation works.
Statutory planning/ regulatory	Prevent or mitigate effects through revised regulations and planning frameworks: • Amend local planning schemes. • Improve building design standards. • Prevent new infrastructure from being built in high risk areas.
Strategies, plans and internal procedures	Revise strategies, plans and practices at an organisational level: • Revise environmental management planning. • Improve emergency management planning. • Revise strategic plans. • Lengthen strategic planning horizons (from say 5-10 years to 20-30 years).
Research and knowledge building	Research to improve understanding of relationship between climate change and risk: • Improve knowledge of relationship between changes in climate and performance of infrastructure. • Improve understanding of relationship between changes to extreme events and critical outcomes. • Research efforts to improve understanding of adaptation options.
Education and awareness raising	• Educate and inform community about climate change risks and adaptation measures. • Educate community about approaches to and benefits of changing behaviour.
Spread or displace risk	Insurance and diversification strategies: • Use of insurance products to off-lay the risk. • Risks shared between Council and other agencies. • Geographical diversification (e.g. location of assets).

Shortlisting options

Once adaptation options have been identified, it may be necessary to undertake a process to derive a shortlist of options that warrant detailed analysis (Step 7). This process is particularly useful if many and varied adaptation options have been identified. A detailed assessment of options, such as a cost benefit analysis, can be a time-consuming and costly process. Thus, it makes sense to remove options that are unlikely to be feasible before the detailed analysis is undertaken, so that the assessment focuses on a small number (e.g. 2-4) of realistic options.

Shortlisting of options can be effectively undertaken by applying multi-criteria analysis (MCA). A well-structured MCA can reveal if any of the options have serious flaws, preventing them from being feasible or viable in practice. A set of qualitative decision criteria are used to establish a "Go / No-Go" decision for each option as the basis for determining the short-list. Each option is qualitatively reviewed against the set of decision criteria and simple ratings (e.g. positive, negative, unknown) assigned per criterion. Box 3 lists a range of possible decision criteria that can be used for this process. Decision-makers can develop their own criteria however, with criteria selection being linked to the nature of the issue, local circumstances and the objective identified in Stage 3.

Box 2: Possible decision criteria for the shortlisting process

Effective: Is the proposed action likely to meet the primary objective? Will it result in perverse outcomes in the longer term (e.g. maladaptation)?

Proportional: Are the costs of the action likely to be proportional to the expected benefits? Note, as the shortlisting process is a qualitative exercise, estimates of scale only rather than precise figures are required.

Compliant: Does the option comply with existing legislation, policies and guidelines?

No-regrets / low regrets: Is the action something that should be undertaken anyway (i.e. in the absence of climate change)?

Acceptable: Is the option culturally, socially, environmentally or politically acceptable by the majority or could there be a major backlash? Note, separate criteria might be required each of these aspects. For example, the wider community may not be agreeable to an option, despite it being environmentally acceptable.

Flexible: Can the option be adjusted? Does it allow for incremental implementation? Does it enable alternative/additional options to be implemented in the future?

6. Pathways and triggers

Key points

- Once adaptation options have been identified, but before the assessment is undertaken, it is useful to consider whether different options can be sequenced over time and possible triggers for implementing the option or options.

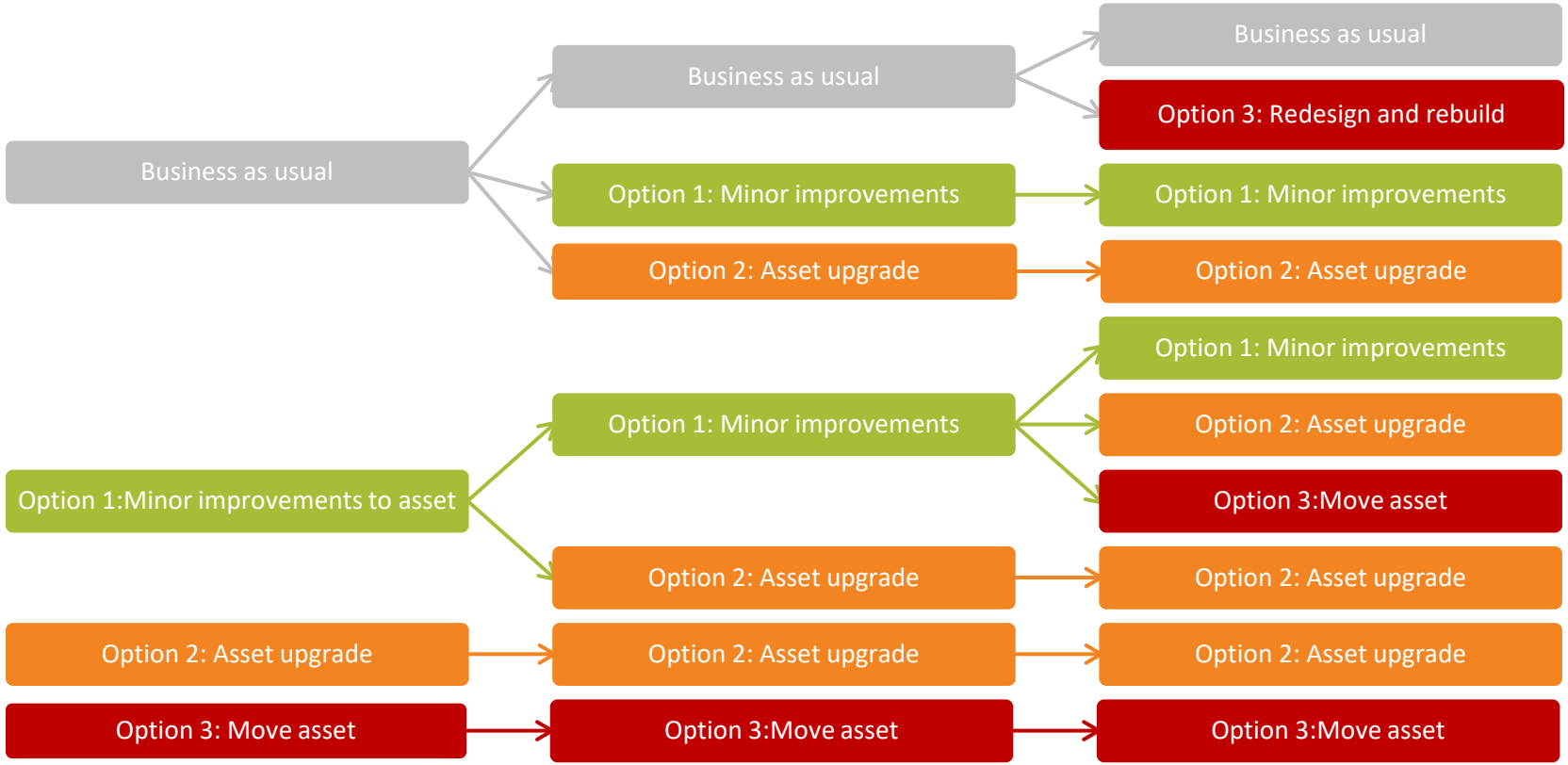
Once options have been identified, but prior to assessing them, it will often be useful to consider:

