GUIDE

SEPTEMBER 2012

Deciding for the Coast: A Guide for Decision-Making on Cost Effective Adaptation

Prepared for South East Councils Climate Change Alliance

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TABLE OF CONTENTS

The project Deciding for the coast was conducted for the South East Councils Climate Change Alliance Inc (SECCCA), an association of 8 councils to Melbourne's south east.

The project was managed by SECCCA's Executive Officer Greg Hunt who led a Steering Committee comprising representatives of the four member councils which participated:

Bass Coast Shire Council – Liza Price, Alison Creighton

Cardinia Shire Council – Lisa Brassington, Janene Vurlow

City of Casey – Clare Alexander, Sonia Rappell

Mornington Peninsula Shire – Gabrielle McCorkell

Funding by the Australian Government represented by the Department of Climate Change and Energy Efficiency

Coastal Adaptation Decision Pathways projects - An Australian Government initiative

About this guide

Context

Public policy on climate change is rapidly progressing into the sphere of adaptation. The increased attention being given to adaptation, in Australia and elsewhere, has been prompted by a recognition that regardless of international action to curb greenhouse gas emissions the world is facing significant, albeit uncertain, impacts associated with global warming.

Adaptation actions, if carefully considered and applied, can result in benefits including reduced damage from climate change. Adaptation actions can also incur costs however. Effective decision-making is therefore needed to ensure that adaptation occurs in a timely manner, maladaptation does not occur and that the costs of adaptation are minimised and benefits maximised (Box 1).

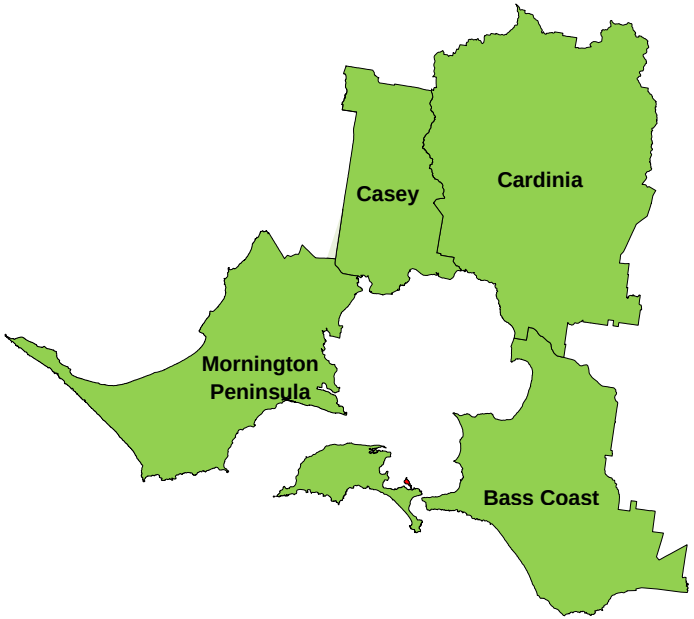
Coastal adaptation is a key aspect of adaptation decision-making in Australia. Coastal planning and management here already poses great challenges to decision-makers. As Harvey and Caton (2010) note:

> *The Australian coast and its thousands of beaches have an iconic status in the Australian culture and way of life. Most Australians live on or near the coast where there is continuing population and development pressure. There is also a heavy use of coastal resources and added pressure from recreational users.*

Climate change and associated impacts adds to these challenges, adding further layers of complexity and uncertainty to the decision-making process.

This Guide has been developed through the Australian Government's ***Coastal Adaptation Decision Pathways*** program to assist local council members of the South East Councils Climate Change Alliance (SECCCA - Figure 1) make decisions on coastal adaptation. It aims to promote a more consistent and transparent approach to decisions that lead adaptation responses in the context of land use planning and asset management within and across participating councils. It seeks to address, at least in part, identified concerns regarding ad hoc decision-making on coastal climate change adaptation (see for example Blake Dawson 2011). The focus of the Guide is on process rather than outcomes. No presumptions are made as to how or even whether councils and other decision-makers should respond to observed or potential impacts of climate change. Rather, guidance is given on the process of determining the best course of action, having decided that a response is necessary or desirable.

Figure 1: SECCCA member councils involved in the project



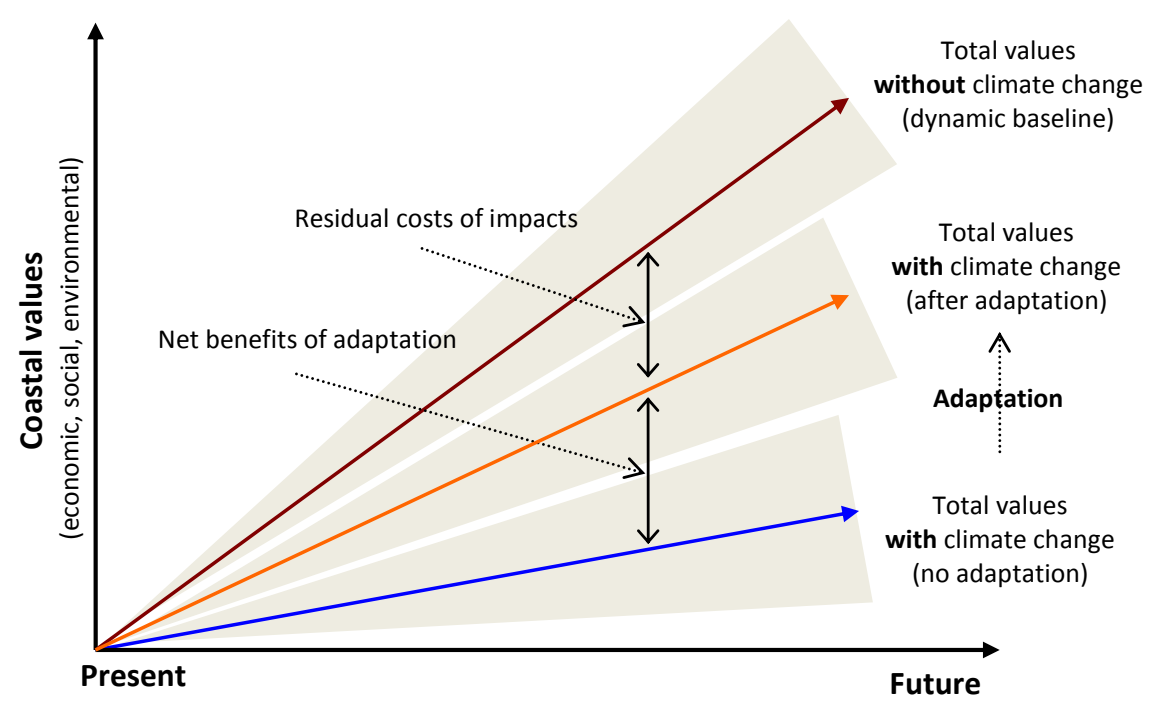
Box 1: Climate change adaptation

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.* Adaptation takes place in the context of interacting non-climatic (economic, social and ecological) changes and can range from short-term coping to longer term, 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 coastal hazards and risks on economic, social and environmental values, considering potential trade-offs between those values. Due to uncertainties and trade-offs it may not always be feasible to take a 'rational' approach to assessing actions.

Figure 2: Benefits, costs and uncertainties of coastal adaptation



Focus of the Guide

The focus of this Guide is on coastal adaptation decision-making in response to the potential economic, social and environmental impacts of climate change linked to:

- sea level rise;
- coastal recession associated with more frequent or severe storms, storm tides, and changes to coastal currents and other coastal processes;
- changes to extreme rainfall and associated flooding (rivers and flash flooding) in coastal areas;
- a combination of these events.

Coastal areas are defined broadly to include:

- beaches, dunes, cliffs, headlands and foreshore areas on the open coast;
- estuaries, wetlands and lagoons, coastal lakes, and tidal river systems;
- coastal catchments and the coastal hinterland.

This is similar to the 'coast' as defined in the *Victorian Coastal Strategy* (2008) except that marine areas and impacts on marine ecosystems are not intended to be covered by the Guide.

The nature and severity of climate change impacts on coastal communities and ecosystems will differ from location to location, influenced by local environments and coastal processes and by economic and social contexts. Likewise, the timing of impacts could differ between locations. Thus the Guide has been prepared with the aim of accommodating these differences.

Structure of the Guide

The Guide comprises three main parts.

Part A provides an overview of the framework that underpins coastal adaptation decision-making, outlining:

- the stages and steps in the decision-making process;
- the pathways and choices available at each step; and
- an understanding of the context in which decisions are made.

Key elements of decision-making that should be addressed at all stages in the process are also discussed:

- integrated decision-making;
- dealing with risk and uncertainty; and
- stakeholder and community engagement.

Part B represents the core of the Guide, providing decision-making guidance and supporting information. This advice is presented in a series of numbered sections, reflecting the main decision-making stages and steps, logically sequenced, noting that:

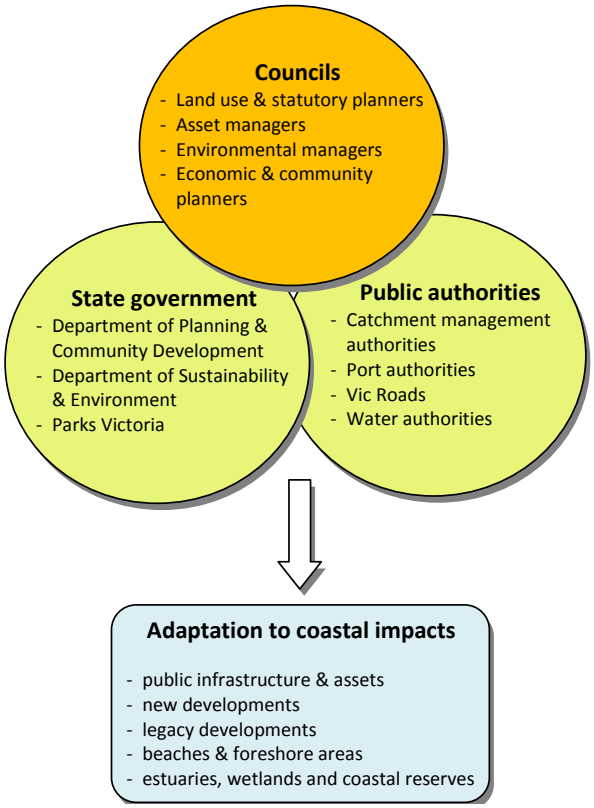
- not all issues will require decisions to be made at every stage;
- the order in which decisions are made will vary from issue to issue; and
- the process is iterative, with decisions often jumping backwards and forwards between stages.

Parts C provides supporting information including a glossary, links to other useful materials and references.

Who can use the Guide

The Guide was produced for use by SECCCA member councils, including by their land use and statutory planners, asset managers and engineers, environmental managers and community planners. However, the Guide is relevant to a much wide audience. Other local councils in Australia could benefit from its use[1], as could other public decision-makers, including State government departments and public authorities, especially where their decision-making involves interaction with local councils.

Although not intended for use by stakeholder groups and the general community, interested members of the community may wish to apply the Guide, especially if they are working in partnership with councils and other decision-makers on coastal management issues (see Part A, Community Engagement, Consultation and Communication).



[1] Indeed, a similar guide has been produced for use by coastal council members of the Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS) relevant to their policy and strategic contexts.

Using the Guide

The Guide is not intended to be a stand-alone document. It is a companion document to a '***Workbook***', which provides checklists and worksheets to assist councils and other decision-makers work through each stage of the decision-making process.

Users of the Guide should also be cognizant of legislation and strategies that will guide decision-making around coastal adaptation in the areas of coastal planning, land management, property rights, environmental management and assets management.

These legislation, strategies and plans are important for designating State, regional and local level objectives and in defining the roles and responsibilities of the various levels of government and relevant agencies, notably for planning. They are also important for setting 'rules' for different aspects of decision-making processes. Every effort has been made to align the advice in this Guide with established decision-making processes. If users find inconsistencies between advice in the Guide and legislation and strategies however, then the other documents should be deferred to.

Key supporting information

- *Aboriginal Heritage Act* 2004
- *Coastal Management Act* 1995
- Coastal management plans
- Council strategic plans
- *Crown Land (Reserves) Act* 1978
- *Emergency Management Act* 1986
- Floodplain and stormwater management plans
- Draft Guide for Coastal Floodplain Management Authorities (DSE)
- *Land Act* 1958
- *Local Government Act* 1989
- Local Government Victorian Planning Provisions (including Clause 13.01: Climate change impacts and Clause 13.02: Floodplains)
- Ministerial Direction No. 13
- *National Parks Act* 1975
- *Parks Victoria Act* 1998
- *Planning & Environment Act* 1987
- Planning Schemes (including State Planning Policy Framework, Municipal Strategic Statement and Local Planning Policies)
- Planning for Sea Level Rise: Interim guidelines (Melbourne Water)
- Port Phillip and Westernport Region Flood Management and Drainage Strategy
- *Road Management Act 2004*
- *Subdivision Act 1988*
- *Traditional Owner Settlement Act* 2010
- Victorian Coastal Strategy 2008
- Victorian Coastal Hazard Guide 2012

**Note: Laws and policy documents are subject to change. This is not an exhaustive list and the applicability and currency of each document should be verified prior to use.*

Part A: Decision-making framework

Overview

Decision-making process

Context

Critical elements of decision-making

Guiding principles

Overview

Framework development and application

The coastal adaptation decision-making framework has been developed considering public policy decision-making theory as applied to the challenges posed by climate change adaptation, complex social-ecological systems and local decision-making (e.g. Ostram 1990, Anderies et al. 2004, Moser & Ekstrom 2010).

A range of criteria were considered in developing the framework (Box 2). Importantly, although the framework is intended to promote a consistent and transparent process of decision-making on coastal adaptation this does not mean that consideration of similar issues by SECCCA member councils will necessarily deliver the same or even similar outcomes – ***local context will always have a significant influence on outcomes***.

Box 2: Criteria underpinning framework development

A number of criteria were used to underpin development of the coastal adaptation decision framework.

- **Consistent and transparent**: The framework will lead to consistent and transparent approaches to decision-making on coastal adaptation.
- **Comprehensive**: It is applicable to a range of different issues.
- **Scalable**: It can be applied at different scales and over different timeframes.
- **Adaptive**: It should enable risk and uncertainty to be addressed through adaptive decision-making processes.
- **Community and stakeholder focussed**: It should recognise the crucial role and input of local communities and stakeholders to the decision-making process.

Framework outline

The decision-making framework comprises four main planks.

1. A **rational decision-making process** that encompasses a series of stages and steps.
2. The **context** in which decisions are made including:
   - the institutional context;
   - stakeholders, the community and other 'actors' who have a role on the decision-making process; and
   - the social and biophysical environments.

   The context will frame the issue, influencing the policy objective, available options and assessment approach, and facilitate or provide barriers to effective decision-making.
3. **Critical elements** of effective decision-making that will help to overcome many of the barriers to adaptation decision-making.
4. A series of **principles** has been developed, drawing on discussion of the context and critical elements. These will help guide decision-making at all stages in the process.

Decision-making process

Adaptation decision stages

A sound decision-making process provides the foundation for effective coastal adaptation. Figure 3 identifies the key stages comprising 'good practice' in decision-making. These stages cover the entire decision-making process as shown:

Structuring of the problem

- Stage 1 Define the issue or problem;
- Stage 2 Clarify roles & responsibilities;
- Stage 3 Establish the decision-making objective;
- Stage 4 Assess hazards and risks;

Analysis of adaptation options

- Stage 5 Identify options and pathways;
- Stage 6 Establish threshold and triggers;
- Stage 7 Assess options;
- Stage 8 Manage risk and uncertainty in the assessment;

Managing adaptation response

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

These stages are discussed in depth in Part B of the Guide noting that each Stage involves a number of steps (Figure 4), with each step providing a range of choices and thereby potential pathways.

Figure 3: Stages in the decision-making process

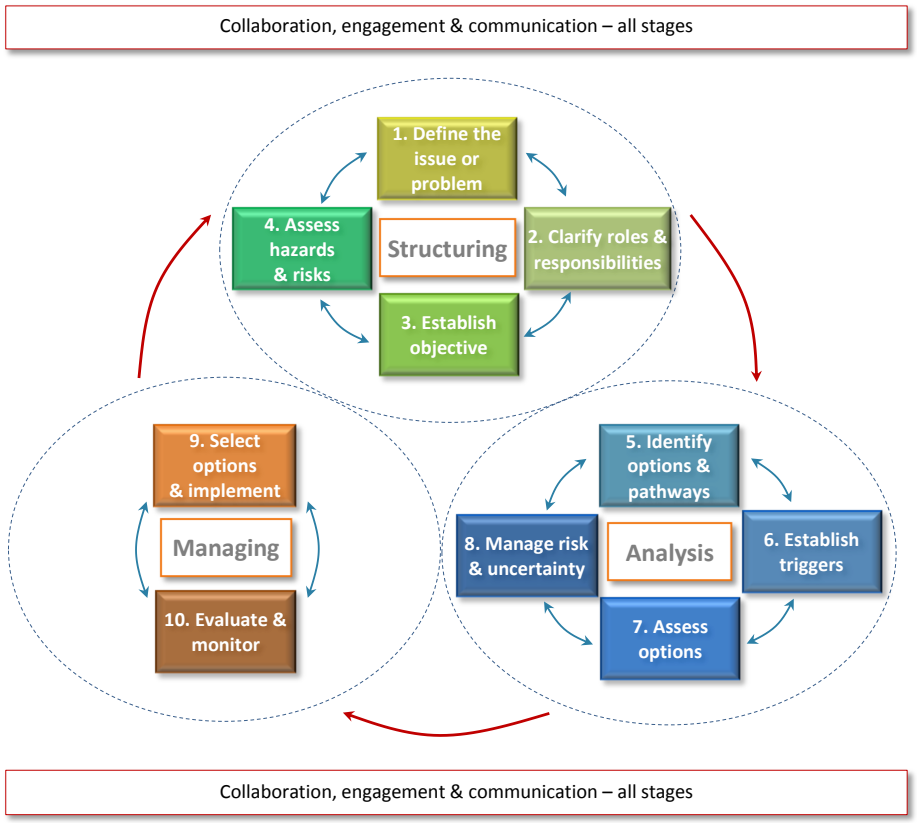


Figure 4: Stages and steps in the decision-making process

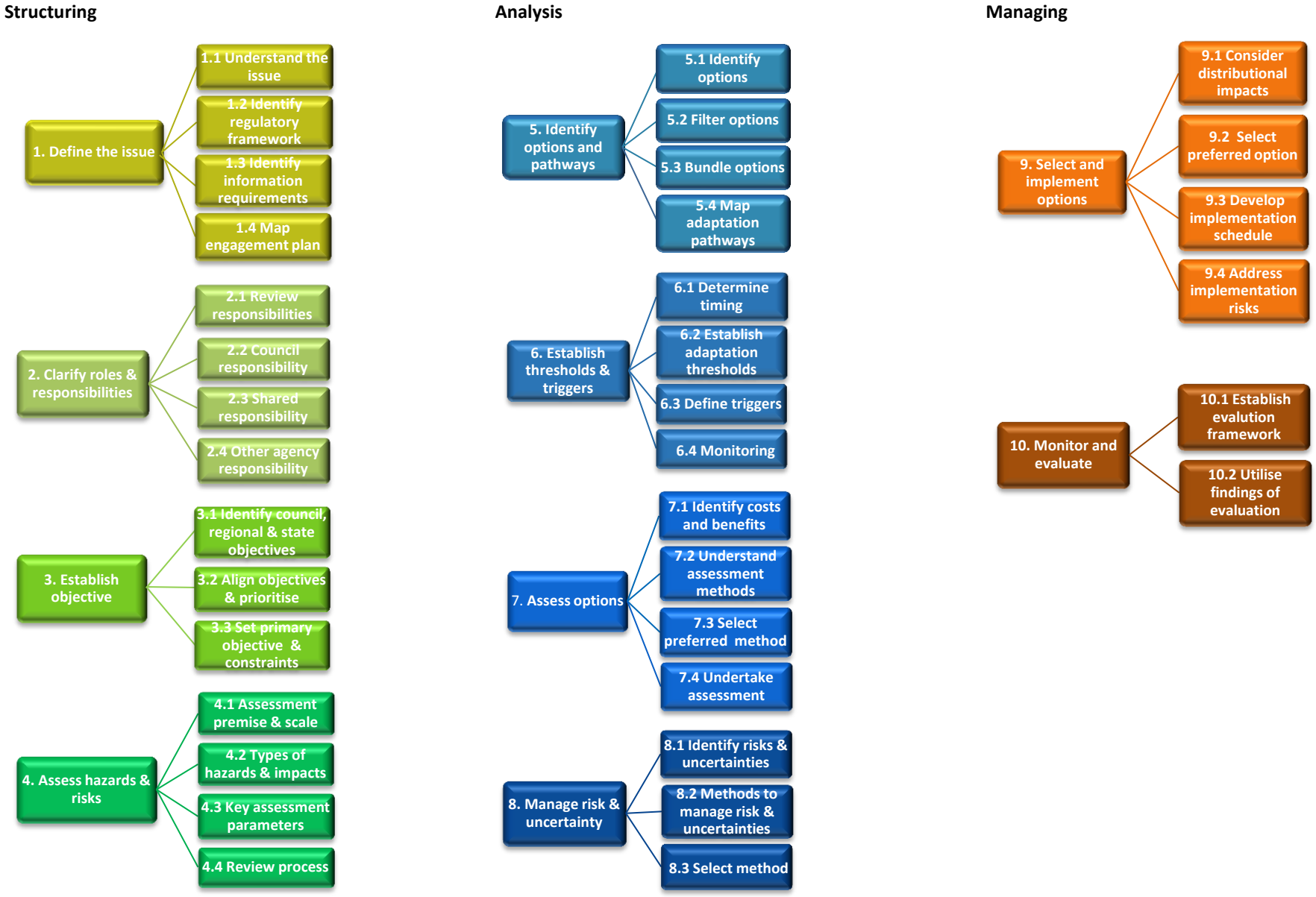


Table 1: Steps and decisions at different stages in the decision process

	Decision stage	Step I decisions	Step 2 decisions	Step 3 decisions	Step 4 decisions
Structuring	1. Define the issue or problem	**Understand nature of the issue** - scale (macro, micro) - issue category (land use, statutory planning, infrastructure) - issue type (established land use, new land use) - time horizon	**Identify regulatory and policy framework** - relevant instruments (Acts, regulations, plans, policies) - binding requirements and guidance	**Identify information & resource requirements** - risk priority setting - costs and feasibility of options - resource requirements - statutory framework	**Map communications and engagement plan** - collaboration (who and how); - communication and engagement (who, how and when)
	2. Clarify roles & responsibilities	**Establish primary responsibility** - council - State government, authority, utility - shared	**If council responsibility** - constraints - internal roles & responsibilities - resourcing - consultation	**If shared responsibility** - identify responsibilities & map - constraints - resourcing - collaborative decision-making	**If other agency** - council liaison - watching brief - implications for council plans
	3. Establish objective	**Identify objectives** - local - regional and State level	**Align and prioritise objectives** - economic development - environmental protection - social, cultural and community	**Establish primary objective and constraints** - primary objective - conditions	
	4. Assess hazards and risks	**Determine assessment premise and scale** - site specific - multiple locations/ regional	**Consider types of hazards & risks** - sea level rise - storm tides and coastal flooding - coastal recession - range & scale of impacts and associated risks	**Set parameters** - site specific or regional? - timescale	**Assessment approach and review** - technical specifications - sensitivity analysis - expert review
Analysis	5. Identify options & pathways	**Identify options** - identify possible adaptation strategies	**Filter options** - criteria - timeframe (short term, medium term, long term)	**Bundle options** - complementary options - mutually exclusive bundles - timeframe	**Map adaptation pathways** - timeframe - flexibility

	Decision stage	Step I decisions	Step 2 decisions	Step 3 decisions	Step 4 decisions
	6. Establish thresholds & triggers	**Determine timing** - short term - medium term - long term	**Establish adaptation thresholds** - physical - economic - level of service - social - transformational	**Define triggers** - threshold projections - timing of response - safety buffer - monitoring interval	**Monitoring of thresholds & triggers** - monitoring process including intervals - monitoring of the trigger variable
	7. Assess options	**Identify costs & benefits** - direct market - indirect market - direct non-market - indirect non-market	**Understand assessment methods** - cost-benefit analysis - cost effectiveness assessment - multi-criteria analysis - rules based & qualitative	**Select method** - assess benefits and put a monetary value on them? - resources and time	**Undertake assessment** - assessment approach - business as usual - feasibility of options - assumptions - assessment review
	8. Manage risk & uncertainty	**Understand risks & uncertainties** - uncertainty or risk?	**Consider methods for managing risk** - scenario analysis - sensitivity analysis - threshold analysis - Monte Carlo simulation - real options	**Select preferred method** - uncertainty or risk? - probabilities? - external expertise required?	
Managing	**9. Select and implement options**	**Consider distributional impacts and cost recovery** - who benefits? - cost sharing - funding of options	**Select preferred option** - Basis for the decision (decision rule)	**Develop implementation schedule** - when? - how?	**Address implementation risks** - what are the risks? - how can they be mitigated?
	10. Monitor & evaluate	**Establish evaluation framework** - evaluation aim - timeframe - benchmarks - evaluation methodology	**Utilise findings of evaluation** - adjust adaptation approach?		