- Whether different options are mutually exclusive (i.e. either Option 1 **or** Option 2 **or** Option 3) or are complementary and therefore have the potential to be sequenced over time.
- If options can be sequenced – what are the potential triggers for implementing an option (physical/environmental, social, policy, planning) and given those triggers what is the likely timing of options (see Table 3)?
- Possible triggers include:
  - The end of an asset's useful life
  - Following a hazard and associated impacts on an asset
  - Changes in planning regulations or design rules
  - The passage of time, with new or improved information on climate changes and associated exposure of an asset to the hazard.
- The process of mapping adaptation pathways can help to clarify whether to focus on short term options in the assessment process or whether to also assess longer term options (important if implementing a short-term option precludes a longer-term option being implemented) (see Figure 5).

Table 3. Example of sequencing of adaptation options for a council asset exposed to a hazard (e.g. flood)

Short term (e.g. <10 years)	Medium term (e.g. 10-30 years)	Long term (e.g. >30 years)
Business as usual. No changes to asset. Replaced with like-for-like at end of useful life (e.g. 30 years)	• No change; **or** • Implement Option 1, Option 2 or Option 3	• No change; **or** • Implement or continue with Option 2 or 3
Option 1. Minor improvements to asset and operations to achieve some increase in resilience if impacted by hazard	• Option 2 or Option 3	• Continue with Option 2 or 3
Option 2. Redesign and rebuild asset to greatly increase resilience if impacted by hazard	• Continue with Option 2	• Continue with Option 2 or implement Option 3
Option 3. Move asset away from hazard	• Continue with Option 3	• Continue with Option 3

Figure 5: Example of alternative adaptation pathways (using options presented in Table 2)



7. Assess options

Key points

- The process of assessing adaptation options is at the core of the adaptation decision making process.
- The assessment process itself involves numerous steps including: identifying and shortlisting preferred adaptation options; determining the scope of the assessment; selecting the preferred assessment method; and costing climate-related impacts and valuing the benefits of adaptation.

Overview

Options assessment is at the core of the decision-making process, with many of the steps discussed in the preceding sections being geared towards ensuring that assessment of options is correctly focused. This section introduces and discusses methods that can be employed to assess adaptation options and explores the factors that may influence Council's preference for one assessment method over another.

Types of benefits and costs

Prior to the selecting the options assessment method it is useful to identify the potential costs and benefits associated with the adaptation options and will need to be quantified or otherwise considered in the assessment. This is a particularly useful step where the issue is macro in scale and multi-dimensional, involving a range of options that are likely to be implemented over different timeframes. Identification of costs and benefits will assist with two subsequent steps:

- it will assist with selecting the assessment method, since the choice of method will often come down to consideration of whether or not the various options/ bundles/ pathways will deliver substantially different benefits (see Box 5); and
- it will assist in preparing for and framing the actual assessment.

Box 4 outlines the types of costs and benefits that may need to be considered in an assessment and explains the difference between an economic assessment, which considers costs and benefits to the economy, community and the environment as well as to Council, and a financial assessment which only concerns financial costs and benefits to Council.

Box 4. Scope of assessment - economic v financial analysis

Economic assessments seek to measure a full range of costs and benefits associated with the change being explored (generally referred to as total economic value - TEV). These include not just the direct financial costs (expenditure) and benefits (revenue), but also indirect costs and benefits such as related reductions in business activity for a firm affected by the change.

Additionally, a number of 'non-market' costs and benefits may be associated with a change, such as impacts on human health (death or injury), or on environmental assets that are valued by communities (see non-market valuation for more details). Non-market costs and benefits are inherently difficult to quantify but need to be understood in any analysis and described if not estimated.

A key consideration for a council when deciding on an assessment method is whether it is concerned only with the direct financial impacts (expenditure and revenue) of alternative adaptation actions on its operations or whether it is also concerned with the broader economy-wide, social and environmental implications of its decision. If it is the former, then a routine financial cost-benefit analysis (CBA) that only considers expenditure and revenue impacts will be appropriate. If the broader 'economic' values are important to the assessment, then selecting the preferred assessment method will require more thought (see Box 5).

Figure 6: Costs and benefits to consider when assessing adaptation options

	Direct	Indirect

Tangible	- Capital expenditure
	- Operating and maintenance expenditure
	- Revenue loss/gain
	- Corporate
	  - Changes in management overheads
	  - Insurance
		- Emergency response costs incurred by other government agencies
		- Ratepayer financial costs resulting from loss of asset/service
		- Loss of productivity resulting from loss of asset/service

Intangible	- Death, injury, stress (to employees, contractors) - Loss of service to ratepayers (if service levels cannot be maintained)	- Health and safety (community) - Inconvenience and stress (community) - Ecological impacts

Financial Analysis	Economic Analysis			
		Total Economic Value		

Valuing environmental and social benefits

If a decision is made to undertake an economic analysis, then non-market (intangible) social and environmental costs and benefits will need to be valued or in some other way reflected in the analysis. Because these intangibles are not valued through markets, different techniques can be applied to estimating the value of the intangibles. They include:

- Preventative expenditure: an asset (e.g. a natural asset such as a local wetland, reserve or park) is valued at the cost that would be incurred to prevent significant damage to it.
- Replacement cost: the asset is valued at the cost that would be required to replace it or (more likely with a natural asset) restore it should it be lost or damaged.
- Travel cost method: recreational use of natural areas or parklands is valued by assessing the costs of travel to those areas including time, vehicle costs and other costs.
- Hedonic pricing: the positive impact of environmental or aesthetic attributes on house prices is assessed.
- Choice modelling: a survey method in which respondents are asked to evaluate and choose between different sets of attributes including non-market attributes that aren't valued in markets (e.g. a clean waterway or an ecologically significant local reserve) and other attributes that are valued in the market.

Because these techniques can be time consuming and expensive a short cut method known as 'benefit-transfer' can be used to infer values based on the results of one or more other studies. Care needs to be taken in using benefit-transfer however, ensuring that the context of the studies from which values are being inferred are similar to the local context of the issues that Council is examining.

Cost-benefit analysis and other assessment methods

There is a range of techniques available to undertake the options assessment. The applicability of each will depend on the circumstances and context of the decision being made. These methods vary in their level of complexity, strengths and weaknesses and focus on quantitative versus qualitative issues. There are no hard and fast rules for which method should be applied to which situation. Therefore, judgement is required in the selection of an appropriate method. Box 5 provides an indication however, of some simple rules that can be applied to selecting a preferred approach.

Cost-benefit analysis (CBA)

CBA provides a rigorous and defendable framework for the comparison of alternative projects or options, or for assessing if one project is likely to beneficial to Council or the community overall. It is especially useful when benefits and costs are easily quantified and data is readily available. When data is not readily available or significant non-market benefits are difficult to quantify, CBA becomes more challenging. In summary, the strengths of CBA are that it:

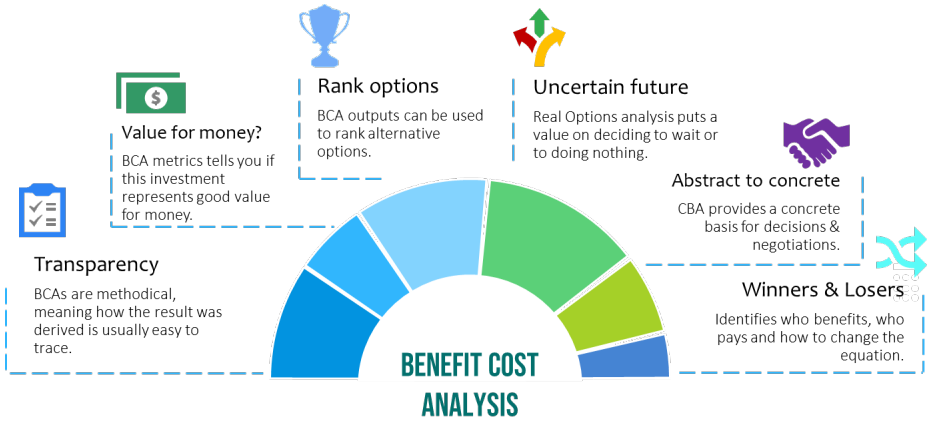
- is robust and defendable;
- considers the gains and losses to all members of society;
- allows comparisons of alternatives with different timeframes by discounting;
- values alternative options in terms of a single familiar unit of measurement; and
- incorporates non-market values using established methods (e.g. travel cost method, contingent valuation, choice modelling).

The weaknesses, or limitations, of CBA are:

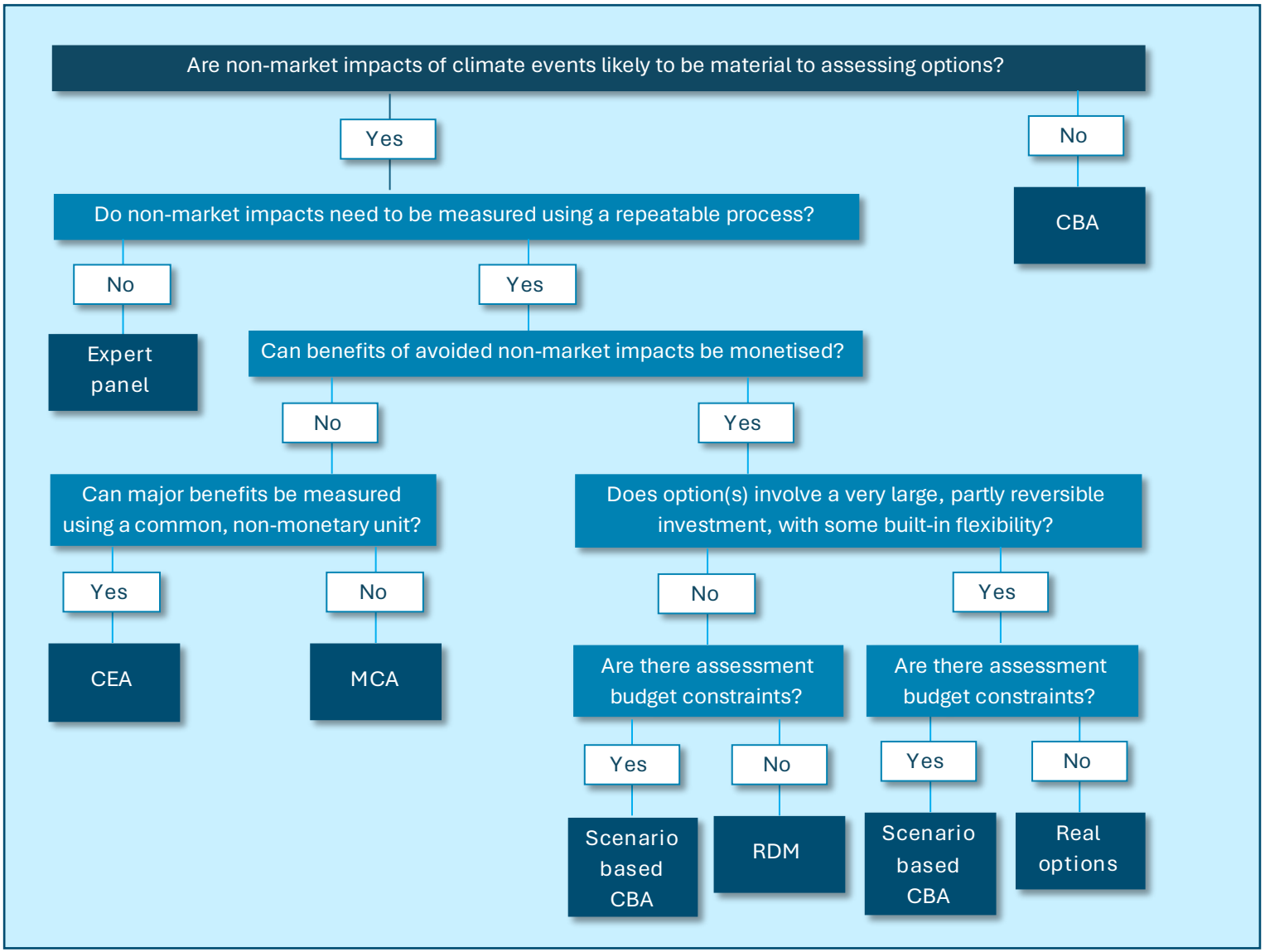
- ascribing a benefit or cost may be very difficult for some attributes and people's estimation of them may vary considerably;
- CBAs of more complicated options may require advanced technical economic skills; and
- non-market valuation can be very expensive and time consuming.