Iterative processes

Public policy decision-making is rarely a linear process. Notwithstanding presentation of the process as a series of numbered stages, in reality:

- the order in which decisions are made will vary from issue to issue;
- the process is iterative, with decisions often jumping backwards and forwards between stages; and
- because coastal issues and actions are interconnected, decisions will need to be reviewed to ensure that indirect as well as direct implications have been considered.

For many coastal decision-makers for example, the stages of 'defining the issue', 'establishing roles & responsibilities' and 'clarifying the objective' will follow the hazard assessment, with the hazard assessment being used to define the problem. Similarly, the process of establishing triggers may need to be closely worked in with the options identification and assessment, since the timing of implementation could well determine its costs and the level of benefit that it delivers.

Users of this Guide should be mindful of this, applying the decision-making process flexibly, depending on the issue at hand.

Approach to assessment and depth of application

Users of the Guide should also be aware that the approach to the assessment and depth in which the decision-making process is applied should be appropriate to the nature of the issue and decision. As discussed further in Part B Stage 1, the overall approach to the assessment is likely to be fundamentally determined by the nature of the issue, in particular the following three factors.

Scale of the issue

The depth of assessment will be fundamentally determined by the scale of the issue. Large scale 'macro' decisions, involving substantial values (market or non-market), long time horizons and/ or a large number of stakeholders are likely to require careful planning and mapping out of the decision-making process and in-depth analysis at a number of stages. Small 'micro' issues on the other hand (a single lot development for example), while still requiring application of the decision-making process, will not warrant the same depth of application.

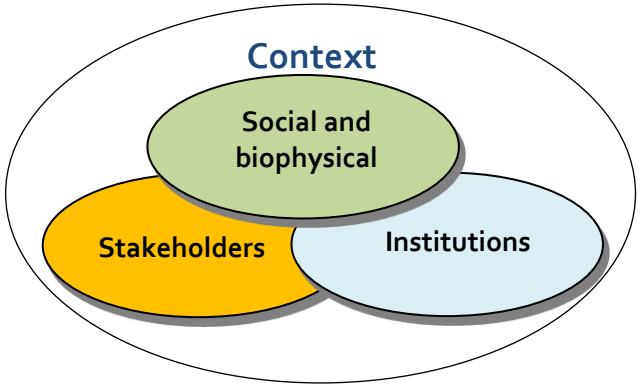
Quantify benefits?

Valuing or otherwise quantifying the benefits of adaptation actions will be one of the more resource intensive and potentially contested aspects of the adaptation decision-making process. Thus if the nature of the issue and policy objective means that it is neither necessary nor useful to value the benefits of adaptation this can substantially simplify the decision-making process.

Regulatory and policy framework

As discussed further in section 1.2, the regulatory and policy frameworks under which the issue or problem may fall can significantly influence the approach to the assessment. These frameworks may contain binding requirements or 'rules' that a decision-maker must comply with in making a decision and may also provide further guidance in determining who is responsible for decision-making and who should be consulted in relation to a decision.

Understand the context



Decisions on coastal adaptation should be based on a clear understanding of the context in which they are being made. Contextual elements include:

- the institutional context, in particular established planning systems and policies;
- the community and other stakeholders who have a role on the decision-making process; and
- the natural and social systems or environments that are influenced by or will influence the decision.

These contextual elements are important since many of the barriers to effective adaptation can be linked to a failure to understand and address them through the decision-making process (Table 2).

Table 2: Common barriers to coastal climate change adaptation

Stage	Barriers
1. Define the issue	Receptivity to information Consensus about the problem
2. Clarify roles & responsibilities	Leadership and control over process Control over options
3. Establish objective	Agreement on objective/ contested values
4. Assess hazards & risks	Access to/ availability of information Credibility of information
5. Identify options & pathways	Ability to develop and agree on options that will meet objectives, especially over multiple timeframes Legality and feasibility of options
6. Establish thresholds & triggers	Agreement on thresholds of concern Ability to measure and monitor thresholds
7. Assess options 8. Manage risk	Agreement on assessment approach and criteria Accessibility/ usability of data
9. Select and implement options	Sphere of responsibility/influence over implementing preferred option(s) Availability of resources/ cost sharing Accountability
10. Monitor & evaluate	Existence of a monitoring plan Agreement on monitoring targets Availability of resources Willingness to learn/ revisit previous decisions

Source: Adapted from Moser & Ekstrom 2010 drawing on feedback from representatives of Victorian and New South Wales local councils.

Institutional and policy contexts

Effective coastal adaptation decision-making requires a full understanding of the institutional context within land use planning, environmental regulation, land management and property rights law. For council decision-makers this means understanding:

- Commonwealth, State and local government and agency roles and responsibilities in relation to making and implementing decisions;
- council's strategic and operational objectives and goals;
- internal decision-making processes and how they are used to meet council objectives;
- relevant regional and State level planning and decision-making frameworks and objectives, including land tenure, and land management and property rights law;
- potential inconsistencies between council and State level objectives (as they relate to coastal adaptation); and
- potential inconsistencies between council's own objectives.

Knowledge of the key supporting information (discussed in the Guide's introductory section) will go some way to understanding the institutional context. With this knowledge next comes the need to address inconsistencies between council and council and State objectives as they relate to coastal adaptation. Approaches to addressing these inconsistencies are outlined in the following section on 'critical elements of decision-making'.

Key supporting information

- *Aboriginal Heritage Act* 2004
- *Coastal Management Act* 1995
- Coastal management plans
- Council strategic plans
- *Crown Land (Reserves) Act* 1978
- *Emergency Management Act* 1986
- Floodplain and stormwater management plans
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- *Traditional Owner Settlement Act* 2010
- Victorian Coastal Strategy 2008
- Victorian Coastal Hazard Guide 2012

**Note: Laws and policy documents are subject to change. This is not an exhaustive list and the applicability and currency of each document should be verified prior to use.*

Stakeholders

Effective coastal adaptation decision-making also requires a full understanding of the stakeholders who can and should play a role in the decision-making process. For council decision-makers this means identifying:

- the full range of council functions and associated staff who are relevant to the decision;
- councillors and council sub-committees;
- relevant State and national government departments and agencies;
- other service providers;
- coastal developers;
- property owners directly affected by the decision;
- other ratepayers and coastal area user groups.

Understanding of stakeholders should also extend to consideration of the relative importance of each group to the decision-making process (e.g. What is a group's level of interest in the issue? Is its role direct or indirect?)

A well-considered collaboration, engagement and communication plan will be critical to addressing these last two points, first by designing consultation and engagement processes that are consistent with the requirements of different groups and second by pinpointing strategies for engaging and communicating with groups who might present a barrier to adaptation.

Social and biophysical systems

Decisions on coastal adaptation actions need to fully consider the underlying biophysical and social contexts.

The underlying physical environment is a dynamic one. As Harvey and Caton (2010) note:

> *...it is important to think of the coast as a dynamic system which is constantly responding to changes at a variety of time scales.*

Even at relatively short time scales of years, months or even days, changes to the coastlines are evident, particularly where they affect coastal communities. These changes can include:

- sediment movements and coastal recession or accretion linked to tidal cycles, coastal processes of wind and waves and long term weather patterns such as El Niño; and
- changes to coastal systems such as dunes, wetlands and estuaries, linked to the coastal processes described above or to human pressures such as land clearing, development (onshore and offshore), increased run-off and pollution.

Underlying social and economic systems in coastal areas are also dynamic. The region covered by SECCCA member councils is undergoing rapid population growth and associated development. Much of this growth and development is in coastal areas (as defined in the introductory section), increasing the exposure of people and infrastructure to coastal climate changes. The growth and development is also adding to the pressures on coastal systems. Other demographic changes, such as population ageing, are

also occurring in the region, potentially increasing the sensitivity of affected communities to the impacts of climate change.

Decision-making on coastal adaptation needs to be made, as far as possible, on the basis of a good understanding of the underlying biophysical and social systems - their dynamic nature and the pressures that they are already facing - and a recognition that climate change could exacerbate (or in some cases alleviate) existing pressures.

A comprehensive hazard assessment process is important in this regard. As discussed at length in Part B, Stage 4 of the Guide, the hazard assessment should include:

- an assessment of underlying environmental and social systems, including established pressures;
- the sensitivity of the systems to climate and other changes; and
- the potential impacts (direct and indirect) of potential changes considering a wide range of values.

As well, 'systems thinking' provides a potential approach to addressing some of the social and ecological systems in the context of coastal adaptation. Systems thinking, defined as a holistic approach to analysis that focuses on the way that a (social or ecological) system's constituent parts interrelate over time and within the context of larger systems, is increasingly being presented as a useful approach for dealing with climate change adaptation. The concept can be somewhat esoteric, but in practical terms and considering the framework presented in this Guide, the application of systems thinking is likely to mean:

1. placing considerable emphasis on the key elements of decision-making (presented in the following section); and
2. incorporating 'no-regrets' options that build resilience and adaptive capacity into all adaptation responses (see Part B, Stage 5).

Figure 5: Western Port contains nationally and internationally significant mangrove forests

Source: SECCCA

Critical elements of decision-making

Three elements of coastal adaptation decision-making are critical to the decision-making process. They are:

- integrated decision-making;
- dealing with risk and uncertainty; and
- effective collaboration, engagement and communication processes.

Application of these elements at different stages in the decision-making process will go a considerable way to addressing the common barriers to adaptation as outlined in Table 2.

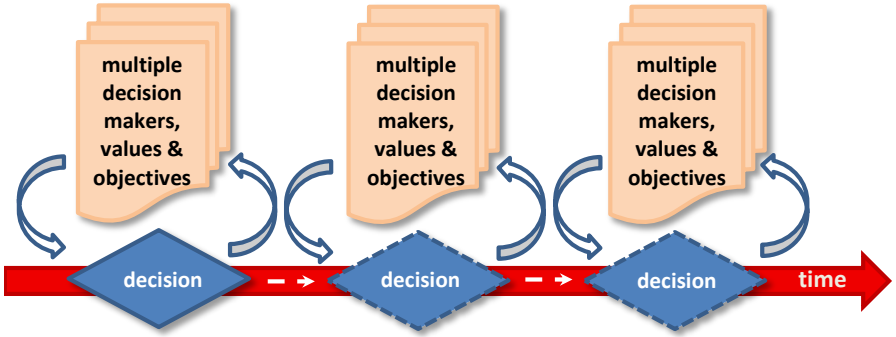
Integrated decision-making

Integrated decision-making aims to achieve the progressive integration of economic, social and environmental issues in the pursuit of public policy objectives.

An integrated approach to decision-making on coastal adaptation is particularly important given that many coastal adaptation decisions are likely to entail multiple dimensions (Figure 6):

- interconnected issues and actions;
- multiple decision-makers and service providers;
- multiple objectives;
- multiple values; and/ or
- repeat decisions occurring over time.

Figure 6: The multi-dimensional nature of coastal adaptation decision-making



The application of established integrated decision-making conditions (Box 3) to coastal adaptation would suggest that the following **goals** should be pursued as part of an integrated approach to adaptation decision-making by **councils**:

- Adopt a **collaborative approach** to adaptation decision-making where feasible. This would involve a cross-section of council staff and functions and other relevant agencies and service providers (discussed later in this section).
- Instigate **effective engagement and communication** processes (also discussed later in this section).
- For a given area, pursue **consistency of objectives** between adaptation decisions, strategic plans and other key planning documents. **Prioritise objectives** where there are multiple and potentially competing objectives for that area (see Part B, Stage 3, for further discussion).
- Have a clear understanding of the **full range of coastal values** - direct and indirect, market and non-market – potentially affected by climate change and by adaptation decisions - this understanding is particularly important for the hazard assessment (Part B, Stage 4) and options assessment (Part B, Stage 7) stages of the decision-making process.

- Recognise that **trade-offs** between competing values will be an inherent part of the adaptation decision-making process and that there will be 'winners' and 'losers' (distribution effects) arising from that decision (see Part B, Stage 7). Mechanisms should be built into the decision that addresses the distribution effects.
- **Build adaptation decisions into strategic and annual plans** (see Part B, Stage 9).

Box 3: Conditions for achieving integrated decision-making

The United Nations sets the following conditions for the achieving integrated decision-making in the context of sustainable development:

1. Ensure integration of economic, social and environmental considerations in decision-making at all levels.
2. Allow consideration of multiple goals in planning and decision-making.
3. Adapt a long term, cross-sectoral approach as the basis for decisions, taking account of the linkages between and within the various political, economic, social and environmental aspects of an issue.
4. Ensure transparency of, and accountability for the decision-making process.
5. Ensure access by the public to relevant information, facilitating the reception of public views and allowing for effective participation.
6. Monitor and evaluate outcomes of the process systematically.

Source: United Nations Department of Economic and Social Affairs, Division of Sustainable Development

Dealing with risk and uncertainty

Risk and uncertainty defined

A decision-maker has certainty if s/he has complete knowledge of all aspects of the decision problem and can therefore accurately predict the likelihood of an event and its consequences. In reality, decision-makers will rarely, if ever, have complete knowledge about the decision problem.

Uncertainty can be defined as poor knowledge of the likelihood (or probability) that an event or state-of-nature will occur. Uncertainty can constitute anything from 'confidence just short of certainty' to 'speculation'. Uncertainty about adaptation to the impacts of climate change can derive not just from lack of knowledge, but also from disagreement about what is known or even knowable. Sources of uncertainty may include:

- data problems, such as missing data, or data errors;
- problems with models (physical or economic) such as structure, parameter values and underlying assumptions; and
- other sources of uncertainty such as inappropriate spatial or temporal units, and uncertainty due to projections of human behaviour.

It may often be possible to place bounds on or estimate probabilities for the uncertainty though. When this uncertainty is quantifiable or measurable in terms of likelihood and consequence (e.g. a minimum value and maximum value for sea level rise and associated impacts on coastal communities) it is referred to as a **risk**.

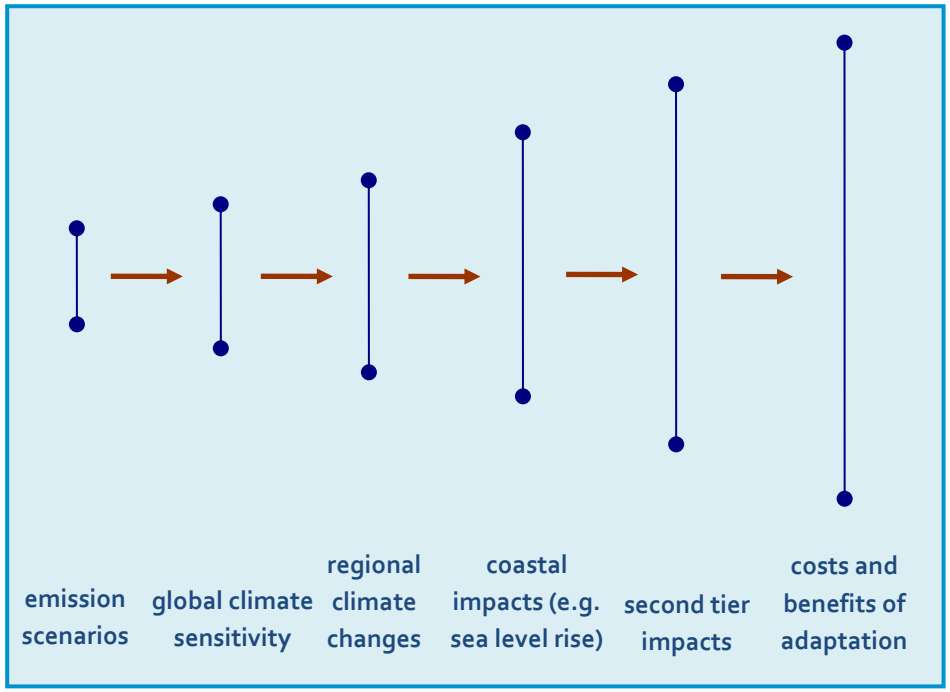
Dealing with risk and uncertainty in coastal adaptation decision-making

Most decisions involving the assessment of adaptation options will involve uncertainty. As Pittock and Jones (2000, p.9) note

> *.. climate change predictions relevant to impacts on most sectors and ecosystems are still highly uncertain" and this uncertainty is magnified by the fact that "climate change in the foreseeable future will not be some new stable 'equilibrium' climate, but rather an ongoing 'transient' process.*

As illustrated in Figure 7, the range of uncertainty associated with climate change increases as we move from biophysical to socio-economic impacts, with very wide bands of uncertainty associated with the costs and benefits of second tier (economic, environmental and social impacts) and the corresponding benefits and costs of adaptation.

Figure 7: Range of uncertainty in climate impact and adaptation assessments



Source: Adapted from Moss and Schneider 2000.

In many circumstances it may be possible to put bounds on this uncertainty, a 'known known' (quadrant I, Figure 8). When the bounds of uncertainty for a known event or consequence cannot be quantified however, by any reasonable measure, then it becomes a 'known unknown' (quadrant II, Figure 8).

Techniques are available to deal with 'known knowns'. These are discussed at length in Part B, Stage 7 of the Guide. An important aspect of the hazard assessment process (Part B, Stage 3) will be to place boundaries on the uncertainties, both the direct and second tier impacts.

Techniques are also available to deal with 'known unknowns' - when boundaries cannot be placed on the uncertainties. These are also discussed Part B, Stage 7 of the Guide.

Figure 8: Known and unknown coastal impacts of climate change

	known probability (risk)	**unknown probability**
known event or consequence	(i) 'known knowns' (e.g. change in return interval for a given storm tide height under sea level rise projections to 2100)	(ii) 'known unknowns' (e.g. combined effects of sea level rise, rising groundwater and pollution on viability of wetland system to 2100)
unknown event or consequence	(iii) 'unknown knowns' (i.e. a potential impact is known but has not been communicated to councils)	(iv) 'unknown unknowns' (i.e. an unforseen, possibly nonlinear coastal impact)

Source: Adapted from Dobes 2012.

Dobes (2012) suggests that the standard formulation of risk and uncertainty is incomplete because it does not include instances where the event itself is unknown and unforeseeable – 'unknown knowns' and 'unknown unknowns' (quadrants III and IV, Figure 8). By definition though, there is no ready means of identifying or assessing adaptation options relevant to an event or consequence that is unknown. The pursuit of good governance in the form of coherent objectives (see Part B, Stage 3), clarity of roles and responsibilities (Part B, Stage 2), and a sound monitoring regime (see Part B, Stage 10) provides the best means of guarding against 'surprises'.

Community engagement, consultation & communication

Community engagement and consultation

Meaningful stakeholder and community engagement processes should be undertaken to ensure that adaptation decisions reflect community values and preferences and that the community is fully informed about adaptation decisions – the nature of the decisions and the rationale for them.

The benefits of an effective consultation, engagement and communication process lies in its potential to overcome barriers to adaptation, notably by:

- **increasing public understanding and awareness of climate change** and coastal impacts, including the status of science, the nature of uncertainties and implications of this for policy making;
- **improving council's understanding of community values** (especially as they relate to coastal areas) and perceived threats to those values;
- **broadening and deepening input into council decision-making** on adaptation; and
- **strengthening public support for coastal adaptation decisions**.

The level of engagement by council on any given issue should reflect the significance of the issue and the extent to which community members have a stake in the decision, i.e. are likely to be affected by it either directly or indirectly. Table 3 sets out a model of public participation, developed by the International Association of Public Participation (IAP2). This sets out a spectrum of public participation levels and types. The spectrum has been reworked to provide guidance on the level and nature of participation that might be required for the different categories and scales of coastal adaptation issues.

Collaborative decision-making

Contested values, uncertainty over authority for adaptation decision-making, lack of leadership and concerns over the credibility and/ or legality of decisions are often cited as significant barriers to coastal adaptation (see Table 2).

Collaborative decision-making, which is essentially a subset of the broader engagement process, could help to overcome these barriers by:

- increasing mutual awareness and understanding of jurisdictional responsibilities and objectives;
- enhancing the prospects of an agreed outcome;
- boosting the legitimacy of the decision in the eyes of the community; and
- increasing efficiencies and the potential for resource sharing (for analysis, implementation and monitoring).

There are different levels and models of collaborative decision-making. The 'pendulum of citizen engagement' for natural resource management (Oliver & Whelan 2003) places participation in decision-making along an arc of a pendulum, with citizen or community management of a problem being at one end of the arc, government management of the problem being at the other end and a community-government partnership being at the base of the arc. While natural resource management issues are often well suited to community management or shared government-community management, the nature of many coastal planning and public infrastructure issues means that government (either council, state government agencies or other service providers – see Part B, Stage 2) may need to take responsibility for decision-making on many if not most of these issues. It is possible that in some areas of public land, particularly where community organisations already play an active role in their management (e.g. coastal foreshore or wetland areas) a community-government partnership would work well.

Table 3: Public participation spectrum, indicating coastal issues and potential levels of engagement

Increasing level of public engagement →				
Inform	**Consult**	**Engage**	**Collaborate**	**Empower**
Public participation goal To **provide** the public with balanced and objective information and assist them in understanding the problems, alternatives and/or solutions.	**Public participation goal** To **obtain** public feedback on analysis, alternatives and/or decisions.	**Public participation goal** To **work** directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	**Public participation goal** To **partner** with the public in each aspect of the decision, including the development of alternatives and the identification of the preferred solution.	**Public participation goal** To **place** final decision-making in the hands of the public.
Promise to the public We will keep you informed.	**Promise to the public** We will keep you informed, listen and acknowledge concerns and provide feedback on how public input influenced the decision.	**Promise to the public** We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	**Promise to the public** We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	**Promise to the public** We will implement what you decide.
Example tools ▪ fact sheets ▪ web sites ▪ open houses	**Example tools** ▪ public comment ▪ focus groups ▪ surveys ▪ public meetings	**Example tools** ▪ workshops ▪ deliberate polling	**Example tools** ▪ advisory committees ▪ consensus-building	**Example tools** ▪ delegated decisions

Increasing level of public engagement →				
Inform	**Consult**	**Engage**	**Collaborate**	**Empower**
Issue category[2] micro, medium scale, macro	**Issue category** micro, medium scale, macro	**Issue category** medium scale, macro	**Issue category** macro	**Issue category** macro
Relevant groups[3] service providers, stakeholders, community	**Relevant groups** service providers, stakeholders, community	**Relevant groups** service providers, stakeholders	**Relevant groups** service providers, stakeholders	**Relevant groups** service providers
Relevant decision stages[4] **4, 5, 9**	**Relevant decision stages** **1, 4, 5, 9**	**Relevant decision stages** **1, 2, 4, 5, 9, 10**	**Relevant decision stages** **all**	**Relevant decision stages** **all**

Source: Adapted from International Association for Public Participation, 2004

2 **Issue category**: ***macro*** = large scale decisions involving protection of important and extensive assets (infrastructure or natural) or major land use decision, potentially affecting a broad cross-section of the community; ***medium scale*** = decisions involving significant new public infrastructure or developments, potentially affecting multiple stakeholders; ***micro*** = small scale infrastructure or development approval, affecting only a small section of the community.