An important aspect of CBA is the use of discounting of future benefits and costs. As discussed in Box 6, this can be a contested issue.

Figure 7: Advantages of CBA



Box 5. Selecting the preferred assessment method



Cost effectiveness analysis (CEA)

CEA is a useful method to assist decisions for which values for key non-market benefits are lacking and a budget cannot be provided to fill this gap. It is especially useful for decisions in which the outcome is predetermined (e.g. protecting a highly valued asset from a climate hazard), and alternative options are available for achieving that predetermined outcome. It is also useful if there is a key benefit that can't be readily valued monetary terms but can be quantified in some other way (e.g. tonnes of pollutant reduced, kilolitres of water saved, hectares of land or kilometres of road protected). While not as complex as a full CBA, it operates under the same economic principles. Because CEA makes no attempt to value the benefits of adaptation options (it assumes that all options will achieve an equal level or at least type of benefit), unlike CBA it cannot be used to measure the inherent economic worth of different adaptation options.

Multi-criteria analysis (MCA)

Multi-criteria analysis (MCA) is a decision-making framework that allows for several criteria to be concurrently used in one analysis. MCA is useful for decisions in which some critical benefits are difficult to quantify, especially in dollar terms, and for which expert opinion can be trusted to inform the decision. MCA allows for these benefits to be introduced as rankings, ratings or other non-monetised inputs. Unlike the economic principles underpinning CBA and CEA frameworks, MCA accepts the validity of measuring the relative merits of competing options using different measurement methods (dollars, rankings, scales). Expert opinion can be used in lieu of quantification in dollar terms – for example, environmental value of areas can be ranked by experts by comparing their merits. These different measurement approaches are then combined using weightings reflecting the importance of each element measured. The result is typically a score that can be used to compare options. Thus, MCA presents as an alternative to the strict economic framework of CBA or CEA.

When rigorously undertaken, MCA has the strength of being able to incorporate unquantifiable elements within a consistent and defendable framework, if assumptions are explicitly stated. The main weaknesses of MCA relate to the transparency involved in reaching its outcomes (relating to its choice of weightings), and its lack of a rigorous and repeatable decision rule on whether a project produces net benefits. When compared to CBA, it may not be recognised by funding bodies if used in a business case.

In some circumstances, MCA can be a good complement to CBA. As discussed in section 5, MCA can be particularly useful for shortlisting options prior to undertaking a CBA.

Robust decision making (RDM)

Robust Decision Making (RDM) seeks to identify adaptation options which perform well over a wide range of future scenarios. RDM is particularly useful where there is a high level of uncertainty, and where probabilistic information is low or absent. Typically, it will entail undertaking CBA under numerous different scenarios (climate change and/or other) and

determining which option performs best under the widest range of scenarios.

Real options (RO)

In a CBA, options are often evaluated on the basis of expected cash-flows (or benefit and cost streams). However, there may be quite a lot of uncertainty surrounding these benefit and cost items and the central case is just one of a number of possible and plausible outcomes. Typically, when there is a high degree of uncertainty it makes financial and strategic sense to adopt strategies like 'wait-and-see', staged investments, retention of flexibility in how assets and investments are used or the ability to cost effectively reverse investment decisions when more information comes to light. All other things being equal, a strategy with this flexibility is better than one without. Real Options (RO) analysis is a way to understand and quantify the value of flexibility. It is essentially an add-on to CBA.

RO analysis refers to the ability to change the type, scale or use of investments after an initial investment decision, project, or action has commenced. An RO approach can be applied where projects have these 'embedded options'. Conversely an RO approach would not yield significantly different results to a standard CBA in a situation where the initial investment is 'sunk', that is, the investment is 'locked-in', cannot be cost effectively reversed and cannot be used in any other way than what was intended when the initial investment was made.

Embedded options come in a few different forms, including but not limited to the option to:

- expand, or scale up investment or capacity when information reinforcing the case for the initial investment comes to light;
- abandon, or cost effectively discard or scale back investment or capacity when information that weakens the case for the initial investment comes to light;
- wait, or time investments in response to additional information; and
- alter production, which essentially means the ability to use the asset or investment for more than one purpose and selecting the appropriate asset use (or 'production') in response to additional information.

Thus, RO can be used when both of the following conditions are met:

- It is apparent that the business case, project or investment decision has these embedded options and these options have been identified and understood; and
- It could make a material difference to the evaluation or specifically, that the value of these options is likely to be significant enough that it could change whether or not the project goes ahead.

For example, in land use planning, the decision to preserve a floodplain as an environmental asset or as farmland may be reversed as and when the effects of climate change are better understood.