3 **Relevant groups**: ***Service providers*** = council staff, councillors, other agencies, other service providers; ***stakeholders*** = organisations or community members directly affected by the decision; ***community*** = other members of the community with an interest in the decision but not directly affected by it.

4 **Relevant decision stages** = decision process stages as outlined in Figure 3 and detailed in Part B.

Furthermore, a government driven process does not take away from the need for widespread consultation and engagement of the community (Table 3, columns 2, 3 and for some issues 4). Moreover, although most coastal adaptation issues are likely to be government driven, a collaborative approach to decision-making, involving a partnership between (say) council, other agencies and service providers, will be desirable, even necessary for many of the issues.

For any given issue, councils may choose to take a leadership role in establishing the partnership and driving the process, especially if it believes that the nature and importance of the issue warrants this. Before establishing a collaborative decision-making process, councils will need to carefully consider the agencies, authorities and other stakeholders that will need to be involved in the process (Box 4).

Communicating climate change and climate change adaptation

A major challenge for coastal adaptation decision-makers is communicating the complexities and uncertainties of climate change to the public and the basis for their decision-making in light of those uncertainties.

Considerable attention has been given in recent years to climate science communication in response to public confusion and misconceptions about the status of climate science, the causes of global warming, whether there is any, and the nature of uncertainties. Most of the literature providing guidance on improving climate science communication is targeted at climate scientists themselves (e.g. Somerville and Hassol 2011, Shome and Marx 2009). Comparatively little attention to date has been given to communicating climate adaptation decision-making and policy, an equally if not more challenging task.

Box 4: Collaborative decision-making on coastal adaptation in Victoria

Many coastal adaptation decisions, particularly those involving multi-dimensional, macro scale issues will have implications for service delivery by a range of other agencies and authorities and/ or influence the ability those agencies and authorities to meet their objectives (either positively or negatively).

Agencies and authorities in Victoria with a potential interest in the coastal adaptation decisions of councils include but are not limited to:

- adjoining local government areas;
- Building Commission;
- Central Coastal Board;
- Department of Planning and Community development (DPCD);
- Department of Sustainability and Environment (DSE);
- Melbourne Water;
- Parks Victoria;
- Port of Hastings Development Authority;
- Port Phillip and Westernport Catchment Management Authority (PPWCMA);
- South East Water;
- Vic Roads; and
- Victorian Coastal Council.

Nevertheless, some guidance in this area can be gleaned from the literature on public participation in decision-making, especially as it relates to decision-making on other environmental issues, as well as the literature on climate science communication. This literature points to a number of principles that should be followed by council decision-makers when they seek to involve the public in scientifically complex issues and/ or communicate the outcomes of decision-making processes on those issues (Box 5).

Resources and effort put into development of the consultation and engagement plan should be commensurate with the nature and scale of the issue. Thus councils need to weigh improved transparency and reduced liability achieved through public consultation against the administrative costs involved.

Of these principles, the literature is particularly strong on the importance of being explicit about reasons for a decision and about the assumptions, risks and uncertainties behind the decision. Baker & McKenzie (2011) for example, stress the importance of providing reasons for decisions (e.g. minimising development in a vulnerable area) in clear and accurate terms, including relevant laws enabling the decision.

Interestingly, the literature also highlights the importance of collaborative decision-making processes as a means of addressing complex scientific issues:

> *Environmental assessments and decisions with substantial scientific content should be supported with collaborative, broadly based, integrated, and iterative analytic-deliberative processes* (Dietz and Stern 2008).

Box 5: Principles for communicating climate science and adaptation

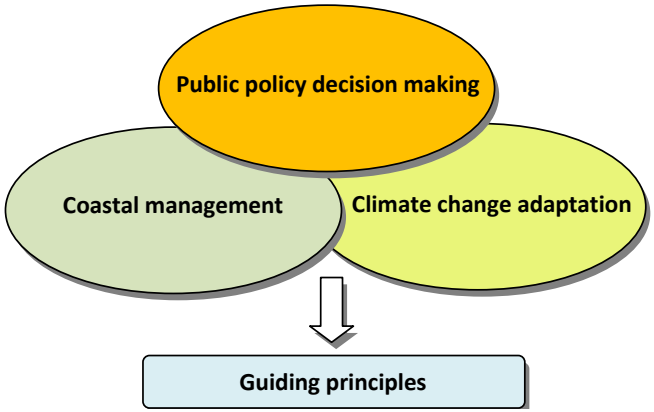
1. Ensure that decision-relevant scientific and technical information and analysis is transparent and available to the community, and is communicated in an accessible manner.
2. Be explicit about reasons for a decision, including assumptions, risks and uncertainties.
3. Pay explicit attention to both facts and values.
4. Avoid the use of emotional language or appeals.
5. Include an independent review of analysis and/or engage in a process of collaborative inquiry with interested and affected parties.
6. Allowing for iteration to reconsider past conclusions on the basis of new information and communicate the new information.

Contested values

Effective stakeholder and community engagement, collaborative decision-making and communication on climate change are critical processes to help overcome barriers to decision-making on coastal adaptation. It is important to note however, that such processes are not guarantees of success. 'Contested values' is a particular case in point. Contested values, linked to differences in perspectives on risk, culture and ethics and different levels of knowledge, present a significant barrier to decision-making on climate change adaptation generally, not just coastal adaptation. Adger et al. (2008, p.350), argue that diverse and contested values underlie adaptation responses and "*thus define mutable and subjective limits to adaptation*". These limits can be overcome – just possibly - by awareness of the diverse range of values and acceptance of some loss through change. Careful consideration of objectives (Part B, Stage 3), will be important in this respect.

Guiding principles

Decision-making on coastal adaptation should reflect both sound public policy decision-making and best practice approaches to coastal management and climate change adaptation.



Box 6 sets out twelve key coastal adaptation decision-making principles drawing on public policy decision-making principles, coastal management principles and adaptation principles. These should guide all decisions on coastal adaptation at different stages in the decision-making process. Adhering to the principles will improve the credibility and consistency of coastal adaptation decisions – within and between councils and other coastal decision-makers. They will also help guide decisions where there is uncertainty about the best way to proceed at a particular stage in the decision-making process.

Box 6: Coastal adaptation decision-making principles

1. **Objective focussed**: 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 benefits, 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 between councils, relevant agencies and authorities, and, where feasible, other stakeholders.
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.

Part B: Decision support guidance

1. Define the issue

Questions addressed in this section

- Why is it important to define the issue?
- What aspects of an issue should be defined?

Overview

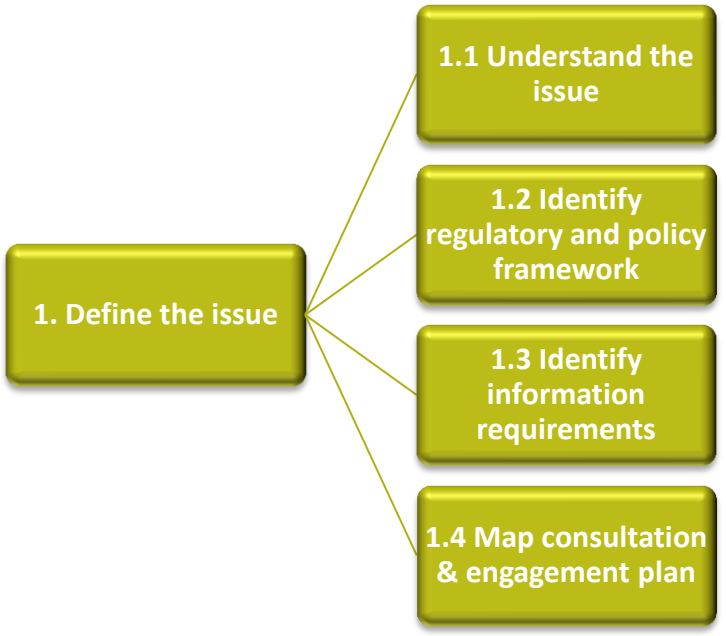
At an early stage in the decision-making process it is important that councils and other decision-makers define the issue or problem that they are seeking to address. This means:

- understanding the nature of the issue by describing:
  - the general nature and level of hazards faced and the locality or region affected
  - the category and type of issue
  - its scale
  - who is affected
  - the time horizon over which decisions may need to be made;
- identifying and understanding the regulatory and policy framework under which decisions may need to be made;
- identifying information and resource requirements and gaps; and
- understanding who will need to be consulted and engaged over the course of the decision-making process.

Issue definition is important for informing:

- the level of priority that should be assigned to the issue;
- the overall decision-making approach (i.e. whether a very comprehensive, detailed assessment is required or whether a more contained assessment will suffice); and
- other stages of the decision-making process, especially other stages of the structuring phase (i.e. clarify roles and responsibilities [Stage 2], establish the objective [Stage 3] and assess hazards and risks [Stage 4]).

Figure 9: Steps in defining the issue



Box 7: Why is it important to clearly define the issue?

A clear definition of the issue is important for framing the decision-making process. In particular it will help councils to:

- determine who will need to be engaged through the course of the process, when and how;
- formulate the objective (i.e. what they are seeking to achieve by undertaking adaptation actions);
- identify options to address the problem;
- establish the most appropriate method for assessing those options; and
- identify gaps in information needed to undertake the assessment.

For example, adaptation decisions about future land use for a substantial coastal area, encompassing a range of values and having significance for a large number of stakeholders and the broader community could potentially require:

- collaborative decision-making;
- a comprehensive and wide-ranging community engagement strategy;
- consideration of multiple options over multiple timeframes;
- a quite detailed and comprehensive assessment method; and
- substantial new information and data.

Development approval decisions on the other hand, will tend to be geographically confined, micro in scale, and have direct implications for a narrower range of stakeholders. This points to a less sophisticated assessment – one that is guided largely by legislative conditions and constraints.

Similarly, if the nature of the issue and policy objective means that it is neither necessary nor useful to value the benefits of adaptation this can substantially simplify the decision-making process.

The importance of defining the issue and carefully mapping it out is amplified for multi-dimensional issues, i.e. those issues potentially involving:

- multiple categories (e.g. land use, development approval and infrastructure dimensions);
- repeat decisions occurring over different timeframes (short, medium and long term); and
- multiple decision-makers.

For example, a decision by council about protecting an established land use (e.g. a residential area) could involve a number of layers, at different levels and over different time horizons.

- First is the question of whether to **protect** the area or to **retreat**. This decision itself requires consideration of many factors not only the impacts of the decision on residents directly affected but also flow-on effects for adjoining areas and for service providers (e.g. electricity and water services).
- If a decision is made to protect an area, an ensuing decision will centre on how best to protect it, again considering not just the direct costs of the protection measure but also indirect costs.
- A third category of decision is whether to allow new developments in the area and if so, what conditions to attach to those developments - a decision category that may play out over an extended period of time as individual development and redevelopment applications are made.
- A decision to retreat will also involve multiple layers over different time horizons, centred on the question of voluntary versus compulsory retreat.

These 'multiple dimensions' will have implications for the consultation and engagement process, the range of options that will need to be considered, the approach to assessing those options, information and data requirements and the level of monitoring required.

1.1 Understand nature of the issue

It is important that decision-makers have a clear understanding of the nature of the issue or problem to be addressed. This understanding can be gained by identifying the location or region affected and the hazards and risks driving the issue or problem at that location, defining the category and type of decision that needs to be made, its scale and the time horizon over which he decision is likely to play out.

Identify location, hazards and risks

Decision-makers should be clear on the geographic area of concern – location or region. This may be self-evident to key decision-makers, but it is important that location of the region of concern is described in as much detail as possible for the benefit of other decision-makers who could be brought into the process, as well as the organisations and community members who are likely to be consulted (see Steps 1.4 and 2.3).

It is probably beneficial to accompany the description of the area of concern with a brief, initial description of the hazards or potential physical hazards that the area faces (e.g. coastal recession, sea level rise and coastal flooding) and the risks that could stem from those hazards (i.e. to people, property, services etc). A high level, qualitative risk assessment is a useful (although not essential) way of identifying and describing these hazards and risks (see Stage 4, Box 20). This qualitative risk assessment should not be seen as a replacement for a detailed quantitative hazard and risk assessment but it could be a useful way of:

1. clarifying whether the area of concern is a high priority for decision-making on adaptation (important if the council or other decision-maker needs to prioritise between a number of locations); and
2. helping to understand the nature and level of analysis that needs to be undertaken for the quantitative hazard and risk assessment (see Stage 4).

Define decision category and type

Decision categories and types for which this framework has been developed fall into three broad categories (Table 4) and (Box 8):

- strategic land use planning;
- development approval; and
- public infrastructure and service delivery.

For each of these categories there is also the question of whether the issue can be defined as an established (legacy) use or development or a potential new (greenfield) use or development. In practice, decision-makers will often find that many coastal adaptation decisions are multi-dimensional in nature, cutting across different categories and types of issue.

Scale

There can be no definitive meaning of 'scale' in the context of council decision-making on coastal adaptation - the concept of scale will vary according to the size of the council, its income base and the size of the community that it services. In general terms however, macro scale issues will tend to be those involving an extensive area, protection of important assets (infrastructure or natural), or potentially affecting a broad cross-section of the community. As noted, land use issues tend, by their nature, to be macro in scale. By contrast, micro scale issues are those affecting values on a much smaller scale geographically (an individual lot or a few lots for example), a smaller range of values and smaller numbers of stakeholders. Thus development approval decisions at the individual lot level will tend to be micro in scale. Infrastructure decisions can vary from micro to macro in scale.

Table 4: Decision categories, types and scales

Issue category	Type	Scale	Time horizon	Example
Land use	Protection of established settlements & infrastructure	Tend to be macro in scale	Short to long term	An existing residential area is already affected by storm tides and rising groundwater. Does council protect the area and seek to maintain its current land use or enact a strategy of planned retreat?
	Protection of valued natural area (e.g. beach, foreshore, wetland)	Tend to be macro in scale	Short to long term	A beach and foreshore area is threatened by coastal recession, possibly linked to sea level rise. Does council try to protect the area? If yes, what is the most cost-effective way of doing so?
Development approvals	New developments	Tend to be micro in scale	Tends to be short term	A developer seeks approval for a new development in areas zoned residential. Should the development be approved? If so, what conditions should be attached to the development (e.g. minimum floor height, temporary use/ sunset clause)?
	Legacy developments	Tend to be micro in scale	Tends to be short term	This decision concerns a coastal erosion hotspot. Do you approve a redevelopment? If so, what conditions should be attached to the approval?
Public infrastructure management and service provision	Established or new infrastructure	Micro to macro scale	Tend to be medium to long term	Maintenance costs of local roads are increasing due to periodic inundation from storm tides. Does council continue to bear increasing maintenance costs? Does it upgrade the road to improve the ability to withstand these events (e.g. raise the road in certain locations)? Or does it look at re-routing the roads / alternative routes?
Multidimensional	Combination of above	Tend to be macro, but could have some micro elements	Can affect short, medium and long term	An existing residential area is already affected by storm tides and rising groundwater and council decides to protect the area. What is the most cost-effective way of doing so? Who pays for the protection measure? Does council allow any further developments in the area and if so, what conditions should be attached to those developments.

Box 8: Categories of issue affecting the decision-making process

Land use

Strategic land use planning is the process by which land is allocated to a variety of competing uses to provide for community welfare, balancing economic development, social amenity and environmental protection objectives. Within each land use zone, development is controlled to ensure that the objectives and values attached to that zone are being met. Within these broad categories are different types of issue relating to established and uses or new land uses (i.e. rezoning). Examples of strategic land use issues may include:

- rezoning of coastal agricultural land to accommodate future residential or commercial developments;
- a decision on whether to protect an existing development from sea level rise, storm tides and/ or coastal recession; and
- a decision on whether to protect an area of highly valued coast (e.g. beach, foreshore, wetland).

Development approval

Conditions applied to new developments or redevelopments can provide some protection against climate change hazards or the consequences of those hazards for businesses, residential property owners, service providers and others in the community. The development approval process is strongly guided by a legislative and regulatory framework, within which prescriptive, rules-based decisions are made. Within this framework however, councils still have significant discretion. Examples of development approval issues facing councils include the following:

- Whether to notify and inform landowners and potential purchasers of coastal hazards affecting a property (e.g. the use of section 173 agreements).
- Whether to permit new developments or redevelopments in vulnerable areas.
- If so, whether current building and design standards are adequate.
- If changing standards, what is good practice and what are the costs and benefits of upgrading standards?
- Whether standards will need to change over time and if so, what should trigger those changes?

Infrastructure management and service provision

A range of public assets are at risk from climate change in coastal areas, including roads and other transport infrastructure, water, wastewater and stormwater infrastructure, energy and telecommunications, community assets (schools, hospitals etc.) and coastal infrastructure (e.g. piers, jetties, sea walls, foreshore reserves). Councils have direct management or shared management responsibility for only some of these assets (e.g. local roads, stormwater assets, foreshore reserves) but have a stake in other infrastructure for its contribution to community viability. Examples of issues faced by infrastructure managers include:

- whether to protect the assets in the face of actual or potential climate change impacts, whether to wear increased maintenance costs, whether to upgrade and redesign them, or whether to move them elsewhere, considering the timing of climate change impacts and the costs, benefits and timing of these options;
- the indirect effects of decisions on the viability of affected communities; and
- the indirect effects of decisions on other infrastructure and service providers.

Time horizon

As with scale, there is no definitive meaning attached to the concept of time when considering decision-making on coastal adaptation. Generally however, councils should seek to align decisions on coastal adaptation actions with the time horizons attached to its other planning and decision-making processes, for example:

- short term actions and decisions will be aligned with annual planning processes and time horizons (e.g. within 1-2 years);
- medium term actions and decisions will be aligned with strategic planning processes and time horizons (e.g. 5-10 years plus);
- long term actions are those that can be delayed until well after strategic planning time horizons (e.g. 20 years plus).

1.2 Identify and understand the regulatory and policy framework

As part of the process of defining the issue, decision-makers will need to identify and assess the requirements of the regulatory and policy frameworks under which the issue or problem may fall and consequently under which a decision is likely to be made.

These frameworks may contain binding requirements that a decision-maker must comply with in making a decision and may also provide further guidance in determining who is responsible for decision-making, issues to be considered and who should be consulted in relation to a decision. Regulatory and policy frameworks comprise of many different instruments that have a variety of legal force.

Laws, regulations, planning instruments and policy documents are living documents and are subject to amendment, repeal and replacement. It is important to verify the current status of documents before applying them to decision-making.

Councils may need to consider seeking preliminary legal advice where there is uncertainty regarding whether or not a law applies to decisions regarding an issue or problem.

1.3 Identify information and resource requirements and gaps

As part of the process of defining the issue, decision-makers should map out information requirements for the decision-making process. Generally speaking, these requirements fall into three main categories:

1. **Hazards and risks.**

   Information on physical hazards and the risks to people, assets and services will be critical to understanding the benefits, timing of adaptation – i.e. what will be at risk and when if adaptation does not take place, and associated uncertainties. This information will generally be acquired through a hazard and risk assessment (Stage 4). To that end, it is important to understand whether there are any gaps in hazard assessments that may have already been completed.

2. **Other information necessary to assess options.**

   This will include information on the costs and technical feasibility of options. Typically, it will be acquired as part of the detailed assessment of options (Stage 7).

3. **Resource requirements.**

   Councils and other decision-makers should seek to identify the resources (both internal and external) that could be required over the course of the decision-making process, including financial resources, staff resources and contractors. They will need to understand whether, given the nature and scale of the issue, it is desirable or feasible to allocate the desired level of resources to the process and, if not, how the process can be modified to ensure that it fits with available resources.

   On this point it is important to note that although a systematic application of a structured decision-making process, such as the one outlined in this Guide, would appear to be a resource intensive exercise, its application could well lead to saving in time and resources in the long term compared to a more ad hoc decision-making process that initially seems economical, but leads to decisions having to be constantly revisited. Furthermore, familiarity with the process will lead to efficiencies in its application.

1.4 Map consultation and engagement plan

The central role of consultation and engagement to the decision-making process is discussed at length in Part A. Effective consultation and engagement will not only aid the decision-making process but, as noted by Baker & McKenzie (2011), will also limit potential liability for climate change decisions and actions (or inactions). Given the importance of effective consultation and engagement, it is critical that councils and other decision-makers map out a consultation engagement plan.

It may be necessary to map out separate consultation and engagement processes for different sections of the community. Councils, for example, may wish to differentiate between:

- elected councillors;
- other agencies and service providers who have direct roles and responsibilities in relation to the issue and are likely to be partners in the decision-making process (see Stage 2);
- stakeholders (e.g. community members) likely to be directly affected by the decision; and
- interested but perhaps less directly affected sections of the community.

The consultation and engagement plan should detail:

- who will be consulted and engaged;
- when in the process they will be engaged (i.e. the stages); and

- what form the consultation and engagement will take.

This last point is critical, particularly where a distinction is drawn between stakeholders who have been identified as likely partners in the decision-making process and those whose role will be confined to information provision and consultation (see Part A, Community Engagement, Consultation, & Communication).

Figure 10: Stakeholder engagement should encompass local businesses and residents directly affected by coastal impacts and adaptation decisions

Source: SECCCA

Stage 1 checklist

Step 1. Understand the issue

- Where is the affected region or locality and what is the general nature and level of hazards and risks faced? Is this a priority area for adaptation response?
- What is the category and type of decision to be addressed? What is its scale?
- What is the time horizon over which decisions will need to be made?

Step 2. Identify information requirements and gaps and resource requirements

- Has a quantitative hazard and risk assessment already been completed for the affected locality / region?
- Does it address all key hazards and risks?
- If no, what information is missing?
- What additional information (not linked to hazards and risks) could be required to complete the decision-making process?
- Is this information readily available? If not, how can it be obtained?
- What resources (financial, staffing, other) are required for the decision-making process? Are these resources available?

Step 3. Map out engagement and consultation plan

- When (at what stages) and how should elected councillors be engaged and consulted through the course of the decision-making process?
- When and how should other stakeholders and the broader community be engaged through the course of the decision-making process?

2. Define roles & responsibilities

Questions examined in this section

- Who has responsibility for decision-making on coastal adaptation?
- Where council has clear responsibility, what are the constraints and conditions imposed by legislation and planning frameworks?
- How can/should councils deal with shared responsibilities?
- What are the barriers to defining and understanding roles and responsibilities and how can they be overcome?

Overview

Early in the decision-making process it is important that councils and other decisions makers clarify roles and responsibilities for addressing the identified 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 a number of 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.

Figure 11: Steps in clarifying roles and responsibilities

This section of the Guide:

- provides a high level overview of existing roles and responsibilities for coastal planning and infrastructure management in Victoria;
- examines steps for defining roles and responsibilities, including how councils should deal with shared responsibilities or situations where primary responsibility rests with another agency; and
- outlines the barriers and uncertainties regarding councils' responsibilities and suggests how councils may overcome some of those barriers.

Outline of responsibilities in Victoria

Responsibility for land use planning and management in Victorian coastal areas is shared between state government, regional authorities (e.g. coastal boards and CMAs), local councils and other local bodies (e.g. committees of management). This shared responsibility extends to managing coastal climate change risks, which are defined in some, but not all relevant legislation, policies, planning provisions and guidelines (Table 5).

The Victorian Government establishes the legislative and policy framework within which State government agencies, local councils and other planning and management bodies operate (see Box 9 and Figure 12). Under the *Coastal Management Act 1995*, planning and management of coastal Crown Land is shared between the Victorian Coastal Council and Regional Coastal Boards, which are responsible for preparing the Victorian Coastal Strategy and Coastal Action Plans respectively, and local Committees of Management, which are responsible for preparing Coastal Management Plans for coastal Crown Land reserves and the day to day management and maintenance of infrastructure on those reserves.

Under the *Planning & Environment Act 1987*, local councils are generally responsible for planning scheme amendments and determining planning permits in coastal areas. However, decisions on permit applications may be reviewed by the Victorian Civil and Administrative Tribunal (VCAT) and the Minister for Planning retains an overriding power through his ability to "call in" applications, and have the final decision on both the preparation and approval of planning scheme amendments. Particular use and development, often infrastructure related, may also be exempted from planning scheme provisions.

In addition to planning legislation councils may also need to consider land management and property rights law when responding to climate change. Two key aspects of property law that should be remembered when dealing with coastal adaptation include:

- the acquisition by councils of rights in private freehold, either in the form of full fee-simple ownership or lesser interests such as covenants, easements, and section 173 Agreements; and
- the granting of property rights through leases and licences to private tenants – such tenures being legally (or politically) binding contracts and hence a potential source of considerable risk.

It is essential that any analysis proceed from recognition of the distinctions between control of land and the exercise of planning functions in relation to land. These distinctions are clarified in Table 6B.

Table 5: Addressing coastal climate change risks in policy & legislation

Legislation / policy instrument	Addresses coastal climate change risk?
Statewide coastal policy (Victorian Coastal Strategy 2008)	✓
Mandatory Sea Level Rise benchmarks (contained in Clause 13.01-1 of the State Planning Policy Framework)	✓
Coastal manuals or guidelines (e.g. Victorian Coastal Hazard Guide and DPCD Practice Note 53)	✓
Climate change specific legislation (*Climate Change Act 2010*)	✓
State-wide climate change policy/ plan (Climate Change White Paper Action Plan)	✓
State-wide climate change adaptation plan	x
Planning legislation	x
State-wide planning provisions	x
Ministerial planning direction (Ministerial Direction No. 13 under *Planning and Environment Act 1987*)	✓
Planning certificate disclosing coastal climate change risks	x (1)

Source: Based on Blake & Dawson 2011, p.30. Note: (1) Coastal climate change risks may be disclosed through the requirement to provide information as to planning scheme provisions (section 173 Agreements).

Box 9: Parties with responsibilities for planning and management in Victorian coastal areas

Agencies with responsibilities for climate change adaptation in the coastal zone through planning and infrastructure management include:

- Public authorities that own infrastructure that may be affected by planning, e.g. ports, Melbourne Water, South East Water, VicRoads and Emergency Services;
- Committees of Management responsible for Crown lands in Victoria, including coastal lands, as well as associated coastal infrastructure, including natural assets;
- State Government agencies: the Victorian Department of Sustainability and Environment; the Victorian Department of Planning and Community Development; and Victorian Coastal council and regional coastal councils - in particular in the case of the SECCCA, the Central Coastal Council.

Table 6A: Roles and responsibilities for coastal planning and infrastructure in Victoria

Legislation	Function/activities	Prepared/actioned by	Ultimate responsibility
Emergency Management Act	Management flood and storm event management	Department of Emergency Services/ Local councils	Minister for Emergency Services
Planning & Environment Act 1987	Planning scheme amendments Determining planning permits Undertaking referrals as part of planning permit process	Planning Authority (generally local councils) Responsible Authority (generally local councils) CMAs; DSE	Minister for Planning
Coastal Management Act 1995 (CMA)	Preparing Victorian Coastal Strategy Preparing Coastal Action Plans Preparing Coastal Management Plans Determining CMA consents	Victorian Coastal council Regional Coastal Boards Committees of Management DSE	Minister for Environment and Climate Change (MECC)
Crown Land (Reserves) Act 1978	Reservation of Crown land Specification of primary purpose of Crown land Management of coastal Crown land Preparing regulations for Crown land Appointment of Committees of Management Granting of tenures in the form of leases and licences	Committees of Management	MECC
Marine Act 1988 and the Port of Melbourne Authority Act 1958	Management of piers/jetties and recreational boating	Port Manager (Parks Victoria, Gippsland Ports etc)	Minister for Ports
National Parks Act	Management of National Parks along the coast	Parks Victoria	MECC

Legislation	Function/activities	Prepared/actioned by	Ultimate responsibility
Water Act	Preparation of flood studies & floodplain management plans	CMAs	Minister for Water
Land Act	Governing of unreserved Crown land Granting of tenures over Crown land Transfer of land between Crown and freehold	DSE	MCEE
Aboriginal Heritage Act Traditional Owners Settlement Act	Protection of Aboriginal rights and values	Victorian Aboriginal Heritage Council Aboriginal Affairs Victoria	Minister of Aboriginal Affairs
Local Government Act	Determination of councils' seaward boundary	Local Government Victoria	Minister for Local Government
Subdivision Act	Procedure for the subdivision and consolidation of land	DSE DPCD	MCEE, Minister for Consumer Affairs and the Minister for Planning
Road Management Act	Governing of roads and roadways	VicRoads	Minister of Roads

Source: Mornington Peninsula Shire, additional material in this table has been provided by The Public Land Consultancy (http://www.publicland.com.au/)

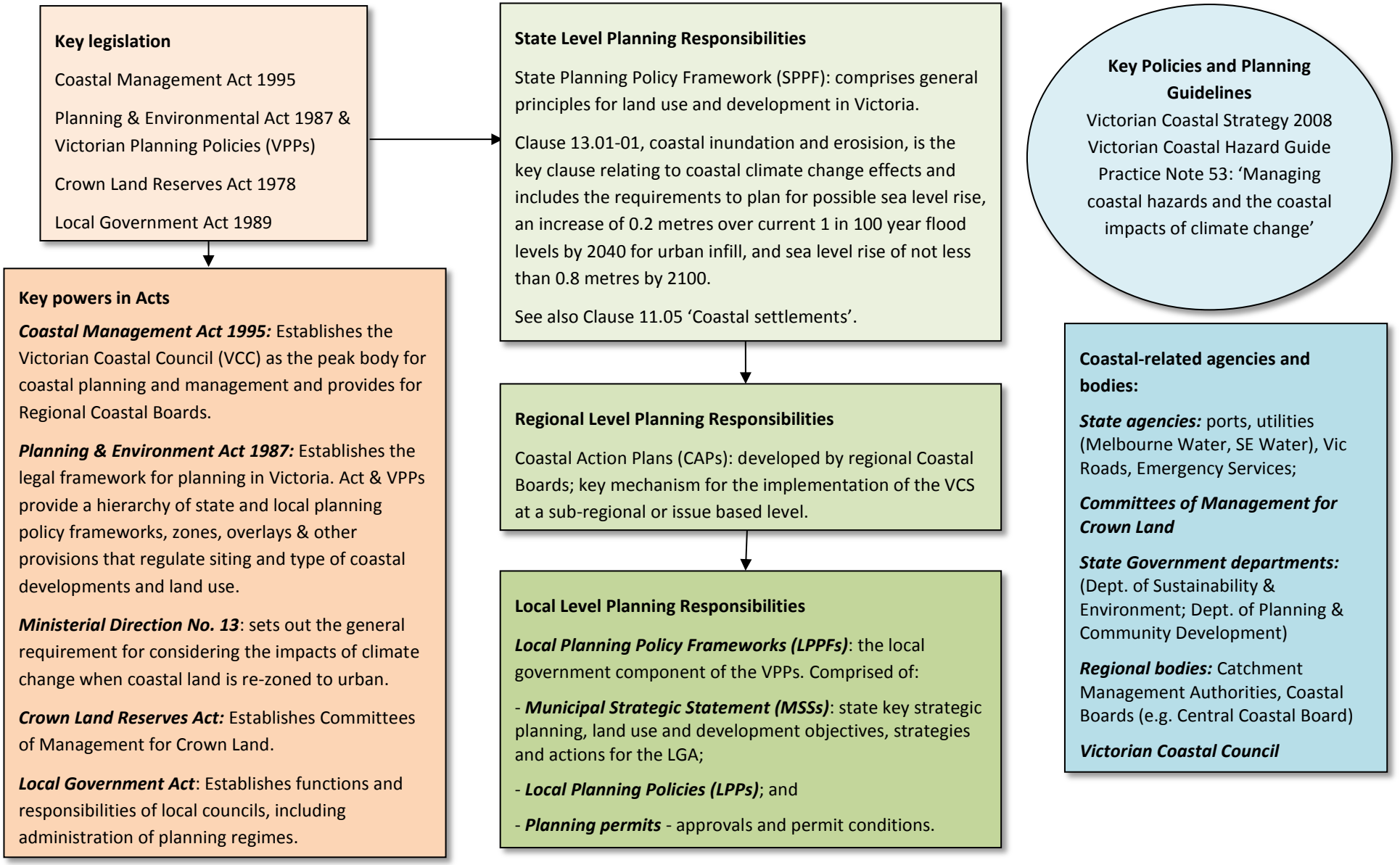
Table 7B: Coastal Land Law

Feature of the Cadastre	Relevant Legislation or law	Relevance to a coastal council
Land Status Every piece of land in Victoria (indeed in Australia) is either Crown land or freehold land. Crown land may be undifferentiated 'default status' Crown land, or may have some further sub-status - e.g. Government road, Crown Reserve or National Park. For Crown land, Native title may be a significant consideration. Freehold land may include roads and reserves.	▪ Land Act 1958 ▪ Crown Land (Reserves) Act 1978 ▪ National Parks Act 1975 ▪ Native Title Act (C'wealth) ▪ Common law Doctrine of Accretion ▪ Subdivision Act 1988	▪ All off-shore land in Victoria is Crown land. Most is undifferentiated 'default status' Crown land; some is Reserved Crown land; some is Marine National Park. ▪ Over 95 percent of the Victorian foreshore is Crown land, less than 5% is freehold. ▪ The Crown land is mostly reserved under the Crown Land (Reserves) Act for 'public purposes;' some is reserved under that Act for other purposes. ▪ Some (e.g. the Shire of Mornington Peninsula's ocean foreshore) is National Park.
Land Ownership All freehold land has an owner, typically a private or corporate entity Crown land may be regarded as being 'owned' by the Crown – represented for our purposes by the Minister for Environment and Climate Change (MECC).	▪ Land Act 1958 ▪ Transfer of Land Act 1958 ▪ Common law of adverse possession	▪ Shire of Mornington Peninsula and City of Bayside both own foreshores in freehold. ▪ Councils own most freehold roads. ▪ Councils may own other freehold property. ▪ The Commonwealth of Australia owns parts of Point Nepean in freehold.
Lesser Interests Interests other than proprietary ownership are recognised and protected by property law. They are negotiable (may be bought and sold) and compensable (may be acquired by negotiation or compulsion).	▪ Land Act 1958 ▪ Property Law Act ▪ Transfer of Land Act 1958 ▪ Crown Land (Reserves) Act 1978 ▪ Land Acquisition and Compensation Act 1986 ▪ Conservation Forests and Lands Act 1987	▪ Tenants (with leases or licences) may hold (or be treated as if they hold) a legal interest in either freehold or Crown land. ▪ Councils may take freehold land or Crown land on lease. ▪ Councils may be the beneficiaries of easements, covenants, or 's.173' agreements over freehold land.
Control of land Often (but not necessarily) the owner of land is also its controller. With Crown land, it is not uncommon for the Crown to vest or delegate control in some public-sector entity.	▪ Port Management Act 1995 ▪ Road Management Act 2004 ▪ Crown Land (Reserves) Act 1978	▪ Port lands are Crown land where control has passed from the Crown to a Port Authority. ▪ All coastal councils are Committees of Management with control over some coastal Crown land reserves, under delegation from the MECC. Some of this reserved Crown land may extend seaward beyond the municipal boundaries. ▪ Committees of Management for other reserved Crown land may be local citizens or bodies such as Parks Victoria. ▪ Arterial roads are Crown land where control has passed to VicRoads as Coordinating Road Authority. ▪ Other Government roads are Crown land where control has passed to Councils as Coordinating Road Authorities.

Feature of the Cadastre	Relevant Legislation or law	Relevance to a coastal council
Management of land Often (but not necessarily) the controller of land is also its manager. On public land, some aspects of management may be delegated to tenants, friends' groups, or Section 86 Committees.	▪ Road Management Act 2004 ▪ Crown Land (Reserves) Act 1978 ▪ Local Government Act 1989 ▪ Common law governing tenures and contracts	▪ Councils may manage land they control, or contract it out, or sub-delegate to a committee under the Local Government Act. ▪ Land subject to a tenure (lease or licence) will be managed by the tenant.
Development and Use Approvals Public agencies may exercise powers and functions in relation to land which they do not own, control, occupy or manage. These are generally reactive rather than proactive powers; negative restraints on the owners' rights rather than positive compulsions on the owners' rights. Included here are: ▪ Making planning schemes ▪ Administering planning schemes ▪ Making and administering controls other than planning schemes	▪ Planning and Environment Act 1987 ▪ Aboriginal Heritage Act 2004 ▪ Coastal Management Act 1995 ▪ Local Government Act 1989 ▪ Water Act 1989 ▪ Marine Act 1988 ▪ Catchment and Land Protection Act 1994	▪ Councils are both Planning Authorities and Responsible Authorities for their municipal areas – plus (in the case of some councils) a band of off-shore land up to 600 metres wide, seaward of Low Water Mark. ▪ As local government, Councils exercise powers and functions in relation to all land within their municipal boundaries – regardless of its cadastral status. ▪ For most coastal councils, their municipal district ends at Low Water Mark. For the City of Greater Geelong, the municipal boundary extends 200 m into Corio Bay. ▪ Parks Victoria is Waterway Manager for Port Phillip and Westernport under the Marine Act. ▪ Catchment Management Authorities (CMAs) have regional waterway, floodplain, and drainage powers under the Water Act 1989 in non-metropolitan Victoria. ▪ Melbourne Water exercises regional waterway, floodplain, and drainage powers in metropolitan Melbourne.
Making the law State Parliament makes primary legislation (i.e. Acts). Ministers (or their delegates within government agencies) apply the law as empowered to do so by legislation. The Governor-in-Council or Ministers make most subordinate legislation (e.g. regulations). Councils make local laws and prepare Planning Scheme Amendments. Courts make the common law.	▪ Federal Constitution ▪ Offshore Constitutional Settlement 1979 etc ▪ Constitution Act 1975 ▪ Subordinate Legislation Act 1994 (Vic) ▪ Local Government Act 1989	▪ The parliament enacted the Crown Land (Reserves) Act in 1978 and since then has amended it 99 times. ▪ The Minister for Environment and Climate Change (MECC) causes Crown land to be reserved under the Act, makes regulations for those reserves, appoints Committees of Management for them, approves tenures (leases and licences) over them, etc. ▪ Coastal freehold boundaries may be affected by the doctrine of accretion (court-made or common law) which holds that boundaries defined by topographic features may move over time.

Source: The Public Land Consultancy (http://www.publicland.com.au/)

Figure 12: The Victorian legislative and policy framework relevant to coastal planning



Box 10: Coastal infrastructure responsibilities in Victoria

As well as their planning responsibilities, local governments also have a strong role in the provision and maintenance of local infrastructure in the coastal zone, including built assets (local roads, coastal infrastructure such as toilet blocks, jetties, walkways etc.) and natural assets (beaches, foreshores, parks).

In some cases, responsibilities are shared with State agencies / utilities, with local governments often responsible for 'local' and smaller scale infrastructure and State Government responsible for larger-scale and more regionally based infrastructure. For example, Vic Roads in Victoria is responsible for management of State roads and highways, with councils responsible for local roads. In addition, State and local governments share responsibility for beach and foreshore management.

Table 8 outlines the main infrastructure types in the coastal zone and associated roles and responsibilities at State and local government levels. It also indicates where responsibilities are shared and whether they are well defined.

In general, where responsibilities are shared, they tend to be quite well defined - e.g. local roads versus State roads. The exception tends to be maintenance of coastal foreshore infrastructure, where there is some uncertainty about the responsibilities of councils versus the responsibilities of Committees of Management for Crown Land. For example, the maintenance of infrastructure in coastal foreshore areas (piers, jetties, toilet blocks etc.) is managed by local committees reporting to council. However, because they do not collect rates for these areas there is limited incentive for council to maintain the infrastructure.

In addition to the issue of responsibility for foreshore management, there are also uncertainties around defining responsibility for coastal protection infrastructure, particularly in relation to shared responsibilities with private owners.

Table 8: Responsibilities for coastal infrastructure

Level of government	Responsibilities re coastal infrastructure	Are shared responsibilities clearly defined?
Local government	Roads - local and urban roads	✓
	Stormwater infrastructure	✓
	Coastal protection infrastructure	?
	Foreshore infrastructure – shared with State / Crown Land Committees of Management, council responsible for some coastal reserves, access ways, foreshore recreational areas	? ✓
	Environmental assets – shared responsibility with State.	✓
Victorian government and energy and water authorities	Roads - regional and State roads	✓
	Energy infrastructure	-
	Water infrastructure	-
	Foreshore infrastructure – shared with local governments. State responsible when assets on Crown Land.	?
	Environmental assets – State responsible for State forests and parks, Committees of Management responsible for beaches & foreshores classified as Crown Lands.	✓

Local councils also have responsibility for the management of significant public infrastructure located in coastal areas, as do a range of other Victorian government agencies and energy and water authorities (Box 10).

The Federal Government's role is limited primarily to high level national policy setting, funding and research, although there may also be an approval role for the Federal Minister for the Environment (through the *Environmental Protection and Biodiversity (EPBC) Act 1999*) if a proposed activity is likely to have a significant impact on a matter of national environmental significance such as a nationally listed threatened species or Ramsar wetlands.

In general terms, roles and responsibilities appear to be reasonably well defined for coastal issues in Victoria, although there is a need for greater clarity around responsibility for funding and managing coastal protection works and other coastal infrastructure, especially for infrastructure located on Crown Lands (Box 10). Uncertainty can also arise where coastal management issues are multi-dimensional, resulting in shared or multiple responsibilities at different stages of the decision-making process.

Where councils are confident that established legislative and policy frameworks provide sufficient guidance to define roles and responsibilities at a high level, the next set of questions for them become:

- ***where council has clear responsibility for an issue***: what are the constraints and conditions imposed by the legislative and policy framework on council decision-making? Are internal roles clearly understood? Are there adequate resources and support to fulfill council's responsibilities?
- ***where there are shared responsibilities****:* again, what are the constraints and conditions imposed by the legislative and policy framework? How can / should council deal with shared responsibilities and multi-layered decisions?
- ***where another agency has clear responsibility***, what is the role of council when other decision-makers have the primary responsibility?

These questions and the resulting decision pathways are discussed in more detail in the following sections. The importance of understanding policy and legislative frameworks and the conditions and constraints that they impose on councils is discussed in each case, as is the importance of identifying the roles of other parties in the context of a collaborative decision-making process.

It should also be noted that there may be a need for councils to seek readjustments of planning, management and property rights using existing law and/or advocate for improvements to existing law.

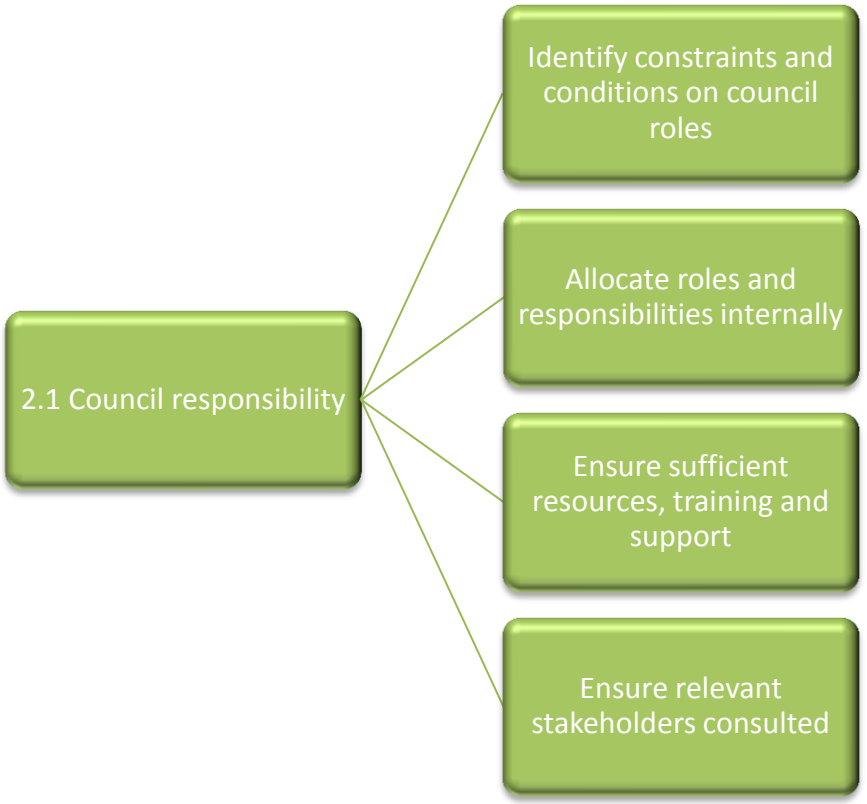
2.1 Decision pathway where council has clear responsibility

If Council determines that it has primary responsibility for a coastal planning or infrastructure decision, there are a number of subsequent steps that it should seek to follow:

- establish the constraints and conditions imposed on its roles 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.

These steps are outlined in Figure 13.

Figure 13: Steps in defining roles and responsibilities when council has primary responsibility



Constraints and conditions imposed by legislation and planning frameworks

As well as defining roles and responsibilities, the existing legislative and planning frameworks impose certain constraints and conditions on council decision-making. For instance, in Victoria, Clause 13.01-1 of the State Planning Policy Framework (SPPF), requires that councils plan for a possible SLR of 0.2 metres by 2040 (for urban infill) and SLR of 0.8 metres by 2100. Box 11 provides more detail on this and other conditions and constraints. It is important that councils understand these constraints and conditions on their roles and responsibilities when making coastal adaptation decisions regarding planning and infrastructure management.

In some cases, Council may feel that constraints are so great (e.g. insufficient advice or guidance at the State Government level) that it is reluctant to make a decision until policy or institutional reforms have been implemented. If this is the case, the focus of decision-making will shift to consideration of:

- whether decision-making on the issue can be delayed until the necessary reforms have been achieved;
- what reforms are required; and
- how they can be effected.

Box 11: Constraints and conditions imposed by legislation and planning frameworks on council roles and responsibilities

Following are some requirements or constraints on councils' role in coastal adaptation decision-making as established through:

The Victorian SPPF, clause 13.01-1, coastal inundation and erosion:

In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill).

Plan for possible sea level rise of 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes and local conditions such as topography and geology when assessing risks and coastal impacts associated with climate change.

Consider the risks associated with climate change in planning and management decisionmaking processes.

For new greenfield development outside of town boundaries, plan for not less than 0.8 metre sea level rise by 2100.

Ensure that land subject to coastal hazards are identified and appropriately managed to ensure that future development is not at risk.

Ensure that development or protective works seeking to respond to coastal hazard risks avoids detrimental impacts on coastal processes.

Avoid development in identified coastal hazard areas susceptible to inundation (both river and coastal), erosion, landslip/landslide, acid sulfate soils, bushfire and geotechnical risk.

Clauses 11.05-5 'Coastal settlement' also imposes conditions on planning with which councils should be familiar.

Allocating roles and responsibilities internally

Councils should ensure that roles and responsibilities for the decision-making process have been identified and allocated internally. Measham et al. (2011) note that planning for climate change is often viewed as exclusively or largely an environmental issue, and thus the issue is often consigned to the environment department. Often however, coastal adaptation decisions will have wide ramifications, necessitating the involvement of staff across a number of council departments.

Ensuring adequate resources and support

Further to Steps 1.1 and 1.2, councils should ensure that adequate resources and support have been allocated to the decision-making process, commensurate with the nature and scale of the issue. This includes ensuring that relevant staff are adequately trained to deal with the issue, have sufficient information on which to base the process and are allocated sufficient time to undertake the process. Adaptation literature emphasises that lack of leadership can be a key barrier to adaptation occurring in practice (e.g. see Measham et al., 2011, Moser & Ekstrom, 2010). To the extent possible, internal leadership, through support from within a council's senior ranks can ease adaptation barriers by ensuring resource and information needs are met, and enabling coordinated decision-making within a council (Critchley and Scott 2005, cited in Measham 2011).