As well as needing to meet certain, strict conditions the other disadvantage of RO is that it is more complex conceptually and in application than a straight CBA and therefore is more resource intensive.

Non-discretionary and qualitative assessments

Some types of decisions do not lend themselves to any of the assessment methods discussed above, either because:

- councils have very limited discretion in terms of the options available to them, since compliance with the legislative or policy requirement is essentially the only consideration; or
- adaptation actions are too small to warrant a detailed and rigorous assessment process.

In either of these situations, a common sense approach underpinned by best practice policy principles is likely to be the most practical way forward. A review of relevant guidelines on policy development suggests that adaptation decisions should align with a range of 'good practice' principles when it is not feasible to use any the options assessment described earlier (see for example COAG 2007). Key principles include:

- Administrative simplicity. The option should not be too administratively complex. Reporting arrangements should be kept as simple as possible and the compliance burden should be kept to a minimum. Administrative complexity should be proportional to the extent of the problem being addressed.
- Effectiveness. The decision should be focused on the problem at hand and achieve its intended objective/s with minimal side-effects or unintended outcomes.
- Equity. Like situated individuals or entities should be treated equally by the decision.
- Stakeholder acceptability. The decision should be acceptable to a broad cross-section of the community.
- Transparency. The decision-making process and outcomes of the process should be open, transparent and credible to those affected.
- Consistency. The process should deliver similar outcomes when dealing with similar situations across a range of locations and communities.

Box 6. Net present value and discounting

Net present value (NPV) is the value of discounted future benefits less discounted future costs. It is the standard framework used for comparing benefits and costs over time in CBA and CEA, whether for a financial or an economic analysis. Two reasons for using this approach are:

- Individuals and businesses place a "time preference" on the value of money'; that is they prefer receive money now than in the future or to pay costs in the future than now.
- Costs and benefits are often "lumpy" from year to year (e.g. the impacts of climate change are likely to continue to occur over many years but could vary significantly from year to year). Therefore, it is best to present costs and benefits over a significant period of time, rather than for a single year.

A 7% discount rate is typically recommended by Australian and state government treasury departments for assessing investments that are commercial in nature. There is increasing debate about discounting and the appropriate rate to use however, especially with intergenerational issues such as climate change. Many economists think that an appropriate discount rate when considering the intergenerational impacts of climate change (e.g. greater than say 30 years) is a very low discount rate about 2% (Figure 8).

In line with State government guidelines, we have applied a 'social discount' rate of 4% in the case studies, since they generally entail non-commercial investment decisions. We have also undertaken sensitivity analysis applying 2% discount rate reflecting the intergenerational nature of climate change.

Figure 8: Impact of discounting on future costs or benefits

Discount rate	Present value of $1 million in -	
	50 years	100 years
1%	$602,019	$366,051
4%	$135,301	$19,039
7%	$31,727	$1,077

Costing climate-related impacts and valuing the benefits of adaptation

The steps and methods applied to assessing the costs of climate-related impacts will vary with each assessment. However, there are some common elements or steps to assessing costs where a climate hazard (or multiple climate hazards) is the known driver of an impact and associated costs. These are outlined below.

Step 1. Define the Base Case

In CBA and CEA the costs and benefits of climate change to Council should always be estimated relative to a Base Case, with Base Case typically defined as a business-as-usual (BAU) operating future. It is important to note that BAU is not a fixed or unchanging operating future. Rather, BAU assumes that Council will not undertake activities in the future, that are specific to the relevant climate change impact, beyond those that have already been implemented or are planned. Other aspects of Council's operations and local community will be changing however, and those changes should be factored into BAU settings (e.g. population growth and associated impacts). The costs of climate change to an asset or service can then be assessed by comparing the costs of these activities under a BAU scenario (which is a realistic assessment of what the future will look like in the absence of adaptation actions), with the costs under different climate change scenarios.

Step 2. Determine the severity and probability of hazards

Determine the severity and likelihood/probability (e.g. return period) of hazards (floods, storms, bushfires, heatwaves) under two of more climate change scenarios. This will typically require technical modelling and/or expert elicitation (see section 4 for further discussion).

Step 3. Establish link between probability and costs of hazard

Establish a relationship between the probability of a climate hazard, the level of impact and the costs of those impacts. For extreme, random events the relationship between cost and scale of the hazard typically displays a log linear relationship. Thus, provided information is available from at least a small number of discrete events (e.g. records of past events) it is possible to generate a continuous function of the relationship between cost and likelihood of a hazard of a certain scale. This relationship is often presented as an Average Annual Damage (AAD) curve (see Figure 8). AADs are calculated as the sum of the cost of each scale of hazard, weighted by the probability of that scale of hazard occurring in a given year.