Engage relevant stakeholders and communicate

Finally, councils should ensure that relevant stakeholders are consulted and engaged through the decision-making process in accordance with the consultation and engagement plan mapped out in Step 1.4. To that end, councils will need to consider carefully whether and how to involve landholders, business and other community stakeholders in the decision-making process. As discussed in Part A of the Guide, Stakeholder Consultation and Engagement, involvement of the community in the decision-making process could range from a genuine council/ agency/ community partnership (particularly pertinent for decisions involving areas of public land where community organisations already play an active role in their management (e.g. coastal foreshore areas)), to effective consultation and engagement of community members about decisions, but with no direct role for them in actual decision-making.

At the very least council and other organisations with shared responsibilities should instigate full and open communication of climate change facts, risks and decisions to affected members of the community. This will not only aid the decision-making process in the long term but, as noted by Baker & McKenzie (2011), will also limit potential liability for climate change decisions and actions (or inactions). Providing property owners with timely and transparent information, such as best available flood mapping and data for example, will assist property owners to adjust their own expectations of the types of development that will be allowed and help avoid planning challenges.

2.2 Decision pathway when there are shared responsibilities

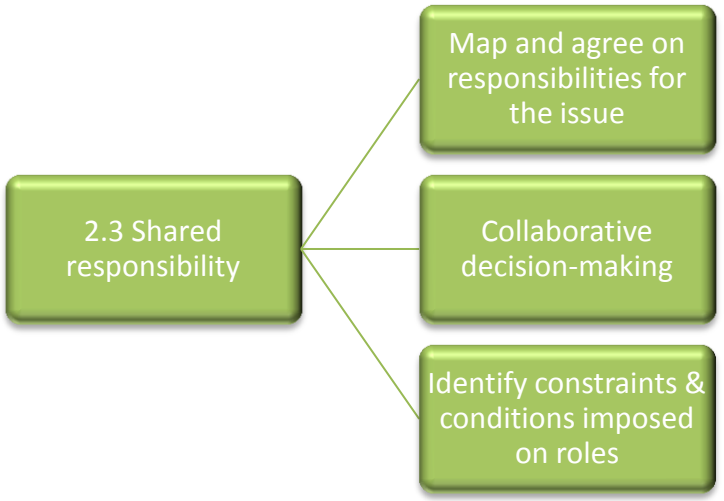
In many instances, responsibilities for coastal planning or infrastructure issues will be shared. In these cases, it is extremely important that decision-makers map and agree on responsibilities for each aspect of the issue, identify constraints and conditions on roles & responsibilities and, as far as practical establish a collaborative decision-making process. These steps are set out in Figure 14 and discussed below.

Map and agree on responsibilities for each aspect of the issue

One of the major difficulties / complexities in allocating roles and responsibilities for decision-making on coastal adaptation is that issues often involve multiple layers. As a consequence, there are corresponding layers of responsibility that may belong to different parties at different levels. Moser (2009) for instance comments:

> *Those involved in organizing, shaping and steering [adaptation] efforts will have to navigate and manage a system made up of multiple actors with a variety of interests, capacities and challenges, often spanning several sectors. Moreover, many (if not most) locally planned adaptation decisions and actions require assistance from, or at least coordination with, higher levels of government - thus bringing additional actors to the table. In turn, adaptation ... requires ... consent from voters and ... (potentially) affected stakeholders in business and civic society..." (p.31).*

Figure 14: Steps in defining roles and responsibilities when responsibilities are shared



While in some cases shared roles will be reasonably clear, for many issues, particularly so for multi-dimensional ones, the nature and allocation of roles & responsibilities could be quite complex or at least not immediately apparent. This highlights the importance of council and other relevant decision-makers mapping out roles & responsibilities, with the aim of identifying and achieving consensus on these roles & responsibilities at each stage of the issue. Mapping the issue at hand will entail breaking it down into its components/sub-issues and clearly assigning responsibilities at all stages in the process. The process of mapping roles and responsibilities will assume importance for subsequent stages of the decision-making process, including in particular decisions on:

- establishing the primary objective and constraints in relation to the issue (Stage 3);

- identifying and assessing options (Stages 5 and 6 respectively); and
- implementation and cost sharing (Stage 9).

All relevant parties should be clear and agree on responsibilities for different aspects of the issue and decision-making process. In some cases, where responsibilities are shared but not well defined by legislation, regulations or administrative precedence[5], councils and other agencies should seek a negotiated outcome, whereby one or other party agrees to take primary responsibility for the issue or an undefined aspect of the issue. If parties cannot reach agreement though, councils (and indeed other decision-makers) will need to decide whether the issue is significant enough to warrant being prepared to take on that responsibility. On this point, the Productivity Commission (2012), in its draft report *Barriers to Effective Climate Change Adaptation*, notes three situations in which councils should not bear responsibility for coastal adaptation (Box 12). In these instances, the Productivity Commission suggests that regional, State or Territory, or national approaches may be more appropriate.

There may be cases where uncertainties about allocation of roles and responsibilities are so great that councils will be reluctant to take the decision-making process any further until roles & responsibilities have been clarified (e.g. through legislative reform). As discussed further in Box 15, there is a strong case for greater State government guidance, coordination and support of council actions in this regards.

[5] For example, some SECCCA member councils have noted that there is uncertainty about the degree of responsibility for managing damage to or loss of beaches, for which councils and the Committees of Management for Crown Lands share responsibilities.

Box 12: Cases where local government may not be the appropriate level of government to undertake adaptation actions

Local governments may not be the appropriate level of government to provide effective adaptation responses in the following situations.

- Where local government actions have positive or negative impacts on other jurisdictions. For example, a local government may invest in a seawall that protects properties within its jurisdiction, but creates erosion in neighbouring local government area. Alternatively, a local government may decide not to protect a beach or area of national environmental significance from the effects of climate change.
- Where there are areas of shared interest or there are economies of scale from a more centralised or coordinated provision of services. For example, it may be more efficient to undertake climate change modelling at a national, State or territory level. Similarly, it may be more efficient to undertake risk assessments at a regional scale through groups of councils, rather than by each individual council.
- Where diversity in local government approaches to adaptation may impose costs that exceed the benefits. For example, there is a tension between allowing local governments to tailor responses to their own circumstances and minimising costs for businesses that operate across jurisdictions, such as property development.

Source: Productivity Commission 2012

Box 13: Example: roles and responsibilities for decision-making in a multiple use area affected by coastal hazards

A multiple use coastal area is currently subject to irregular and relatively minor inundation from storm surges, but sea level projections indicate that the area will be subject to more frequent and severe inundation in the future. Council is under pressure to allow further development in the area in question and must decide whether to permit these developments and, if so, under what conditions. The allocation of roles and responsibilities for decision-making will vary depending on tenure and zoning of the land in question and the range of services provided. In this case though, zones are assumed to include a mix of coastal reserves, public open space and private land (principally residential and commercial). Relevant services include transport (road access) utilities (water, electricity, gas, telecommunications, waste). Thus roles and responsibilities are likely to be shared between council, utilities / service providers, state government and private landholders.

Council has the main responsibility for making a decision on whether to permit intensification of development and redevelopment in the area, and if so, under what conditions. However, asset managers and service providers (including Vic Roads and utilities) have an interest in the issue both from the perspective of protecting and maintaining existing infrastructure but also in the implications of further development for future service provision. There are also emergency service considerations (e.g. access). Private landowners/ residents also have roles & responsibilities in relation to the issue, beyond simply being passive recipients of decisions. The role of private landholders includes contributing to decisions about who will pay for options (Are residents willing to pay?) and taking responsibility for actions to build personal/ household resilience.

Councils could make a proactive decision about the use and development of the land, where they actually own coastal land, public open space or roads.

The following diagram provides a summary of the issues associated with a decision on whether to allow further development, and responsibilities for decision-making on the issue.

Figure 15: Steps in defining roles and responsibilities when responsibilities are shared

Engage in collaborative decision-making

The decision-making organisation with primary responsibility for an issue should seek to involve other decisions makers in a collaborative decision-making process. This will mean:

- ensuring that clear lines of communication and liaison are established between council and other organisations sharing responsibilities; and
- providing relevant organisations with an opportunity to provide input and feedback on all relevant aspects of the decision and keeping them fully informed on aspects of the decision-making process where they do not have a direct role.

A joint decision-making committee may be an appropriate forum in many instances for facilitating the collaborative process.

Establish / understand constraints and conditions on shared decision-making

The legislative and planning framework can impose conditions regarding shared responsibilities for coastal planning issues. Some relevant conditions are set out in Box 14. Councils should ensure that they are familiar with any such constraints, as discussed in the section above in relation to decision-making where councils have primary responsibility.

Box 14: Constraints / conditions imposed by legislation and planning frameworks on shared responsibilities

Following are some requirements for shared responsibilities in coastal adaptation decision-making:

Crown Land (Reserves) Act 1978: Establishes that councils and others, including individuals, may be established as Committees of Management for Crown Land which has been reserved as a public park, garden, or for recreation purposes. Can result in a situation where a small section of coastline is managed by a number of different bodies.

Planning & Environment Act (s12): establishes that councils share or hand over planning responsibilities to the Minister in certain situations – that is, the Minister becomes the consent authority in place of councils. This occurs in the case of matters of State or regional planning significance or certain large scale developments.

Coastal Management Act 1995: establishes the Victorian Coastal council (VCC) as the peak body for coastal planning and management and provides for the Regional Coastal Boards.

2.3 Decision pathway where another agency has primary responsibility

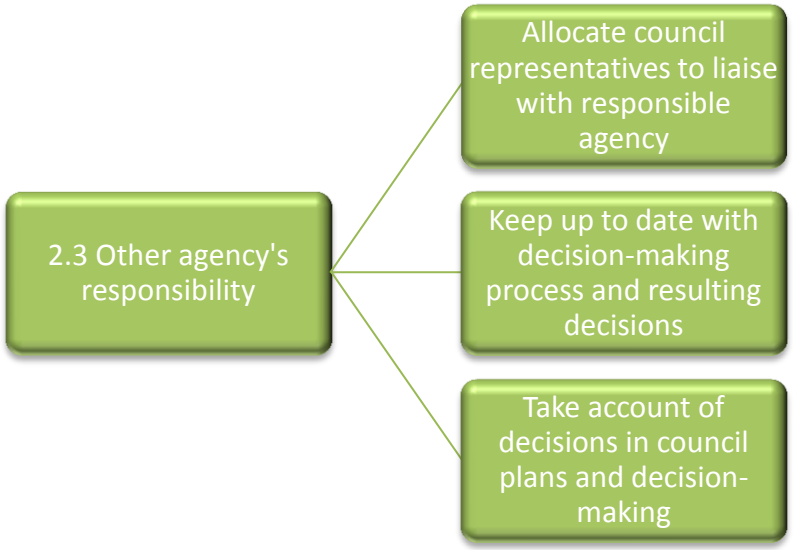
In some cases, it will be clear that another agency has primary responsibility for coastal planning or infrastructure management in response to climate change. For example, the issue may relate to the impact of sea level rise on water infrastructure, which is managed by a State government-owned water authority, or a planning decision may be referred to the Minister for Planning because it meets the criteria for matters of State or regional planning significance under the *Planning and Environment Act* (s12). In this case, the key issue for councils is to define their own role and responsibilities when other decision-makers have the primary responsibility. In this case, councils should essentially aim to stay informed of the decision-making process being undertaken by other parties and its impact on council. In particular, councils should aim to:

- allocate appropriate council representatives to liaise with the responsible agency;
- ensure these representatives keep up to date with the decision-making process and its impact on council; and
- ensure council takes the decisions / plans of the other agencies into account in its own decision-making.

Decision pathways where responsibilities belong to another agency are outlined in Figure 16.

If institutional or policy changes, which are outside of councils' control (e.g. Commonwealth or State legislation or guidelines), are deemed essential to effect a satisfactory decision on coastal adaptation then the focus of decision-making should shift to what changes are needed, how they can be effected and whether decisions on other adaptation options can be delayed until the necessary changes have been made.

Figure 16: Steps in defining roles and responsibilities when another agency has primary responsibility



Box 15: Barriers to defining roles and responsibilities

A number of issues and problems relating to coastal planning decision-making processes were raised by coastal councils in workshops held for the development of this Guide, many if not most of which are relevant to roles and responsibilities. In particular, councils are seeking guidance and coordination from State and Federal Governments, and assistance in managing the burden and costs of adaptation. A number of these issues and concerns are discussed below, with possible resolutions or mitigating strategies identified.

Limited policy guidelines provided by State government on SLR and planning

A major concern raised by councils during workshops was that there is limited policy guidance available regarding land use planning and development assessment in the context of sea level rise. Councils also expressed a desire for legislative rules to refuse inappropriate development. As noted by councils, there is a need for clearer directions by State and Federal governments on these issues.

Even if clearer directions are provided by State and Federal governments however, ultimately councils will still have to make decisions particular to their own circumstances – no state or national level guidance can factor in all local conditions. In this context, councils should consider taking a leadership role on an issue where it (and the local community) believes that this is warranted. This approach is in line with the adaptation literature, which emphasises the importance of local government in driving adaptation response (see, for example, Measham 2011, Moser & Ekstrom 2011, Brown 2005, and Critchley & Scott 2005. In part, councils can do this by acting as "agents of change" - lobbying State and federal governments to revise planning guidelines and processes and provide more practical guidance. As Measham (2011) comments, "by identifying and specifying the limitations of higher level institutional arrangements, it is possible for local levels to argue for a basis for change at the national level ... scientifically sound research combined with local political lobbying can lead to policy change at higher scales" (Measham et al., 2011, p.905).

Any application of a leadership role will need to be within the established legislative and planning framework however, considering the best available legal advice.

Potential for liability due to uncertainty around decision-making responsibility

Councils have expressed concerns relating to potential liabilities arising from coastal management decisions, due to uncertainty in decision-making responsibilities. Councils can potentially be held liable in negligence or nuisance for decisions, acts and omissions relating to their exercise of various powers and functions.

In particular, climate change can create legal uncertainty because there is no specific law that regulates it and it is unclear where climate change fits in the current legal framework for councils (Baker &McKenzie, 2011).

Baker & McKenzie examined key legal risks for coastal councils arising in relation to climate change (see http://www.climatechange.gov.au/publications/local-govt/resolving-uncertainties.aspx). These include:

- tort-based claims - nuisance and negligence;
- claim for approving development when the risk of harm was foreseeable;
- claim for failure to include protective standards in planning schemes;
- claim for failure to maintain or build infrastructure or conduct coastal mitigation works;
- claim for compensation for failing to provide information;
- claim for compensation for providing incorrect information; and
- claims related to administrative law reviews (e.g. of planning permit decisions or planning scheme amendments).

There are at least three potential resolutions to these liability concerns.

First, local governments can mitigate risk and limit their liability by using the Ministerial "call in" powers noted above, meaning that the Minister directly decides the merits of a development application in coastal areas, rather than the council.

Second, in most States and territories there is legislation which can limit the liability of councils in relation to climate change related actions.

Third, councils can mitigate liability risks through balanced, considered and clear decision-making which is based on the best available evidence. For instance, councils should ensure they provide timely and clear information to property owners on the types of development that may be permitted; and should ensure all relevant facts, laws and reasons for decisions regarding the development of planning schemes are publicly available, to minimise legal liability. In addition, circular or continual processes of consultation with the community and other relevant stakeholders should provide further reassurances regarding hazards and triggers, and help built mutual trust, which may help minimise potential liability suits.

Unclear decision-making responsibilities across/ within relevant legislation

Council responsibility and legal liability for climate change risks is not clearly established in legislation in all states/territories in Australia. This can be problematic because it results in legal challenges to council planning decisions and development applications.

For example, legal challenges may arise:

- where other parties/private property owners consider that development is refused inappropriately on the grounds of climate change risks;
- where private parties consider that council has inappropriately approved development because it has not sufficiently taken climate change risks into account; or
- where challenges are made to planning rules that seek to impose development conditions that take climate change risks into account.

'Best practice' in this regard is to clearly establish in legislation that coastal climate change risks are matters which must be taken into account by councils in planning.

For example, in Victoria, the Victorian Coastal Strategy is embedded into the VPP and the SPPF includes coastal references at Clause 11.05 'Coastal settlements', Clause 12.02 'Coastal' and Clause 13.01 'Climate Change Impacts'.

Stage 2 checklist

Step 1. Ensure roles and responsibilities in relation to the issue at hand are clearly understood

- Does responsibility for addressing the issue reside primarily with council?
- Is responsibility shared?
- Is it another agency's responsibility?

Step 2. Where primary responsibility resides with council

- Have constraints and conditions on councils' decision-making been identified? How will the constraints affect the decision-making process?
- Are constraints so great that council feels reluctant to make a decision? If so, how does council propose to respond?
- Have roles and responsibilities been allocated internally?
- Are there sufficient resources, training and support to ensure the roles and responsibilities can be carried out?
- Has a consultation, communication and engagement plan been mapped out?

Step 3. Where responsibilities are shared

- Have roles and responsibilities been agreed between council and agencies?
- Has a collaborative decision-making process been mapped?
- Have constraints and conditions on shared roles and responsibilities been identified? How will the constraints affect the decision-making process?
- In the absence of adequate guidance by the State government or other agencies, is council leadership on the issue warranted?

Step 4. Where responsibilities reside primarily with other agencies

- Does council need to maintain a watching brief on the issue?
- Is there any other role for council?

3. Establish objective

Questions addressed in this section

- What is the objective or objectives against which options will be assessed in the decision-making process?
- What if there are competing objectives, either internal or external?
- What factors should be considered when prioritising objectives?

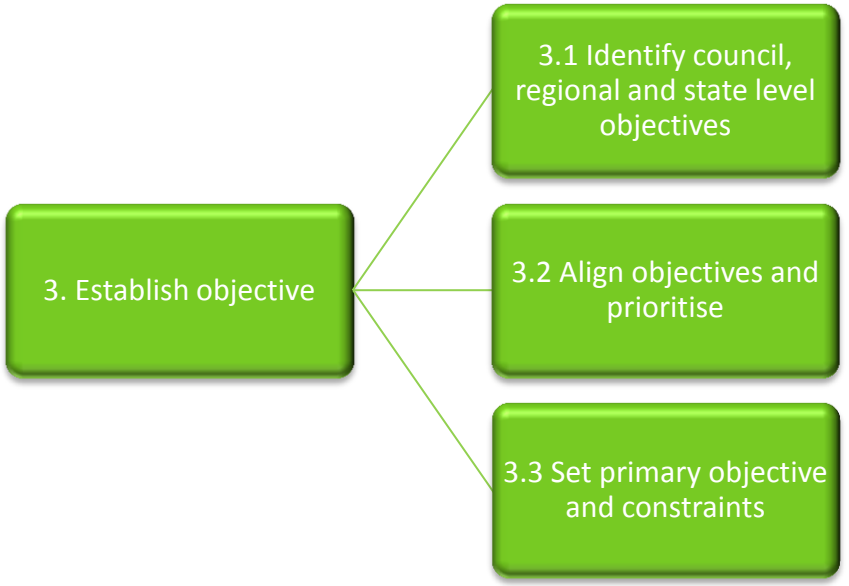
Overview

Before councils can identify and assess adaptation options it is important that they have a clear objective against which options will be assessed. A clearly defined objective will be critical to identifying the 'decision rule', which in turn will provide the basis for selecting the preferred option or bundle of options (see Stage 9). The objective is also important for assisting with the process of identifying, filtering and assessing options (Stages 5 and 7) and selecting thresholds and triggers (Stage 6).

To clarify objectives, councils should seek to:

- identify council, regional and State level objectives, as established in relevant legislation, strategies and related documents;
- align and, if necessary prioritise competing objectives; and
- set a primary objective and constraints (or conditions) that should apply to the primary objective.

Figure 17: Steps in clarifying objectives



3.1 Identify council, regional and State level objectives

To clarify the objectives of coastal adaption decision-making, councils need to understand their internal objectives relative to the decision, and broader regional and State level objectives. Relevant internal objectives are likely to be set out in council strategic plans, local planning schemes and asset management plans (Table 9).

Table 9: Examples of council, regional and State level objectives

Example	Who is responsible	Purpose	Example objectives
Regional strategies			
Victorian Coastal Strategy 2008	State Government of Victoria, along with other key stakeholders (e.g. CMAs, Coastal Boards, Parks Victoria, local councils)	To provide: vision for the planning, management and use of coastal, estuarine and marine environments.	Numerous objectives including: *provide for protection of significant environmental and cultural values; undertake integrated planning and provide clear direction for the future; ensure the sustainable use of natural coastal resources; ensure development on the coast is located within existing modified and resilient environments where the demand for development is evident and impact can be managed*.
Port Phillip and Westernport Catchment Management Strategy	Port Phillip and Westernport Catchment Management Authority	Provides a framework for effort, a funding guide, and a means of integrating policy relating to management of the Port Phillip and Westernport Catchment	Numerous objectives including: *protect and improve the health of land; ensure the management of water resources minimise risks to natural ecosystems, public land, private assets and public safety*.
Planning framework			
Victorian Planning Provisions	Developed by State Government and applied by local councils with local planning policy content	Sets out a comprehensive set of standard planning provisions and provides a standard format for all Victorian planning schemes.	Numerous objectives including: *provide for the fair, orderly, economic and sustainable use and development of land; provide for the protection of natural and man-made resources; secure a pleasant, efficient and safe working, living and recreational environment; protect public utilities and other assets*.
Council plans			
A council strategic plan	Relevant local council	Outlines Council's long term strategic goals, reflecting community's expectations and priorities and how these will be achieved over the ensuing five years.	Numerous objectives relating to long term social, economic and environmental sustainability including for example: *administer the Shires' Planning Scheme to ensure new developments are appropriately assessed and that the outcomes achieved are sustainable having regard the protection of neighbourhood character, heritage values and environmental values; prepare for climate change impacts*.
A council asset management plan	Relevant local council	Guides the work of council staff involved in Building Infrastructure Management.	Numerous objectives including: *maximise the contribution of developers to the provision of physical building assets; advocate for the provision of public and private sector community assets; and investigate more cost-effective methods of maintenance*.

State and regional objectives are established through key regional and State legislation and planning documents including:

- the *Victorian Coastal Strategy* (VCC 2008);
- the *State Planning Policy Framework*, in particular clause 13.01-1;
- *Practice Note 53: Managing coastal hazards and the coastal impacts of climate change* (DPCD 2012);
- the *Port Phillip and Westernport Region Flood Management and Drainage Strategy* (Melbourne Water 2008);
- *Melbourne 2030* (Department of Infrastructure 2002); and
- the *Gippsland Regional Plan* (GRP PCG 2010).

The Victorian Coastal Strategy, Practice Note 53 and clause 13.01-1 of the State Planning Policy Framework are especially pertinent to understanding State level policy objectives relating to coastal adaptation in Victoria.

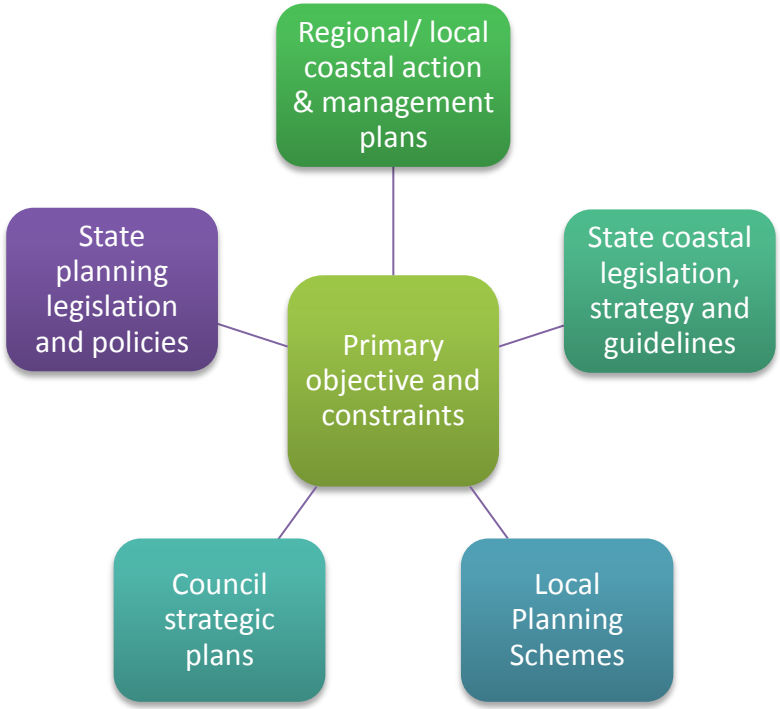
3.2 Align and prioritise objectives

The objective or objectives established for coastal adaptation decision-making should fit within the framework of relevant overarching legislation, policies and plans, similar to those outlined above (Figure 18). It is apparent though, that councils have multiple internal objectives, as set out in their strategic plans for example. Similarly, State and regional plans, strategies and legislation establish multiple regional and State level objectives (external objectives).

While it is possible that some or even many of these objectives will align, being compatible with each other, it is more likely than not that some objectives will conflict. In this case it will be necessary for councils to prioritise objectives. Principles that may assist council to prioritise objectives include (not necessarily in order of importance):

- Understand the factors driving the decision-making process (Box 16).
- Ensure that the objectives align with community expectations and values. An understanding of community expectations can be achieved through appropriate engagement of and consultation with community members and stakeholders.
- Aim to align objectives with those of other decision-makers who are relevant to the decision-making process. A collaborative decision-making will process will help in this respect.

Figure 18: Alignment of objectives



Box 16: Factors driving the decision-making process

The decision-making process could be influenced by the way in which the issue arises, i.e. the factor or factors driving the need to make a decision in the first place. The need to make a decision may be instigated by any of a range of factors, including:

- coastal impacts that are already being experienced (e.g. coastal recession or flooding);
- changes in legislation, government policy, or guidelines (e.g. planning policy);
- major development or investment proposals;
- review of regional strategies, council strategies and plans or strategies of other service providers;
- public concern (possibly reflected by the media or pressure from interest groups);
- new scientific information on present day or future climate risk (e.g. sea level rise projections); or
- new design or technical guidelines having relevance to adaptation approaches (e.g. flood modelling guidelines).

Understanding the factor(s) that have driven the decision-making process could help to prioritise objectives of the decision-making process.

3.3 Set the primary objective and constraints

Primary objective

As noted earlier, the importance of setting clear objectives rests with their role in helping to identify, filter, assess and select options. Setting a primary objective takes this one step further. The primary objective is a clear statement of preferred (long term) outcome that for an area or community. It is the basis against which the effectiveness of adaptation options will ultimately be measured and thus it is desirable if not critical to the decision process to set a primary objective. The primary objective will:

- not contain internal inconsistencies;
- (preferably) be measurable; and
- (often) be subject to constraints or conditions.

The primary objective is likely to reflect the highest priority objective identified earlier, and ideally will have the support of a majority if not most of stakeholders, but it need not be an exact replica of that objective. Hypothetical examples are set out in Box 17.

Box 17: Examples of a primary objective

1. Maintain and protect the amenity and safety of area X for as long as it is cost effective to do so; **or**
2. Protect and maintain the economic, social and environmental values of area X for as long as the benefits of protection outweigh the cost; **or**
3. Respond to coastal risks in area X in a way that achieves greatest long term net benefit to the community.

Constraints

In many cases a primary objective will need to be subject to conditions that have the effect of setting fundamental constraints on the outcome of a coastal adaptation action. These constraints could reflect the requirements of key legislation (see Stage 2, Box 11 and Box 14). They could also reflect the requirements of State or regional level guidelines or strategies (see Box 18).

Box 18: *Victorian Coastal Strategy 2008* and climate change

Following are key objectives relevant to climate change as set out in the Victorian Coastal Strategy 2008 and elaborated in the State Planning Policy Framework.

Planning to manage coastal hazards and the coastal impacts of climate change should:

- *Plan for sea level rise of not less than 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes and local conditions such as topography and geology when assessing risks and coastal impacts associated with climate change.*
- *Apply the precautionary principle to planning and management decision-making when considering the risks associated with climate change.*
- *Ensure that new development is located and designed to take account of the impacts of climate change on coastal hazards such as the combined effects of storm tides, river flooding, coastal erosion and sand drift.*
- *Ensure that land subject to coastal hazards are identified and appropriately managed to ensure that future development is not at risk.*

The State Planning Policy Framework as amended in 2012, specifies:

- *In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill).*

Other constraints could be implied by the (lower priority) objectives of other agencies that were identified in earlier steps – for example minimum levels of service.

Examples of constraints applied to a primary objective are provided in Box 19 below.

Box 19: Examples of constraints

Primary Objective

Maintain and protect the amenity and safety of area X for as long as it is cost effective to do so:

Constraints

- provided actions meet the requirements of the Victorian Coastal Strategy 2008 planning policy on climate change and Ministerial Direction No. 13;
- provided actions comply with the Draft Guide for Coastal Floodplain Management Authorities (DSE) and the Planning for Sea Level Rise: Interim guidelines (Melbourne Water);
- for as long as other service providers are able and willing to service the area;
- in way that ensures no net loss of coastal ecological values in the LGA.

Stage 3 checklist

Step 1. Identify objectives relevant to the issue

- Have **key** council objectives been identified?
- Have **key** regional level objectives been identified?
- Have **key** State level objectives been identified?

Step 2. Align objectives and prioritise

- Do some of the council, regional and State level objectives align – i.e. they are essentially similar or compatible with each other?
- If so, can a revised and condensed list of objectives be produced?
- Are some of the objectives (within the condensed list) inconsistent or incompatible?
- If so, which of these objectives should have highest priority (considering criteria such as community expectations, legislative requirements and objectives of other decision-makers)?

Step 3. Set a primary objective and constraints

- Considering the prioritised list of objectives, what is the primary objective?
- Should the primary objective be subject to constraints or conditions (defined by legislation, guidelines or other objectives)?
- If so, what are those conditions?

4. Assess hazards and risks

Questions addressed in this section

- What is a hazard assessment? What is a risk assessment?
- Why are hazard and risk assessments important to the decision?
- How should the assessment be framed and what hazards and risks should be considered in the assessment?
- At what scale and over what timescale should the assessment be undertaken?
- Should results of the assessment be reviewed? How?

Overview

All decisions on coastal adaptation need to be underpinned by a sound understanding of potential climate changes and the local and regional scale consequences of those changes. A hazard and risk assessment (often referred to as a vulnerability assessment) will seek to do this, considering the likelihood (or probability) of changes, the land, waterways, ecosystems, settlements, infrastructure and communities exposed to the changes and also the underlying environmental and social conditions that can provide an understanding of the sensitivity of systems to the changes and, by extension, the consequences of the changes.

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

- 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.

Figure 19: Steps in assessing hazards & risks

Box 20: Hazard and risk assessments

A **hazard** has been defined as a "condition, event, or circumstance that could lead to or contribute to an unplanned or undesirable impact or consequence." With respect to climate change, that condition could be sea level rise, with the undesirable impact or consequence being the inundation and loss of a residential area or a valued coastal ecosystem. Undesirable events are often the result of multiple events, for example: sea level rise; and/or storm tides; and/or extreme rainfall; and/or coastal recession. A hazard analysis should consider system state, i.e. the underlying environmental and social conditions in the area subject to the impact. A hazard assessment is used as the first step in a process to assess risk.

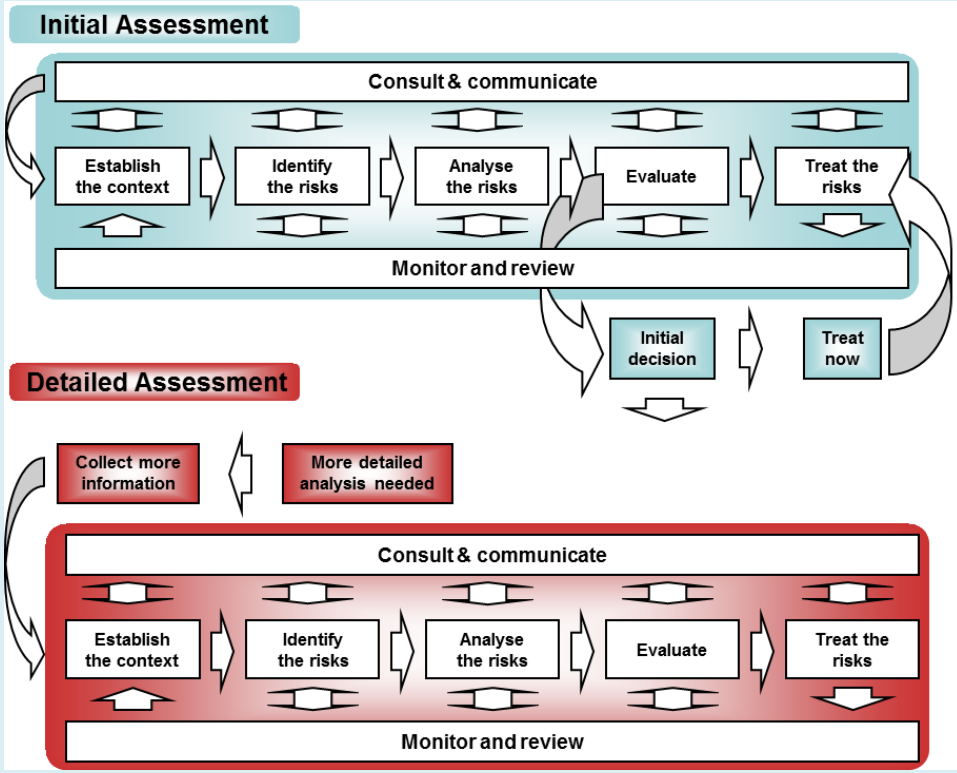
As discussed in Part A of the Guide, **risk** is defined as the likelihood and consequence of a hazard. Thus a risk assessment involves validating and quantifying the range of uncertainty (associated with a hazard) in terms of its likelihood and consequence (e.g. a minimum value and maximum values for sea level rise and associated impacts on coastal communities) as well as the consequences resulting from the hazard (e.g. impacts on assets). Hazard and risk assessments can be and generally will be undertaken concurrently.

As described in the guide *Climate Change and Risk Management: A Guide for Business and Government* (Broadleaf & MJA 2007), a risk assessment can be undertaken at two levels, an initial assessment or a detailed analysis (Figure 20):

1. An initial assessment is a qualitative process that identifies and sifts risks quickly, followed by treatment planning for those risks that clearly require it.
2. A detailed analysis is used where additional information is needed to determine whether treatment (adaptation) is required and what form of treatment to adopt.

Most SECCCA member councils have undertaken an initial climate change risk assessment. That initial assessment is a useful technique for prioritising risks across a range of areas. In most cases, a hazard assessment, combined with a detailed risk assessment will be needed to inform coastal adaptation decision-making.

Figure 20: Initial and detailed risk assessment processes



Source: After Broadleaf Capital & Marsden Jacob Associates 2007

In most cases, a hazard assessment, combined with a detailed risk assessment will be needed to inform coastal adaptation decision-making. Generally speaking, the detailed assessment will require specific technical expertise that councils and other decision-makers may need to source from outside of their organisations.

4.1 Assessment premise and scale

When planning a hazard assessment a primary consideration influencing assessment design is the underlying premise for and scale of the assessment. Historically, councils have tended to take a fairly reactive approach to hazard and risk assessments, with assessments being site specific, undertaken in response to an identified issue or problem (e.g. development applications or impacts of coastal recession on properties).

Ideally, a more strategic approach to hazard assessments will be taken, with assessments being undertaken at a regional scale and used to identify and prioritise issues and locations across a region (i.e. 'hot spots'). This approach can still allow for hazards to be identified at individual locations. The advantages of this approach are that:

- it provides for a consistent approach to assessment of hazards across sites;
- allows for regional scale hazards to be assessed; and
- could prove to be more cost effective over time.

A strategic, regional scale assessment will tend to be resource intensive though, highlighting the advantages of a collaborative approach to hazard assessment, involving a number of councils and agencies and resource sharing.

4.2 Types of hazards and risks

Hazard assessment can potentially consider a range of events including:

- sea level rise;
- storm surges and storm tides;
- freshwater flooding in coastal areas;
- coastal recession and landslide;
- sand drift; and
- multiple events and their interaction.

Plus the consequences of those events for valued assets such as:

- coastal infrastructure (e.g. jetties, piers, sea walls and levees);
- dwellings and other private infrastructure and assets;
- critical public infrastructure (e.g. roads, water and waste water infrastructure, medical facilities);
- beaches and foreshore areas; and
- coastal areas of high conservation value (e.g. coastal wetlands, estuaries) .

Ideally, the hazard assessment will consider not only the exposure of these assets to an event but also their sensitivity (e.g. the typical floor height of dwellings that are exposed to inundation).

Which of these hazards and risks are considered in the assessment will be determined by the nature of the issue or problem (or foreseeable problem) that may need to be addressed (see Stage1). Ideally though, the assessment will cover as broad a range of hazards as possible.

4.3 Key assessment parameters

Key parameters for the assessment will (depending on the breadth of the assessment) include:

- sea level rise;
- storm tide return periods, where storm tide = astronomical tide + storm surge + breaking wave setup + wave runup;

- information relevant to understanding coastal processes and shoreline stability including beach erosion, shoreline recession and coastal cliff instability; and
- flood return periods.

Most of these parameters are site specific and data relating to them will need to be collated in the assessment for all relevant sites. The exception is sea level rise. The *Victorian Coastal Strategy* (VCC 2008) currently has a policy of planning for sea level rise of not less than 0.8 metres by 2100, applying to new settlements, with development proposals in existing settlements and urban zoned areas requiring planning for an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 (see Box 21).

Another key parameter that must be considered in the assessment is temporal scale (or timescale) - i.e. how far back and ahead it looks. The sea level rise timescales of 2050 and 2100 should be used as the long term timescale for the assessment. Given different planning horizons for land use, planning and infrastructure decisions though, intermediate time periods should also be considered for the assessment (e.g. 2030, 2070).

4.4 Assessment approach and review

At present, there are no comprehensive guidelines covering all hazards relevant to a broad ranging coastal hazard assessment. The *Victorian Coastal Hazard Guide* (DSE 2012) provides general information on coastal hazards and the effects of climate change on those hazards. It also provides general information on coastal risk identification and analysis.

Similarly, Melbourne Water guidelines *Planning for Sea Level Rise* (Melbourne Water 2012) provides 100 year flood levels for areas affected by predicted sea level rise and applicable floor levels for new developments and redevelopments given those flood levels (see Table 10).

Box 21: Victorian coastal policy and sea level rise

The Victorian Coastal Strategy (VCC 2008) planning policy on climate change includes the following statement on sea level rise:

> *Plan for sea level rise of not less than 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes and local conditions, such as topography and geology when assessing risks and impacts associated with climate change. As scientific data becomes available the policy of planning for sea level rise of not less than 0.8 metres by 2100 will be reviewed.*

Additionally, The State Planning Policy Framework (clause 13.01-1) as amended in 2012, specifies:

> *In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill)*

The planning levels of 0.2 metres in 2040 and 0.8 metres in 2100 are broadly consistent with projections of the CSIRO (CSIRO 2010) and the Assessment Report Four (AR4) of the Intergovernmental Panel on Climate Change (IPCC 2007). Noting conclusions of studies completed since the release of AR4 (e.g. Vermeer & Rahmstorf 2009), there is a strong possibility that the planning level will change in the future. Given this, it is important that hazard assessments include sensitivity analysis that considers different sea level projections, both higher and lower than the current planning level.

Neither manual provides detailed technical specifications though[6]. Noting this, it is important that the hazard and risk assessment incorporates a review process, especially if the hazard and risk assessment is regional in scale or the problem being addressed is macro in scale.

A review will increase confidence amongst decision-makers and the public that assessment results are robust and will reduce potential for the results to be challenged in the future.

The depth of the review process will depend on the significance of the assessment but generally all hazard and risks assessments should include:

- discussion of the key methods and parameters;
- discussion of assumptions, parameter uncertainties and data gaps;
- sensitivity analysis of the key parameters and assumptions including in particular sea level rise projections;
- discussion of uncertainties in the analysis arising from data gaps; and
- expert (peer) review of methods, parameters and assumptions (for larger scale assessments).

A key aspect of the hazard and risk assessment is baseline analysis. All hazard and risk assessments should include an assessment of present day conditions including naturally prevailing coastal processes and present day vulnerability to given events.

[6] Note at the time of writing work was underway through the Department of Sustainability and Environment to establish more precise advice regarding coastal hazards in the Western Port region. This advice will be available on the DSE website once completed in 2013 (www.dse.vic.gov.au).

Table 10: Applicable coastal flood levels and floor levels for development planning

Applicable flood levels for planning development purposes to Australian Height Datum			
Region	**Existing 100 yr flood level**	**Applicable 2040 100yr flood level**	**Predicted 100yr flood level for 2100**
Port Phillip	1.6 m	1.8 m	2.4 m
Western Port	2.7 m	2.9 m	3.5 m

Applicable floor levels for development planning purposes to Australian Height Datum			
Region	**Applicable 2040 100yr flood level**	**Existing Development Zone floor level**	**Isolated Residential/ Major Development floor level**
Port Phillip	1.8 m	2.4 m	3.0 m
Western Port	2.9 m	3.5 m	4.1 m

Source: Melbourne Water 2012

Box 22: Hazard and risk assessment principles

1. Where possible, adopt a strategic approach to hazard assessments by undertaking regional scale assessments.
2. Pursue a regional assessment through a collaborative approach with other councils and agencies.
3. Cover a broad range of hazards in the assessment.
4. The assessment must include a baseline analysis - assessment of present day conditions.
5. Include a range of time periods in the assessment (e.g. current period, 2030, 2050, 2070, 2100).
6. Undertake sensitivity analysis of key parameters and assumptions including in particular sea level rise projections.

Stage 4 checklist

Step 1. Determine assessment premise and scale

- What is the purpose of the assessment?
- What areas should be covered by the assessment? Will the assessment be site specific or more regionally focussed?
- Particularly if the latter, which other (non-council) decision-makers should be involved in framing and undertaking the assessment?

Step 2. Identify hazards and risks to be covered in the assessment and approach

- Which hazards should be addressed in the assessment?
- Which impacts and risks should be addressed in the assessment?

Step 3. Determine assessment parameters

- What parameters are required for the assessment?
- Are the values for all of these parameters known? What are the data/ information gaps?

Step 4. Undertake and review the assessment

Pre-assessment

- Is external expertise needed to undertake or assist with the assessment? What is the nature of expertise required?
- Has the assessment methodology been detailed? Is it consistent with State requirements?

Post assessment

Has sensitivity analysis of key parameters been undertaken? Is expert review of parameters and assumptions required?

5. Identify options and pathways

Questions addressed in this section

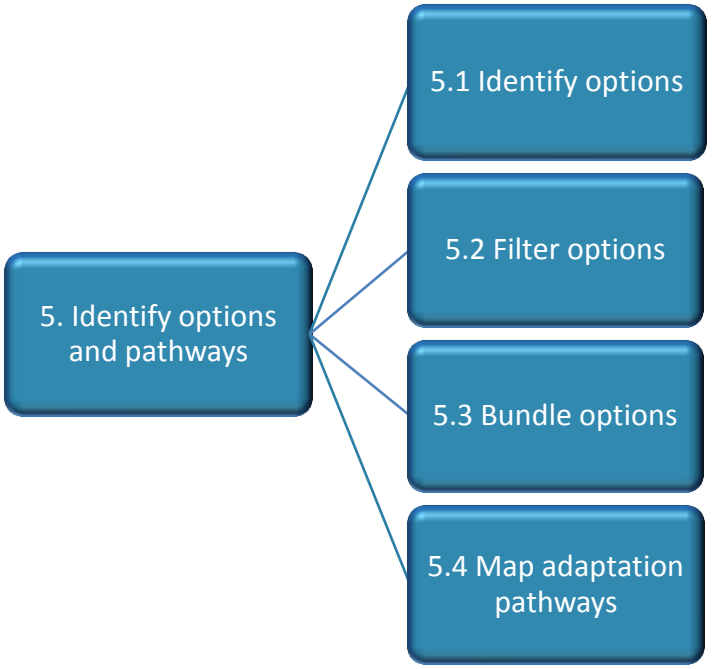
- What options are available to address the issue or problem?
- Which ones should be considered in the assessment?
- Should options be assessed separately or collectively?
- How should options to be implemented over different timeframes be assessed?

Overview

Councils and other decision-makers may already be quite aware of the range of options available to them to assist with adapting to coastal impacts identified through a hazard assessment (Stage 4). This awareness may derive from a sound understanding of the issue at hand (Stage 1) or from previous experience. Notwithstanding this awareness, it is important that councils engage in a process of systematically identifying adaptation options prior to undertaking a full assessment of the options.

This section provides guidance on identifying coastal adaptation options, considering the types of options available and principles underpinning option selection (Step 5.1). Another important step in the options identification process is an initial consideration or 'filtering' of options so as to 'weed out' options that do not pass the common sense test (Step 5.2). Options are not necessarily mutually exclusive but nor will they necessarily have the same implementation timeframes. Rather, an effective adaptation strategy will almost certainly involve implementing a range of options, quite possibly over different timeframes. Thus bundling (grouping) of options (Step 5.3) and the process of mapping adaptation pathways, so that alternative approaches to implementing options over time can be understood (Step 5.4), are crucial steps in preparation for a detailed assessment (Stage 7).

Figure 21: Steps in identifying adaptation options



It is important to note that much of the discussion in this stage is geared to medium or macro scale issues that have multiple dimensions. For smaller or more straightforward issues (e.g. installation or replacement of a single piece of public infrastructure or a small scale development approval) it is probably neither necessary nor useful to go through the detailed process discussed here, particularly Steps 5.3 and 5.4. It will still be important though to identify and filter options prior to assessing them.

5.1 Identify options

Adaptation approaches are often considered in terms of categories of action that strengthen the resilience of communities, organisations or systems (e.g. through information and education, strengthening institutions and governance, and insurance) versus categories of action that reduce the potential impacts of hazards (e.g. through structural and technical works, design standards and planning decisions) (Brooks, Adger & Kelly 2005).

While this is a valuable way of framing adaptation actions, further typology of coastal adaption actions is useful to assist councils to identify and consider options. To that end, Table 11 presents examples of options under different adaptation 'strategies and categories'.

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

- ***'Protect'*** – defensive structures to protect settlements, infrastructure or natural assets from hazard.
- ***'Accommodate'*** – redesign or other changes to reduce sensitivity of assets or people to 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 hazard;
- ***'Adapt'*** – permit developments or land uses but with conditions of consent that reduce exposure or sensitivity of people and assets to hazard;
- ***'Accept'*** – permit developments under established conditions of consent.

There is a variety of specific options available to decision-makers under these general strategies, with the nature and scale of the issue, hazards and risks likely to influence the suitability of strategies and individual options within those strategies. Councils and other decision-makers will tend to find that consideration of as broad a possible range of options under different strategies will be useful, at least in the early stages of option identification. This will provide the best basis for selecting the most suitable suite of options, bundles of options and adaptation pathways later in the stage.

Depending on the scale of the issue, it may be beneficial to consult with stakeholders (other agencies, community representatives, experts) to gain a better understanding of what is technically, socially, environmentally and economically feasible and appropriate, given the location and issue at hand. This may be done in a workshop setting or in small focus groups.