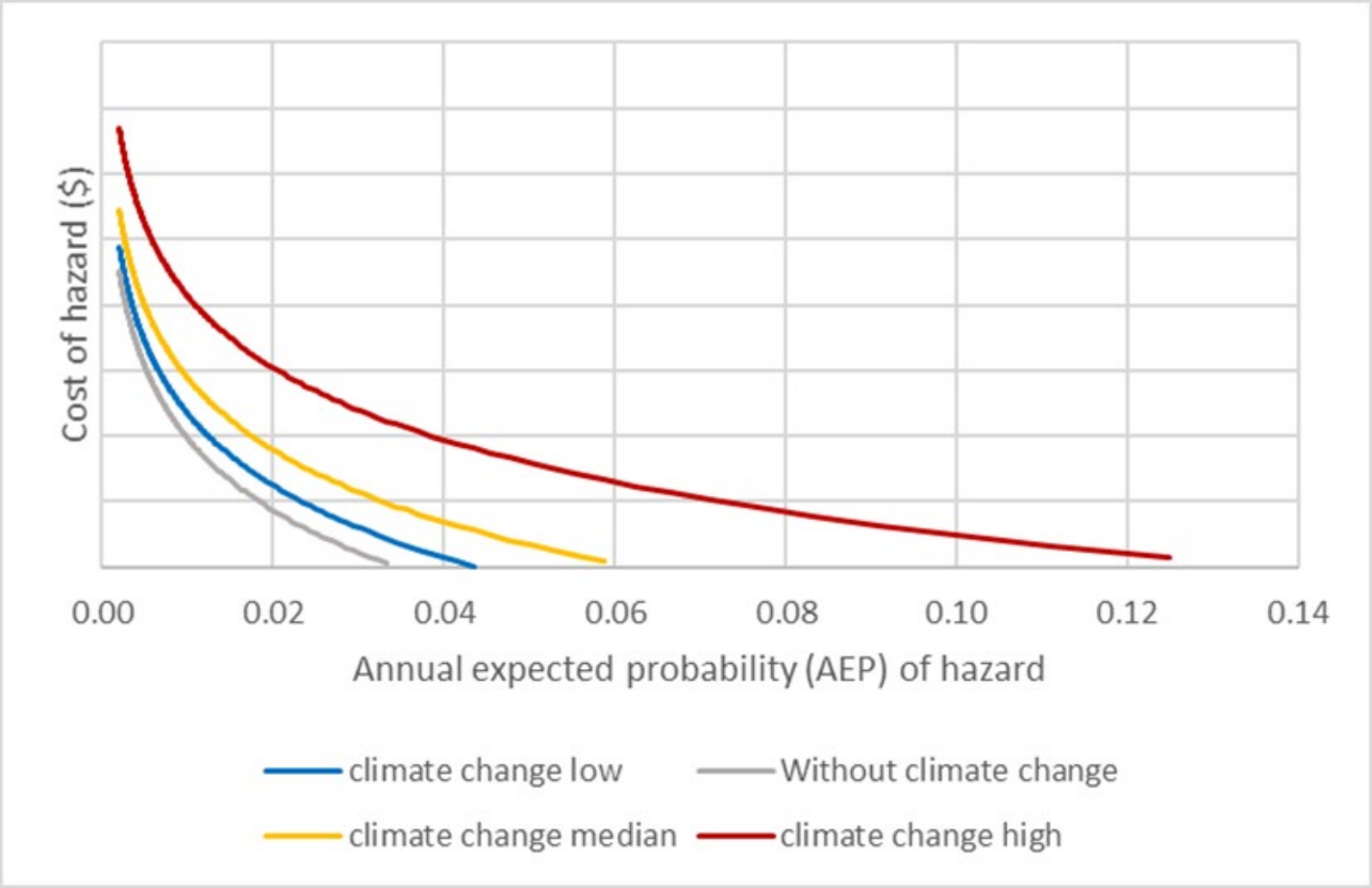
Step 4. Estimate the expected value of the costs over time

Assess the expected value of the costs of the hazard over the total period of the analysis (e.g. 30 years) considering changes in the probability of the hazard occurring over this period due to climate change.

Step 5. Assess costs of hazard after adaptation

Assess the costs of the hazard assuming the adaptation action or actions have been undertaken. This may require Steps 1 to 4 being repeated.

Figure 9: Illustrative example of annual average damage (AAD) curves for different climate scenarios



8. Managing uncertainties in the assessment of options

Key points

- Assessing the costs of climate change often involves significant uncertainties
- There are a range of techniques for managing these uncertainties in an analysis including scenario analysis, sensitivity analysis and statistical techniques such as Monte Carlo simulation.

Although all decisions involve uncertainties, assessing the costs of climate change often involves significant some uncertainties. Uncertainties stem from:

- Climate related hazards which are, by their nature, random events (e.g. extreme rainfall, droughts, wildfires). Based on empirical evidence, we can apply probabilities to these events occurring in any given year (e.g. ARIs - average recurrence intervals). However, we cannot know with any certainty when they will occur or how often.
- Chronic impacts of climate change. The magnitude of long-term changes to climate averages and the impacts the changes will have are uncertain (e.g. reduced average rainfall on run-off).
- Climate change adds to the uncertainty because the projections themselves are also uncertain.
- Where impacts are the result of multiple climate hazards, uncertainties are compounded.
- Some impacts involving costs to Councils are the consequence of multiple drivers, climate- and non-climate. Sometimes it is not clear how important the climate drivers are compared to the non-climate drivers.
- Finally, the cost of a particular impact is often also uncertain.

A range of techniques are available for managing these uncertainties when assessing adaptation options. These are outlined in Table 4, with further discussion of some techniques provided below.

Scenario analysis

A scenario analysis is particularly useful when it is quite difficult (or impractical) to put bounds around the possible values of the uncertain variable. Instead, a scenario analysis relies on the user being able to construct plausible states of the world, normally factoring in how all of the important uncertain variables in the analysis could change. The use of different climate change scenarios in the assessment is the most likely situation where scenario analysis is used.

Sensitivity analysis

It is often useful to understand how results change when an uncertain variable in the analysis changes. It is most useful to apply a sensitivity

analysis when the bounds for values of the uncertain variable can be estimated. To provide an example, if the effect of rainfall intensity on the maintenance costs of roads needs to be estimated, reasonable minimum and maximum return periods for intense rainfall events and associated costs can be estimated and applied in the analysis.

Sensitivity analyses generally answer questions phrased as 'What-ifs'. Additionally, it is also apparent that these bounds represent 'worst case' and 'best case'.

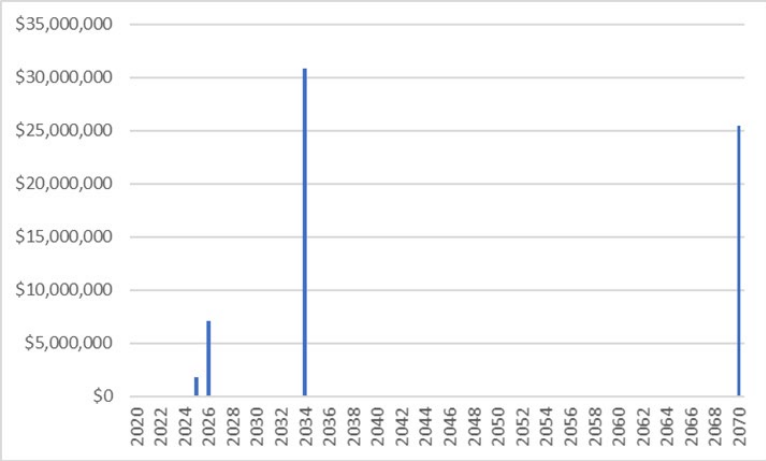
A sensitivity analysis can be applied with varying degrees of complexity. In its simplest form the question a sensitivity analysis answers would end with 'holding all other factors constant'. That is, how does the result change if you change just one of the uncertain variables?