As far as possible, low cost and low effort adaptation options that also have the potential to yield significant benefits should be identified and implemented to address lower level or not yet immediate risks (Figure 22). Climate change projections indicate that coastal hazards and risks will become more marked over time, suggesting that additional, more costly and time consuming adaptation options may be required in the longer term. It is possible that options will need to be sequenced over time, requiring adaptation options to move successively from lower to higher cost options and bundles of options. This approach to building adaptation pathways is discussed in Step 5.4.

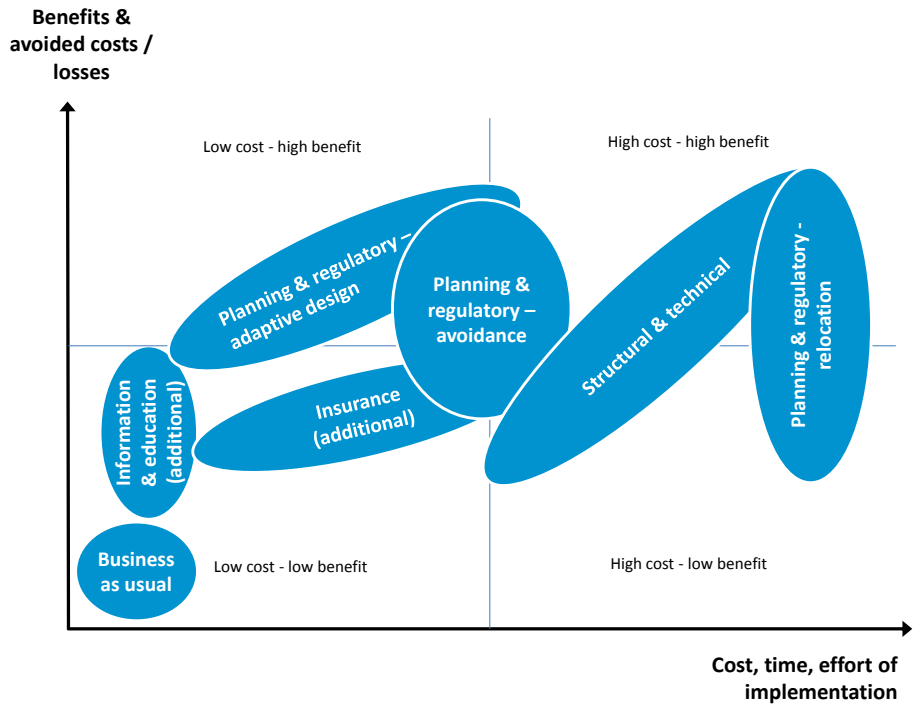
The selection of options, as well as the timing and scale of these options, will be influenced by extreme events (e.g. floods, storms, droughts), changing societal perspectives and appetite for risk, and new knowledge and technologies. This highlights the importance of a flexible and adaptive approach and the benefits of using thresholds and triggers (Stage 6).

Table 11: Examples of adaptation options

Focus	Strategy	Option categories	Examples
Established infrastructure and land uses	**Protect**	Technical & structural	Works to reduce the rate or extent of erosion or the exposure of existing assets and developments to erosion ▪ Sand dune stabilisation ▪ Beach nourishment ▪ Groynes ▪ Artificial headlands ▪ Offshore breakwaters and reefs ▪ Sea walls ▪ Revetment ▪ Piles / excavation to rock Works to reduce flood exposure ▪ Dykes and levees ▪ Raising of land levels ▪ Flood barriers ▪ Management of rainfall / runoff, e.g. through floodways and/or retention basins, ▪ Prevention of sea-water back up into storm sewers
		Information & education	Education of residents about climate change, associated risks and impacts, and possible adaptation measures (e.g. "how to help themselves in an emergency")
	Accomm-odate	Diversification of risk	Insurance to cover unavoidable impacts / losses Share risks between different organisations / agencies Diversification to spread the risks (e.g. alternative uses)
		Technical & structural	Works to reduce flood hazard ▪ Lifting existing dwellings, ▪ Reduction of dependence on services (e.g. telecommunication, electricity) during floods, ▪ Changes / upgrades of existing infrastructure such as roads, bridges, drains, sewer, water, etc. (e.g. floating roads, liftable bridges, raising infrastructure)
		Planning & regulatory – adaptive design	Improved design/engineering standards for new assets and major refurbishments (e.g. to accommodate more intense rainfall in stormwater systems, required upgrades when renovating or extending existing buildings)

Focus	Strategy	Option categories	Examples
	Planned Retreat	Planning & regulatory - relocation	Relocating facilities (e.g. community halls, recreation facilities) and infrastructure (e.g. alternate transport routes via higher land) Relocating residents and businesses from high risk areas: ▪ evacuation of residential areas; ▪ buy-back of coastal properties; ▪ grants for demolition of homes; ▪ relocation subsidies, e.g. low interest loans, for houses and other structures (septic systems, utility connections); Re-zoning of areas (e.g. coastal buffer zones) Managed retreat (decommissioning and removal of assets, e.g. boat ramps, piers)
		Business as usual ('accepting losses')	Closing of recreation areas (e.g. beaches & foreshores) Loss of coastal conservation areas Owners of private infrastructure will bear losses
New development or redevelopment	**Avoid**	Planning &regulatory - avoidance	Re-zoning of areas (e.g. coastal buffer zones) Changing location of new developments and infrastructure
	Adapt	Planning & regulatory – adaptive design	Changes to local planning scheme to account for increased risk (e.g. flooding) / conditions of consent (e.g. improved design standards, minimum floor height, time-limited consent) Improved design standards for public infrastructure (e.g. stormwater, transport) 'Rolling easements' allowing property owners to build on land at risk on the condition that structures will be removed, if and when threatened by coastal erosion or inundation
		Technical & structural	Technical works, e.g. raising land levels/ infill
	Accept	Business as usual ('accepting losses')	Property owners bears the losses
		Technical & structural	Protection works (see also above) to allow development / construction of new infrastructure: ▪ modular homes and moveable dwellings and infrastructure, ▪ floating houses, ▪ water resistant and waterproof construction to withstand flooding
		Information & education	Informing property owners or purchasers of policies relating to coastal adaptation that could affect their land if a new development is proposed (e.g. s149 Planning Certificate).

Figure 22: Categories of adaptation options



It is also important to understand that for most, if not all issues the '***business as usual***' (BAU) option is available to decision-makers[7]. Under this option, additional climate change impacts will be accepted, and associated losses and costs will be borne by councils and/or the broader community. The BAU option should be defined and evaluated as part of the options filtering process (see section 5.2). The BAU option will also be utilised in the detailed assessment (Stage 7), where it will form the baseline against which other options are compared.

Not all strategies and/or options will necessarily be applicable under all circumstances. Options may be constrained by the availability of resources, existing legislation, community acceptance, political will and other factors. For example, 'existing use rights', which protect an established use of land, may prevent changes to planning schemes that prohibit that use. Potential constraints of this nature need to be accounted for in the filtering process (see section 5.2).

It is important and valuable to clearly define options and identify specific subsets or variations in options, as these may have significantly different aspects, or generate significantly different outcomes from the filtering process. For example, the 'planned retreat' option could (and probably should) be split into a number of variations (e.g. 'planned retreat with voluntary acquisition' versus 'planned retreat with compulsory acquisition').

5.2 Filter adaptation options

Once adaptation options have been identified, it may be necessary to apply a "filter" or "screening process" to derive a short list of options that warrant bundling and sequencing prior to detailed assessment (Stage 7).

This step 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 assessment so that the assessment focuses on a limited number of 'short listed' options.

[7] 'Business as usual' can be defined as policies, programs and actions that are currently in place. Business as usual rarely equates to 'doing nothing'.

Filtering options is generally done by undertaking a simple form of multi-criteria analysis and can reveal, if any of the options have fatal flaws, which prevent 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 23 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.

It is suggested though, that some criteria, such as 'effective', 'proportional' and 'compliant', are essential or critical; that is, an option only warrants advancing to a short list for more detailed assessment if it meets these criteria. Other criteria, such as acceptability or flexibility, are merely desirable.

Different options could be judged differently against the criteria depending on the timeframe being considered (e.g. short-, medium- or long-term). For example, in most circumstances and in most locations, the 'retreat' option will most likely fail against the 'proportional' criterion in the short term, but may meet that criterion in the long term. For this reason, an important part of the filtering process will involve setting out and assessing options in different implementation time periods (e.g. short term, medium term, long term). This is an important first step in the sequencing process leading to mapping of adaptation pathways (see Step 5.4).

Given the uncertainties regarding future climate change, 'no regrets' options (actions that should be undertaken regardless of climate change) are particularly important and likely to constitute a part of all adaptation strategies. Conversely, options that result in 'mal-adaptation' should be avoided (Box 24).

Box 23: Possible decision criteria for a screening 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 in proportion to the expected benefits? Note, as the filtering process is a qualitative exercise only, estimates of size 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, if the social, environmental, political and cultural acceptability is evaluated, separate criteria should be used for 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?

Source: MJA after UKCIP2003

Box 24: Principles of good adaptation

The cost, effort and time required to develop and implement adaptation measures will vary considerably (see also Figure 22). The following principles may be useful in guiding the development of adaptation strategies:

1. **Focus on cost effective actions – 'no regrets' or 'low regrets' adaptation.** 'No regrets' adaptation options would be justified and worthwhile (i.e. deliver a socio-economic benefit) under all plausible future scenarios. 'Low regrets' adaptation options incur relatively low cost and increase the capacity to cope with future climate change.
2. **Use a flexible / adaptive management approach.** Flexible adaptation options include incremental measures that allow for adjustments as knowledge, technology and experiences advances. This is important for dealing with climate change uncertainties.
3. **Achieve balance between climate and non-climate risks.** Organisations should take a balanced approach to managing climate and non-climate risks. Priority should be given to actions that have 'win-win' outcomes, contributing to both climate change adaptation but also providing wider social, environmental and economic benefits.
4. **Avoid adaptation constraining decisions ('high regrets' adaptation).** Adaptation options should not lead to perverse outcomes of constraining the ability to adapt to climate change in the future. High regrets adaptation options, as opposed to adaptive management options, are one-dimensional, are largely irreversible and may involve significant costs, thereby running the risk of stranded assets and irrecoverable costs.
5. **Avoid catastrophic outcomes through maladaptation.** Actions should not be taken that could ultimately lead to or fail to prevent catastrophic outcomes.

Source: MJA after UKCIP 2003

5.3 Bundle adaptation options

Individual options are not necessarily mutually exclusive, with combinations of options having the potential to reinforce each other. For example, changes to building standards, combined with an information and education campaign, may produce greater overall benefits than if the two actions are implemented piecemeal. Actions may also work in combination because they address different aspects of an objective (for example one action may be focused on protection of residential areas, while another is focused on transport access). These synergies should be exploited by grouping options, where it is beneficial and feasible to do so, and assessing them as 'bundles' of options. This will ensure that additional benefits and synergies resulting from the grouping of the options are accounted for in the detailed options assessment (Stage 7).

A defined process for bundling of options is not established. However, the following steps provide a possible way of going about the bundling process:

1. Once all options have been identified (Step5.1) and reviewed against the filtering criteria, a short-list of options should be created by selecting options that rate favourably against the criteria (Step 5.2).
2. Interdependent and/or complementary options should then be grouped or bundled. Each bundle will contain one or more options. No two bundles will contain identical options, but some bundles may contain two or more of the same options.
3. 'Business-as-usual' should be one of the bundles, consisting of all relevant measures that are currently in place.
4. Arguably all bundles should contain options assessed in Step 5.2 as being 'no-regrets' (with the exception of the business as usual bundle).
5. As in Step 5.2, bundling of options should occur for different time periods (e.g. short term, medium term and long term). That is because

some bundles may be suitable for implementation in the short term (e.g. an information campaign) while other bundles may only be suitable for implementation in the long term (e.g. a bundle containing the retreat option). This is an important second step in the sequencing process leading to the mapping of adaptation pathways (Step 5.4).

6. For any given time period, bundles identified for that period should be mutually exclusive; that is, only one of the bundles would be implemented in that period.

7. It is useful to number or label completed bundles for each time period (e.g. 1, 2, 3, etc.) and clearly identify the options that they comprise.

Box 25 provides an example of the outcomes of the process.

5.4 Map adaptation pathways

As noted earlier, sequencing of options (adaptation pathways) is likely to be necessary to address changed conditions or circumstances over time and because options differ in flexibility and/or life span. In the short term, for example, a restricted number of small scale options, may suffice to address the issue. As changes and threats become more marked over time however, additional, potentially more costly options may be required. In some circumstances however, implementing an option or bundle of options in the short term may actually constrain a council's ability to implement other options in the medium or long term. Thus there is a need to understand which options can be and should be implemented in different time periods and how this affects assessment of those options.

Figure 23: Various short and longer term options have been employed to stabilize beaches and foreshores in the SECCCA region

Sources: SECCCA

Box 25: Example – bundling of options

Further to the example presented in Box 13, a coastal location is expected to come under increased threat from storms tides and sea level rise, in the latter half of this century. Public and private infrastructure (e.g. roads, water and sewer, electricity, and residential houses) are increasingly being affected by temporary flooding and in some areas eventually by permanent inundation. As major impacts are not expected within the next 30 to 40 years, Council and other decision-makers are focusing mainly on planning options. Council does not currently have any specific planning controls in place for the area. The 'business as usual' (BAU) option consists of Council's standard planning controls as applied to other areas in the LGA. Council and other decision-makers have identified the following shortlist of new options to address the issue.

Timeframe	ID	Option
Short term	i	BAU (regular planning scheme)
	ii	Prevent intensification of development
	iii	Increased floor heights for new dwellings (above expected inundation levels in 2070)
	iv	Time limited consent for new dwellings (triggered by flooding above floor level)
	v	Community education program re flooding and impacts of sea level rise
Medium term	iv	Time limited consent for new dwellings (triggered by flooding above floor level)
	vi	Increased floor heights for new dwellings (above expected inundation levels in 2100)
	vii	Construction of protective infrastructure (e.g. levee)
Long term	vii	Upgrade of levee
	vi	Planned retreat

The 'community education program' (Option v) and also 'prevention of intensified development' (Option ii) are assessed as being 'no regrets' options across all timeframes and are therefore included in all bundles. Decision-makers are also of the view that Option iv (time limited consent) will provide greater benefits when combined with Option iii (increased floor heights). As such, Option iv is only considered in combination with Option iii). Options iv and vii are mutually exclusive and only one of these three options will be implemented. Taking this into account, Council and other decision-makers have derived the following list of mutually exclusive bundles.

Timeframe	Bundle ID	Options included
Short term (now – 2020)	Bundle 1	**Business as usual**
	Bundle 2	**Increased floor heights**, no intensification of development, community education
	Bundle 3	**Time limited consent**, no intensification of development, community education, increased floor heights
Medium term (2020 – 2050)	Bundle 4	**Increased floor heights**, no intensification of development, community education
	Bundle 5	**Time limited consent**, no intensification of development, community education, increased floor heights
	Bundle 6	**Construction of levee**, no intensification of development, community education
Long term (beyond 2050)	Bundle 7	**Upgrade of levee**
	Bundle 8	**Planned retreat**, community education

Filtering and bundling of options in different time periods represent the initial steps toward sequencing of options and provides an indication of whether individual options (Step 5.2) and bundles of options (5.3) should be implemented in the short, medium or long term.

Following this, the next key step in the sequencing process is to map out adaptation pathways, a process that will not only provide an understanding of how different options fit together over time but also how the timing of options will be treated in the assessment process. That is, if a highly inflexible bundle with a long life span that locks in a particular pathway is to be compared against more flexible bundles with shorter life spans, adaptation pathways (sequencing) need to be established for the latter to allow a meaningful assessment of the bundles over time.

Bundles of options need to have the same lifespan in order to provide a useful basis for comparison in the detailed assessment. To illustrate this point, a cost effectiveness assessment is undertaken of two bundles 1 and 2, with Bundle A, having a short life span (e.g. 10 years) and Bundle B having a longer life span (e.g. 80 years). If the assessment only considered these two bundles it may come down in favour of Bundle A, but fail to take into account the likelihood that further options will be required in another ten years. Thus the cost of renewal or follow-on bundles to Bundle A have to be taken into account in the assessment by mapping out adaptation pathways for Bundle A and subsequent bundles (e.g. Bundles C and D) over (at least approximately) the same timeframe as Bundle B.

Mapping out bundles and sequences of bundles over time also enables decision-makers to visualise and distinguish between bundles that provide a flexible adaptation pathway and bundles that 'lock in' a particular strategy for the long term.

Box 26 provides an illustrative example of the adaptation mapping process using the same bundles of options identified in the previous example (Box 25).

Considering the output of this example (i.e. adaptation pathways A to F), it is important to note that identification of thresholds and triggers (Stage 6) will enable more precise timeframes to be applied to the different bundles and adaptation pathways. Also, the detailed assessment of options at Stage 7 will actually be an assessment of bundles or pathways rather than individual options, noting further that:

- If, having mapped out adaptation pathways council or other decision-makers decide that more detailed assessment of the long term, inflexible pathway (i.e. Bundle 3) is warranted, then it will be important to compare the different adaptation **pathways** in the detailed assessment[8].
- If, on the other hand, council decides that a long term, inflexible pathway (i.e. Bundle 3) does not warrant more detailed assessment, then the detailed assessment at Stage 7 will be more straightforward, entailing a comparison of **bundles** (in this case, Bundle 1 and Bundle 4 v Bundle 2).

[8] This will ensure a meaningful comparison of the bundles / pathways over the long term.

Box 26: Example – mapping adaptation pathways

This example is a continuation of the example presented in Box 25.

Through the process of identifying, filtering and bundling options, Council has developed the following list of potential adaptation options and bundles. The life of the bundle, shown in the table below, indicates how long the option is considered to be effective and therefore includes the life of the asset affected (i.e. residential dwellings with an average life of 50 years). Residential dwellings constructed under the BAU option may be impacted in 40 years' time. Therefore the option is only effective over the next 40 years. Considering that residential dwellings have a life of about 50 years, the BAU option does not meet the objectives any longer.

Timeframe	Bundle ID	Options included	Life
Short term (now – 2020)	Bundle 1	Business as usual	40 years
	Bundle 2	Increased floor heights	60 years
	Bundle 3	Time limited consent	indefinite
Medium term (2020 – 2050)	Bundle 4	Increased floor heights	80 years
	Bundle 5	Time limited consent	indefinite
	Bundle 6	Construction of levee	40 years
Long term (beyond 2050)	Bundle 7	Upgrade of levee	40 years
	Bundle 8	Time limited consent	indefinite

Because the short term bundles have different levels of flexibility, it is important that Council maps out the adaptation pathways before undertaking a more detailed assessment.

Figure 24 below indicates adaptation pathways available to Council, taking account of the different asset and design lives of bundles (arrow length indicates duration).

Figure 24: Adaptation pathways

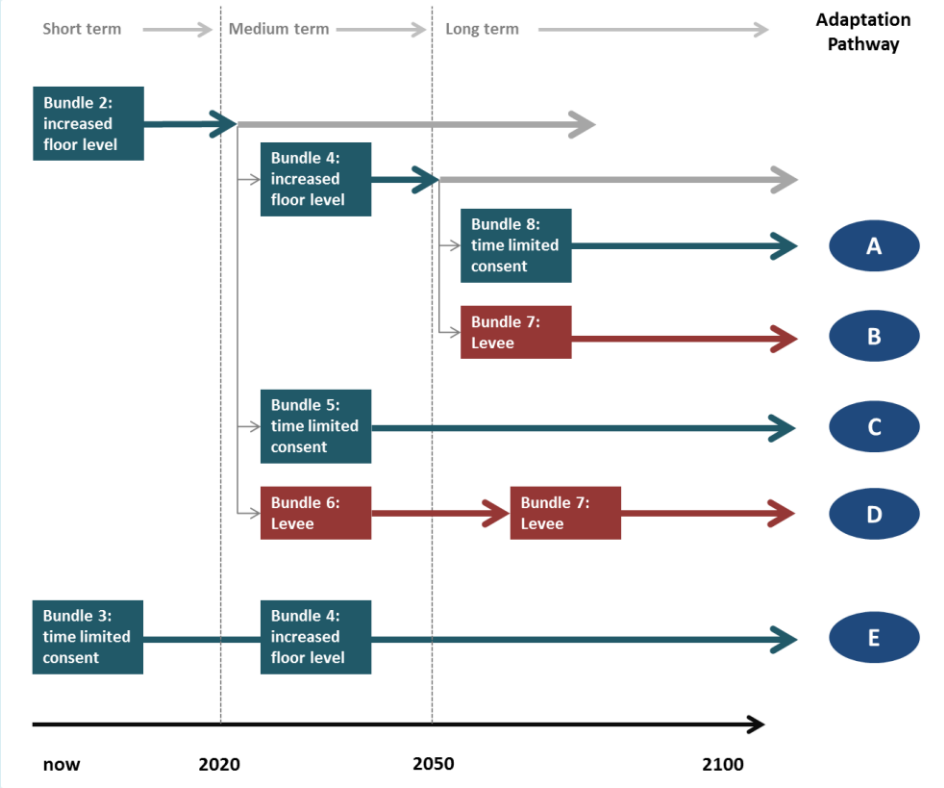


Figure 24 reveals the outcome of that mapping process, with Council identifying five potential adaptation pathways:

- **Pathway A – Mix of Adapt, Avoid and (eventually) Retreat :** Bundles 2 and 4 (Increased floor heights), Bundle 8 (time limited consent)
- **Pathway B – Mix of Adapt and Accommodate:** Bundles 2 and 4 (Increased floor heights), Bundle 7 (levee)
- **Pathway C – Mix of Adapt, Avoid and (eventually) Retreat:** Bundle 2 (Increased floor height), Bundle 5 (time limited consent)
- **Pathway D – Mix of Adapt and Accommodate:** Bundle 2 (Increased floor heights), Bundles 6 and 7 (Levee)
- **Pathway E – Mix of Adapt, Avoid and (eventually) Retreat:** Bundle 3 (time limited consent), Bundle 4 (increased floor heights)

The map of adaptation pathways (Figure 24) gives an indication of the different levels of flexibility as well as life of the bundles. For example, implementing Bundle 3 (time limited consent) in the short term locks Council into that bundle over the short, medium and long term (Pathway E), except that additional planning controls, such as floor heights, may be added. By contrast, implementing Bundle 2 in the short-term is more flexible, allowing Council to move from 'adapt' to 'accommodate' in either the medium term (Bundle 6) or long term (Bundle 4 and Bundle 7) or 'avoid' (Bundle 5 and 8).

Consideration of bundle flexibility has important implications for deciding which bundles should be included in the assessment of options and when. For example, if Council decides that it may be worthwhile implementing Bundle 3 in the short term, despite its inherent inflexibility, it will need to assess all adaptation pathways over the short, medium and long term to account for the inflexibility and/or long life of Bundle 3. That is, to allow a meaningful comparison of whole of life costs, all pathways will need to be assessed over the same timeframe.

It should be noted, that this assessment of medium and especially long term bundles will, by necessity, tend to be 'high level' in terms of estimating their costs and benefits. By undertaking the assessment over medium and long time periods though, even at a high level, Council should get a reasonable understanding of the whole of life costs and benefits of the different adaptation pathways – likely to be sufficient to rule out any of the pathways that have prohibitively high costs from further consideration.

In some circumstances Council may want to specifically value the flexibility provided by pursuing certain pathways (i.e. implementing Bundle 2). Applying the 'real options' method, discussed at length in Stage 8, will enable Council to do this. However, it should be noted that there are constraints regarding the feasibility and practicality of this rather complex assessment method. The main constraints being:

- the availability of probabilities of the possible value of unknowns (in this example, sea level rise and storm surge); and
- the high level of expertise required, in particular advanced modelling and statistics, and advanced financial theory.

Stage 5 checklist

Step 1. Identify adaptation options

- What are the possible adaptation options given the nature of issue and primary objective? Has a full range of options been considered?
- Has the 'business as usual' option been included and detailed?
- Has each option been sufficiently detailed to allow a meaningful review:
  - What is the focus and location of the option (i.e. what specific aspect of the issue is it seeking to address)?
  - Does the option have different subsets?