Monte Carlo simulation

Monte Carlo simulation is a statistical technique used to understand the impact of risk and uncertainty in financial, project management, cost, and other forecasting models. It involves repeated random sampling drawing on parameters specified for one or more input variables used in the calculation of value. When calculating the expected cost of climate change associated with a hazard, for example, if we can specify the mean and standard deviation of the AADs associated with that hazard we can generate a frequency distribution of expected costs based on a large number of random samples. Taking a step back in the assessment process, it is also feasible to apply Monte Carlo simulation to generate probability distributions of climate hazards under climate change compared to BAU, based on projected changes to means (see Figure 9).

Figure 10: Illustrative example of outputs from a Monte Carlo simulation

Low climate change scenario



High climate change scenario

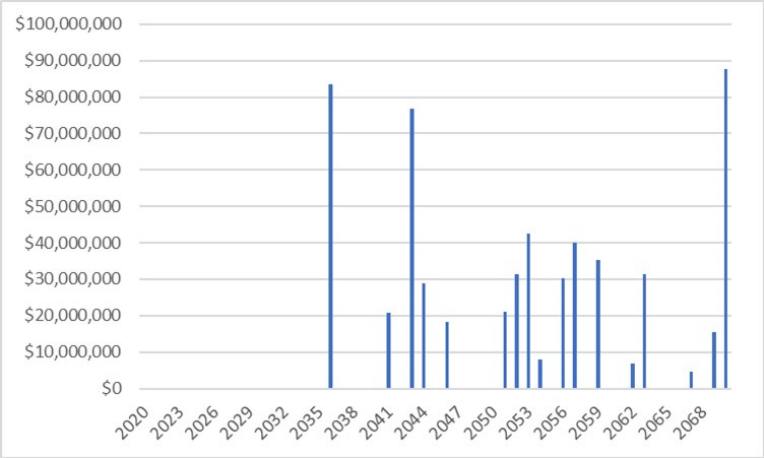


Table 4. Overview of techniques for managing uncertainty

Method	Situations where method is suitable	Example
Sensitivity analysis	A range of outcomes for the uncertain variables and the impact that this is likely to have can be estimated.	A reasonable minimum and maximum cost of the adaptation option can be estimated.
Scenario analysis	A range and probabilities of outcomes cannot be estimated but a set of *plausible* outcomes can be constructed.	Applying different climate change scenarios to estimate upper and lower bounds for hazards and associated costs
Sensitivity analysis with 'correlations'	Same circumstances where a standard sensitivity analysis would be used but also the *interaction* between the different uncertain variables can be estimated or predicted.	A numerical link between different scale of a hazard and cost of the hazard can be established (e.g. through AAD curves).
Threshold Analysis	It is useful to understand at what point/value for an uncertain variable does the best course of action change.	The return period for a flood height needed to determine whether an adaptation action is likely to result in a net benefit.
Monte Carlo simulation	Same circumstances where a standard sensitivity analysis would be used but also the *probability distribution* for values of the uncertain variable can be estimated.	The ARI for different flood levels can be determined under different climate change scenarios.
Real Options	When the value in having flexibility to respond to uncertain variables as and when they become more certain is useful to quantify.	It may be worth deferring the decision for how best to protect infrastructure by monitoring increase in maintenance cost due to flooding over time.

Managing

Step 9. Selecting preferred option, recovering costs & implementing
Step 10. Monitoring & review

9. Selecting preferred option, recovering costs & implementing

Key points

- Key factors influencing selection of the preferred option are the 'decision rule' and cost sharing and recovery.
- An implementation plan should be developed for the selected option which details roles, responsibilities and timeframe for implementation.

Selecting the preferred option or options

Once options have been identified and assessed, Council will need to select the preferred option, noting that for some issues complementary options or a pathway constituting multiple options over time could be selected to be implemented over time. A key factor influencing the selection of the preferred option or options is the 'decision rule', which in turn is influenced by the assessment method (Step 7) as well as the objective and constraints (Step 3).

Another important factor to be considered prior to options selection is 'distributional analysis'. If a CBA has been undertaken, selection of an adaptation option by Council and will generally be based on the objective of maximising net benefits to the community or in the case of a CEA, minimising costs to the community. Nevertheless, attention needs to be given to identifying segments of the community who will benefit or benefit most from the decision and segments of the community who may be adversely impacted by the decision – often referred to as 'atemporal distributional impacts'. Ideally, assessment of options through a CBA or CEA, will include an appraisal of distributional impacts. Similarly, other assessment methods, such as MCA, can and should include at least a qualitative assessment of distributional impacts.

Cost sharing and recovery

Where appraisal of distributional impacts assumes most relevance is with the issue of cost sharing and recovery. Decision-making on recovering the costs of adaptation actions is a key aspect of the assessment of adaptation options (see following sub-section). In line with principles of good governance, councils and other agencies should seek to recover the full costs of adaptation actions.

If all members of a community benefit more or less equally from an adaptation action, then it is likely that the costs of the action will be recovered through general sources of revenue (e.g. rates or a State or Federal government grants program). In this situation, the key issue becomes one of cost sharing between jurisdictions (federal/state/local government), with decisions on how costs will be shared between the different levels of government negotiated as part of the discussions around roles & responsibilities (Step 2).

If specific sections of the community benefit from the action however, then consideration should be given to how to redress this inequitable outcome through application of cost sharing principles. Cost sharing and recovery is not an exact science. As with all policy decisions any decision on the preferred approach needs to start from a clear understanding of the goal of the cost recovery exercise. There is no single approach that fits all circumstances, but there are two widely used approaches:

- 'polluter pays' (and the closely related concept of 'impactor pays'); and
- 'beneficiary pays'.

Under a 'polluter/ impactor pays' principle the responsibility for paying for an action rests with the individual or entity who has created the problem or issue that needs to be addressed. Under a 'beneficiary pays' approach the costs are borne by those who benefit from the action. These approaches could result in very different cost recovery outcomes.

Cost recovery options

There are a range of options open to councils to fund or recover the costs of adaptation actions. Some of these, such as rates and grants, may be suitable where the costs of adaptation actions are to be borne by the wider community. Levies may be more appropriate if the costs of adaptation are intended to apply to a specific group.

Implementation

Implementation will differ depending on the nature or scale of the adaptation action but will generally involve a number of established steps.

Implementation plan

An implementation plan details the roles, responsibilities and timeframe for implementation of the agreed adaptation options(s) thus minimising the risks associated with implementation of the option(s). Particular attention in the schedule should be given to developing a monitoring framework for the implementation triggers (see Step 10). Additionally, the schedule should address some or all of the following elements depending on the nature of the options:

- integrating the preferred options into council's strategic and operational plans;
- key implementation roles and responsibilities;
- compliance with existing legislation and regulations;
- approvals for the implementation and operation of the adaptation option - particularly important for infrastructure options;
- procurement processes for relevant design and construction services;
- training for staff , contractors and others with implementation roles; and
- a communications strategy to inform community and stakeholders of the outcomes of the assessment and implementation schedule.

Community and stakeholder engagement

Engagement of stakeholders and the wider community could be a crucial success factor for the implementation and operation of adaptation measures. As noted in Part A, the scope and scale of the engagement process will depend on the nature and scope of the adaptation measure itself. For example, a measure involving significant land use decisions and/ or major capital works will require substantial community engagement

compared with a measure involving changes to council internal procedures.

Implementation risks

There are many potential risks and barriers to implementation. These can range from a lack of resources and funding to a lack of buy-in from stakeholders or the broader community.

These risks and barriers need to be identified at the beginning of the implementation process to ensure that they can be adequately addressed (Table 5). When implementing larger adaptation measures it may be useful to conduct a risk assessment to identify potential impediments.

Table 5: Potential barriers to implementation and management responses

Potential barriers	Management responses
Lack of funding and resource constraints	Seeking State or Federal Government funding
Lack of political will	Raising additional revenue through levies
Lack of awareness and will amongst other stakeholders and community	Providing information and engaging stakeholders in decision-making process, in particular explaining the issues, objectives and decision rule and option identification and assessment process
Lack of consensus around certain issues	As above
Lack of awareness and in-house expertise	Education and training program
Organisational and professional inertia	Cross council / agency working groups to share knowledge and expertise
Short planning horizons of organisations compared to those of climate change	Change management process
Complications through different levels of decision-making (e.g. national, regional and local)	Engaging Councillors and Senior Managers in the decision-making process

10. Monitoring & review

Key points

- Ongoing monitoring and periodic review of adaptation actions is important for measuring their effectiveness, especially given the uncertain and long term nature of climate change.

Overview

Climate change is a complex and long term issue, and the magnitude of change and impacts is uncertain. Adaptation to climate change is still relatively new for councils and communities. It is also, in many instances, a continuous and flexible process. It is therefore important to learn and improve over time how to best address climate change hazards, reduce vulnerability and enhance resilience.

Regular monitoring and evaluation of adaptation measures will provide necessary insights and answers to questions such as:

- Are we undertaking the most appropriate adaptation actions?
- Are we implementing those actions well?
- How can we do things better?

Monitoring and review framework

Ongoing monitoring and periodic review of adaptation actions is important for measuring their effectiveness, especially given the uncertain and long term nature of climate change.

By monitoring and reviewing adaptation measures they can be adjusted and refined, both in terms of the validity of underlying assumptions (e.g. climate change projections, population and/or economic growth, attitude towards risk, etc.) and their effectiveness.

Monitoring means 'being informed about the status of a system and keeping track of progress being made'. Monitoring implementation of adaptation measures will entail assessing progress of implementation against objectives, as well as inputs, such as time and budget. It will allow Councils to adjust and correct processes as new information becomes available. Monitoring is usually undertaken to establish ways of improving a project or program while it is underway. Hence, the monitoring will take place at regular intervals during the project or program.

A review involves systematically and objectively assessing the effectiveness of an adaptation measure against its objectives considering a range of indicators of success. Thus, it will usually be undertaken following completion of the project or program or sometimes following climate-related hazard that has tested the effectiveness of the action. Factors to consider when undertaking the review include:

- the framework that will be adapted for the review; for example, program logic is now a commonly applied framework for reviewing programs (see

Box 7); and

- indicators of success that will be used in the review (see Box 8).

Box 7: Program logic

Program logic is an approach to program planning. It captures the rationale behind a program, probing and outlining the anticipated cause-and-effect relationships between program activities, outputs, intermediate outcomes and longer-term desired outcomes. Program logic is usually represented as a diagram or matrix that shows a series of expected consequences, not just a sequence of events. Program logic expresses how change is expected to occur.

The concept of program logic has been applied since the 1970s, particularly in international aid programs. Since then it has been used in many different disciplines in a variety of formats. More recently it has been adapted for use in natural resource management (NRM) programs.

Source: Commonwealth of Australia, 2009, Developing and Using Program Logic in Natural Resource Management – User Guide

Box 8: Review of adaptation actions – possible indicators of success

Effectiveness: Has the adaptation action achieved its objectives and produced the outputs or outcomes as intended?

Efficiency: Was the adaptation action delivered on time and on budget? Were high risks involved in undertaking the action?

Equity: Were the benefits and costs of the adaptation measure shared equitably? Did certain groups bear additional costs? Were some groups exposed to higher risks than others?

Improvements / Learning: Did the adaptation action work? Why or why not?

Ultimately, the framework adopted for the review and the resources applied to the review will depend on how significant the adaptation actions are and the nature of the climate-related hazards and impacts that the actions are seeking to address.

It is recommended that processes for the monitoring and evaluation of adaptation actions be set up at the implementation phase.

Useful references

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