Step 2. Filter adaptation options

- What are the most appropriate filtering criteria given the objectives defined in Stage 3? What are critical criteria, what are merely desirable?
- Have suitable timeframes been defined?
- Given assessment against the criteria, do any of the options have flaws or constraints that are so great to prevent them for being advanced for further assessment - e.g. fails any of the critical criteria or fails to meet a number of desirable criteria?
- Do interdependencies between options exist? Can benefits be gained from bundling any of these options? If yes, with which other option(s) should the option be bundled?
- Has a short list of options that warrant further assessment been established for each time period?

Step 3. Bundle and shortlist adaptation options

- Has a shortlist of bundled options been established for each time period?
- Have no-regrets options been included in all bundles?

Step 4. Map adaptation pathways

- Are any of the bundles inflexible? Does the implementation of any of the bundles preclude options or bundles from being implemented in the future?
- Should inflexible bundles be subjected to more detailed analysis?
- Have all potential adaptation pathways been mapped?

6.Establish thresholds & triggers

Questions addressed in this section

- What are adaptation thresholds and triggers? What is the difference?
- When / under which circumstances is it suitable to use thresholds and triggers? What are the benefits of using thresholds and triggers?
- How are thresholds established? Is it possible that multiple thresholds exist?
- What types of triggers are available?
- How should appropriate triggers be selected? Will multiple triggers be required?
- Why is monitoring of triggers important? How and when should monitoring be undertaken?
- How will the results of the monitoring be used to trigger an adaptation action and/or adjust projects and trigger points?

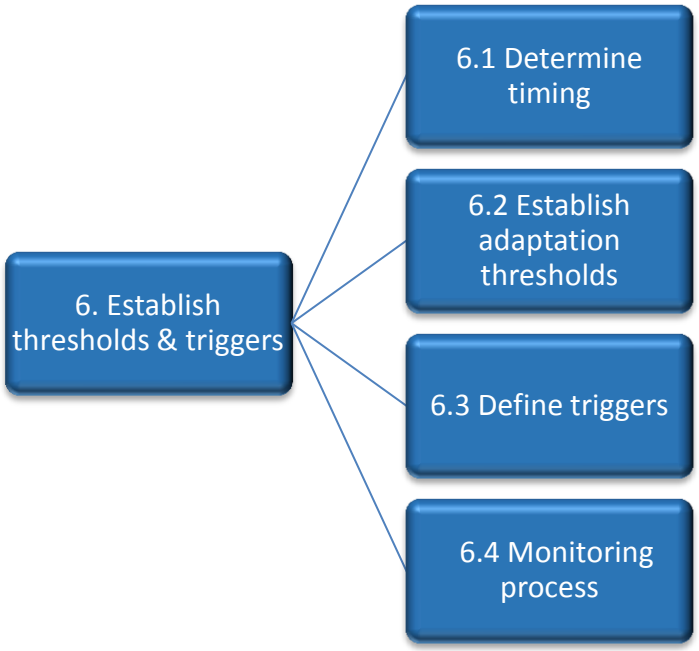
Overview

Climate change poses significant uncertainties, with a range of plausible future scenarios for sea level rise and other climate related hazards. Climate change projections on the local and regional level are being continually revised as new information and data become available. This calls for a flexible and adjustable approach to climate change adaptation to avoid premature redundancy of valuable infrastructure and putting communities and assets at risk.

Thresholds and triggers carefully selected to fit given circumstances and options, can serve as 'red flags' and prompt management response and/or implementation of a predefined option or set of options at an appropriate time. Thresholds and triggers support adaptation strategies that maintain the acceptable level of risks and only implement adaptation actions, if actual changes in risk start to eventuate.

This section discusses the importance of thresholds and triggers. It provides guidance on whether and what thresholds and triggers are appropriate. It also discusses the importance of monitoring to the process of setting triggers and thresholds.

Figure 25: Important steps in establishing thresholds and triggers



Box 27: Definitions and examples of thresholds and triggers

A **threshold** is a point or minimum level at which a possibly irreversible change, response or specified effect would happen or cease to happen. In the case of decision-making for coastal adaptation, an objective, as defined in Stage 3, can be achieved / met until a particular threshold is reached. The threshold therefore defines a point or level when a certain risk has reached an unacceptable level and an objective can no longer be achieved without intervention and implementation of adaptation options.

Example: At a sea level rise of 0.5 metres an area will be inundated and can no longer be utilised.

A tipping point is a subset of thresholds, where a relatively small change or aggregation of small changes causes a rapid and possibly irreversible change in a system, resulting in either a new equilibrium or a dramatic acceleration of the process or change occurring. As with other thresholds, a tipping point defines a an unacceptable level of risk.

Example: A small increase in salinity level in a wetland results in irreversible change to the wetland ecosystem.

A **trigger** is an incident or occurrence that initiates other events. In the case of decision-making, a trigger is used to indicate when a management response is required and/or an option should be implemented.

Example: At 0.4 metres of sea level rise the construction of a levee is triggered to protect an area from flooding.

There are essentially four points along the decision pathway where the use of thresholds and triggers may be beneficial (see Figure 26):

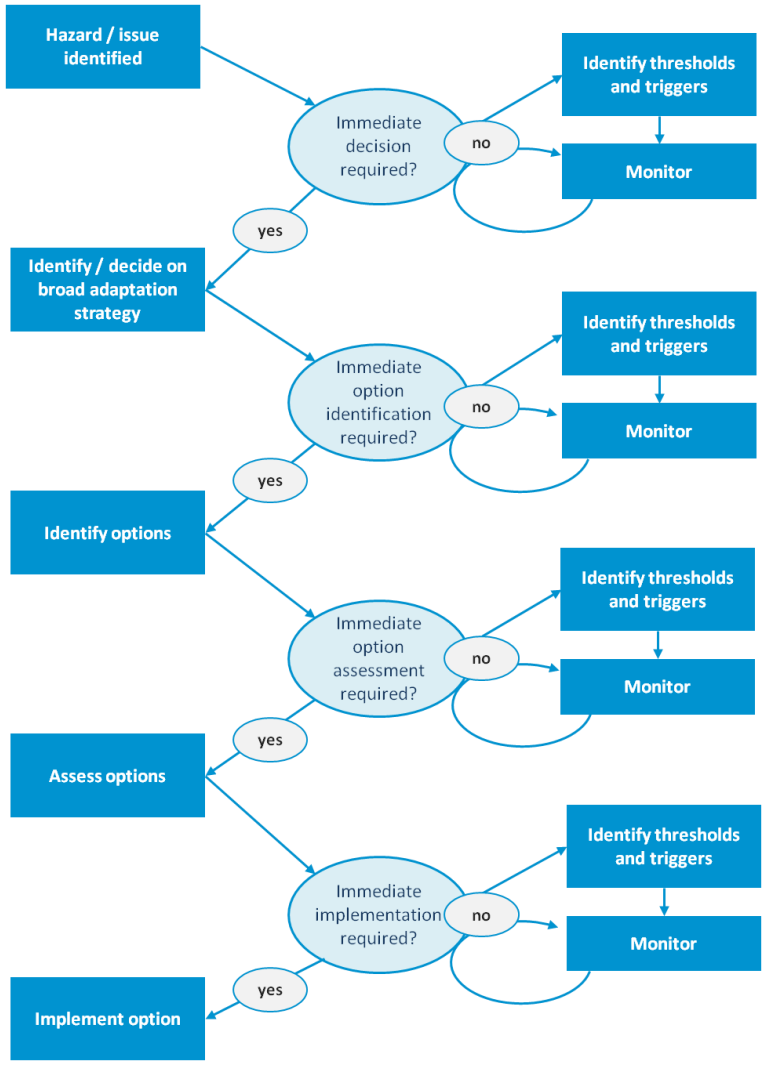
1. A potential issue has been identified and threshold / triggers are then used to determine when a decision on the broad strategy will be required;
2. The issue has been identified and a decision on the broad strategy has been made, threshold / triggers are then used to determine when specific adaptation options need to be identified;

   This may require a first (high level) assessment of the broad types of adaptation strategies (see Stage 5), weighing up the benefits and costs of, for example, 'protect', 'accommodate' and 'retreat', before a decision can be made and thresholds and triggers established.
3. The issue and specific adaptation options have been identified; thresholds and triggers are then used to determine when the options need to be assessed.
4. The issue has been identified and a decision regarding specific adaptation options has been made (after undergoing an option assessment – see Stage 7), thresholds / triggers are then used to determine the timing of the implementation of the preferred option.

Given that decision-making is an iterative process, it is possible that adaptation thresholds and triggers are used more than once along the decision pathway (see Figure 26).

The use of thresholds and triggers is probably most common for the latter two points described. Using thresholds and triggers also facilitates delaying a decision that can assist in gaining further knowledge and information on the issue in order to reduce the uncertainty surrounding it. Extending the timeframe for implementation of a particular measure will defer the expenditure and avoid cost increases for users (e.g. increases in council rates or levies).

Figure 26: Decision pathways for thresholds and triggers



For example, delaying the decision on the renewal or decommissioning of transport infrastructure exposed to flooding may result in new technology for maintaining, upgrading or replacing the infrastructure becoming available. It may also reveal a change in customer expectation or the usage of the infrastructure, which then necessitates (allows) up-sizing (downsizing) of the capacity of the assets and may also change the decision pathway altogether.

Similarly, delaying the renewal of an asset defers the capital expenditure and associated financing costs and (temporarily) frees up funds for other projects. It may also yield other benefits such as cost reductions in materials and/or of new technologies.

6.1 Determine timing

Timing is a crucial element that needs to be determined, before making a decision on whether thresholds and triggers are useful tools under the given circumstances. At each step in the decision pathway (Figure 26) the question is "*Is a decision / action required now?*" or in other words *"What is the appropriate timing for a decision / action?"*. It depends on the answer to these questions, whether the use of thresholds and triggers should be examined further.

Overall, there are three aspects to timing that need to be examined in the context of thresholds and triggers (Figure 27). The first point is discussed in more detail below, with the latter two points being discussed in sections 6.3 and 6.4 respectively.

Figure 27: Timing in the context of thresholds and triggers

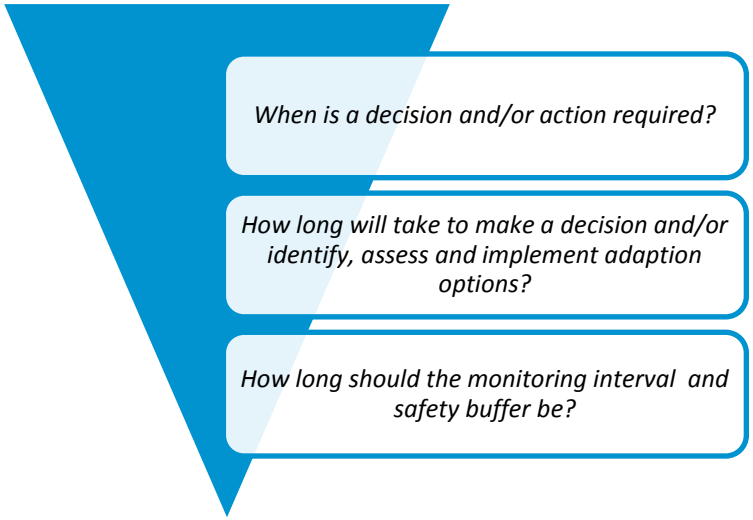
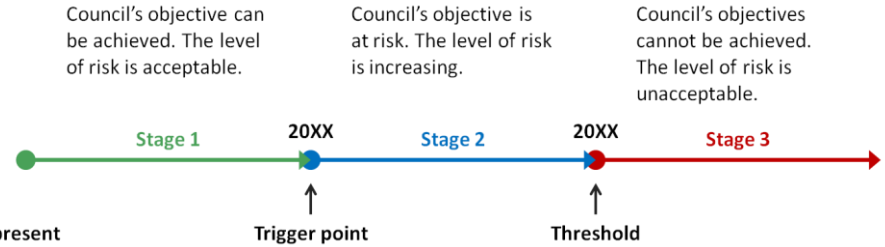


Figure 28 illustrates three distinct stages in timing, which relate to thresholds and triggers. The first stage (green) shows the time when the objective(s) can be achieved and the level of risk to these objectives is acceptable. The use of triggers and thresholds during this period is appropriate and recommended.

During the second stage the level of risk is increasing and objectives are increasingly difficult to meet. The trigger point has been reached and adaptation options should be developed and implemented to avoid major, possibly irreversible, consequences.

In Stage 3, the impact / consequences have already occurred; the threshold has been passed. Adaptation options to protect or retreat need to be implemented immediately.

Figure 28: Timing



Source: MJA after "The Time Continuum Model" (Fisk and Kay (2010))

When is a decision and/or action required?

To determine the answer to this question it may be helpful to ask the following additional questions:

- *"How much more climate change before we will be constrained in our adaptation strategies?";*
- *"How much more climate change will we be able to live with or are we willing to tolerate?"*, and/or
- *"How much more climate change before we will no longer be able to meet our defined objectives* (see Stage 3)*?"*

If the answer to these questions is

- *"We need to decide on 'protect', 'accommodate', 'retreat' or 'No-Go', 'Slow Go', 'Go' now, otherwise not all of these options will be available."*
- *"We cannot live with or are not willing to tolerate the existing climate change / variability any / much longer."*
- *"We are already struggling to meet the objective."*

an immediate response, in form of a decision or action is required and thresholds and triggers should not be used. That is, a broad adaptation strategy or adaptation options will need to be identified (Stage 5), options will need to be assessed (Stage 7) and/or implemented (see Stage 9).

If the answer to this questions is along the lines of

- *"As long as X does not exceed / fall below Y, adaptation actions are not yet required", or*
- *"We do not need to make a decision, we can achieve our defined objective, provided that X does not happen."*

the use of adaptation thresholds and triggers should be examined further.

The use of different timeframes during the option filtering process (see section 5.2) may also provide some indication on whether it might be appropriate to use thresholds and triggers for some of the options. Options which are likely to be implemented in the medium- to long-term (e.g. 2025 and beyond) are also likely to benefit from the use of thresholds and triggers.

Sequencing of adaptation options

As noted earlier (see Stage 5), a succession of options (i.e. adaptation pathways) will be required in some instances to deal with increasing impacts of climate changes, and also changes in the social and economic context. Staging options over time enables a flexible and cost effective approach. For example, a potential, not yet imminent threat from climate change, such as flooding, may be addressed through changes to building standards and an education campaign, then followed, when required, by technical protective works and eventually, once all other feasible options are exhausted, by retreat.

The use of thresholds and triggers in the sequencing of options will provide guidance to decision-makers on the timing of adaptation options, taking into account future climate and socio-economic developments and possible changes in community and political attitude. The use of thresholds and triggers in sequencing of adaptation options is highly recommended.

6.2 Establish adaptation thresholds

Before setting specific adaptation thresholds, decision-makers should establish how climate change may impact on the primary objective defined in Stage 3.

Climate changes impacts could be:

- direct, such as flooding, erosion of beaches and foreshores, rising water tables, and/or increases in salinity levels; and
- indirect, such as increases in operating or insurance costs, non-compliance with specified level of service, increases in complaints and/or a decline in customer satisfaction.

Most, if not all, indirect impacts will be a flow-on effect from direct climate change impacts. For example, an increase in insurance premiums for or maintenance cost of public infrastructure (e.g. roads, stormwater systems, and water and sewerage systems) may be a flow-on effect from an increase in the frequency and/or severity of extreme events.

Physical thresholds (e.g. sea level rise, salinity levels, groundwater levels, maximum flood height) are an obvious choice. For example, if an objective cannot be met once sea level rise reaches 50 cm, then the physical threshold would be set at a sea level rise of 50 cm.

In addition, thresholds for the level of economic or social impact may complement or be used as a substitute for physical thresholds, if these are difficult to measure. Examples of thresholds are listed in Table 12.

Box 28: Threshold and trigger types

Physical / Environmental thresholds and triggers are an obvious choice and examples include sea level rise, annual event probability (e.g. flooding), salinity levels and changes in ecosystems.

Social thresholds and triggers are largely concerned with the community's attitude towards risks (e.g. related to climate change impacts) and the community's expectations and satisfaction regarding the services provided by agencies (e.g. defined levels of service).

Economic threshold and triggers are concerned with the economic impacts and consequences on the council and other agencies as well as the wider community. This includes, for example, the ongoing maintenance costs for infrastructure, the insurance premiums to lay off risk, or the economic loss expected should a particular event occur.

A combination of thresholds may be useful in some circumstances.

For example, if a number of pressures from several direct or indirect impacts exist or if the variable of one threshold can be monitored more often or easier than the variable of others.

An economic threshold, such as the maximum acceptable maintenance cost, may - under some circumstances - be reached earlier than the physical threshold. It is also likely that maintenance costs can be monitored more readily and easily than some physical thresholds.

Identify possible thresholds

Applying a process used in risk assessment and risk management may be helpful in identifying a range of potential thresholds. Risk assessments often identify and record not only the risks but also the drivers or causes of these risks as well as the resulting consequences (Figure 29). Both the causes and the consequences of a particular risk or issue at hand present potential thresholds. These will vary depending on the specific circumstances and locations.

Figure 29: Risk approach to identify thresholds

It is important to note that thresholds need to align with the primary objective defined in Stage 3. That is, thresholds will represent a point when the primary objective can no longer be met. For example, if the primary objective is '*to maintain and protect the amenity and safety of area X for as long as it is cost effective to do so*', a threshold would describe a particular state or situation, when - once reached - it is no longer possible to maintain and protect the amenity and safety of area X.

Select appropriate thresholds

Once this range of thresholds has been identified, decision-makers need to determine, which of these thresholds are most appropriate to use in their situation.

In order to work most efficiently and effectively thresholds and the underlying variable should meet the following criteria:

- align with the primary objective;

- be quantifiable and measureable;
- follow a trend;
- be available over time and at the right scale; and
- not be susceptible to influences from unrelated drivers and manipulation.

As noted above, thresholds need to align with the primary objective. They also need to be quantifiable, easily measurable and follow a trend, as predictions are not feasible if a variable follows a random path.

If thresholds are established for a smaller area, data needs to be available for this level. For example, maintenance costs are usually recorded by asset classes and cannot necessarily be tracked for individual assets that may be impacted. If a biophysical threshold is difficult or costly to measure, an economic or social threshold may be used as substitute.

As decades will elapse until some thresholds are reached, the variable or data underlying the threshold needs to be available over this timeframe. This may be an issue, if decision-makers do not have control over the provision of data. That is, if the threshold utilises very specific data or projections, which are provided by other organisations, such as the Australian Bureau of Statistics (ABS), the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) or the Public Health Information Development Unit (PHIDU). These organisations may cease to report on certain statistics. Decision-makers should be reasonably certain that the variable will not only be measurable and quantifiable, but also available for the time until the trigger or even the threshold is reached. For example, one can be reasonably certain that Census data will be collected and published every 5 years.

It should also be considered whether the threshold variable may be influenced or easily manipulated by other unrelated drivers. If this is the case, a change in the threshold variable may not accurately reflect the actual change of the level of risk associated with an issue. That is, the change in the level of risk may appear larger or smaller due to the impact of other drivers on the threshold variable.

For example, increases in maintenance costs may not only be driven by extreme events, such as flooding, but also climate unrelated incidents such as vandalism, accidents or premature failure of the assets. Similarly, some threshold variables may be easily manipulated. If customer complaints regarding a particular issue are used as threshold to determine when adaptation measures need to be implemented, customers could accelerate the implementation by lodging more complaints.

In some case it may be feasible to use the same threshold for several locations and issues. This provides a win-win situation through cost sharing (e.g. monitoring cost) and this threshold should be utilised, provided it meets the necessary criteria discussed above.

Box 29: Example – identifying thresholds

Sea level rise and increases in storm surge pose a threat to coastal transport infrastructure. A low lying and very popular coastal road maintained by Council is expected to be severely impacted in the future. Council's objective is to ensure well maintained and safe roads, with a limited number of days with road closures per year.

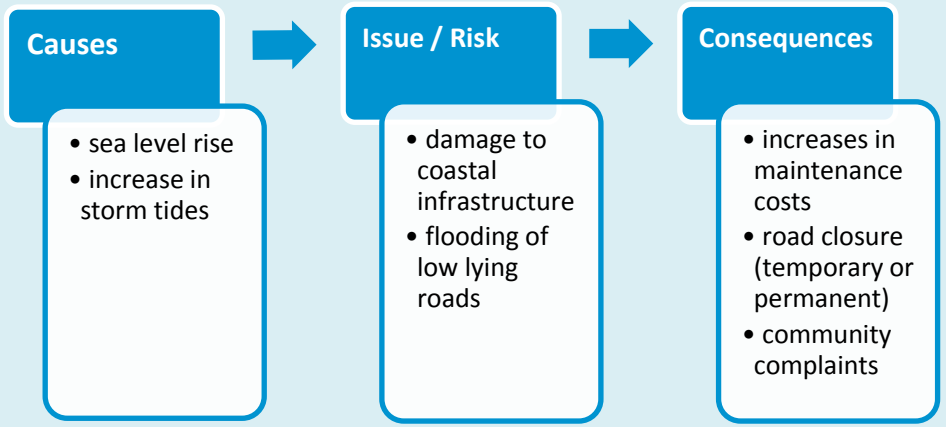
To better understand when a decision regarding adaptation options for the popular coastal road will be required, Council establishes thresholds by applying a risk assessment approach (see Figure 30).

Physical thresholds – often the causes of the issue – indicate that Council's objective(s) can no longer be met once sea level rise reaches 0.5 metres and storm tides a maximum height of 1.5 metres, as the coastal road would be flooded several times per year, if not permanently.

The consequences of this risk also provides possible thresholds; in this example, economic and social thresholds. Based on the current annual budget for road works, the objective (well maintained roads) would no longer be achievable, if maintenance costs (an economic threshold) increase to more than $500,000 per year. Similarly, the community considers a closure of the popular road of more than 3 consecutive days or a total of 10 days per year as unacceptable.

From these four potential thresholds (sea level rise, storm surge height, maintenance costs and days of road closure), Council selected sea level rise and maintenance costs as thresholds for its decision-making process.

Figure 30: Identification of causes and consequences of risk



Sea level rise will be monitored and projections will be revised and published regularly by the State Government and maintenance costs can easily be obtained from Council's financial records. The number of days the road was closed has fluctuated significantly in the last five years and does not follow a clear trend. In addition, the variable might be influenced by unrelated events, such as accidents or major non-climate related maintenance works.

Table 12: Examples of thresholds

Type	Strategy	Physical / Environmental Thresholds	Economic Thresholds	Social Thresholds
Established infrastructure and land uses	**Protect**	▪ sea level rise ▪ probable maximum flood level ▪ annual exceedance probability ▪ frequency of nuisance flooding (minor damage) ▪ frequency of flooding above floor height (major damage) ▪ extent of erosion / shore line recession ▪ water quality (e.g. salinity level) ▪ loss of (protected) species / decrease in species population	▪ maintenance costs ▪ frequency of unplanned maintenance ▪ frequency of disruptions to businesses and residents (e.g. closure of areas, transport / shipping routes) ▪ usability of assets	▪ community outrage / customer satisfaction ▪ number of complaints ▪ public and political appetite for risk ▪ people and properties at risk
	Accommodate	▪ as above	▪ operating and maintenance costs ▪ frequency of disruptions to businesses and residents (e.g. closure of areas, transport / shipping routes)	▪ Community outrage / customer satisfaction ▪ Number of complaints
	Retreat	▪ as above	▪ insurance premium ▪ operating costs ▪ remaining life of existing assets	▪ Number of lives at risk ▪ Number of days areas (e.g. recreation facilities, reserves, roads) need to be closed per year

Note in some cases a threshold may also be used for adaptation strategies regarding new developments. For example, a physical threshold may trigger protective works, 'activate' conditions of consent or a retreat policy.

6.3 Define triggers

Having established the adaptation threshold(s), decision-makers need to determine an appropriate trigger for each threshold. Once the trigger point is reached, adaptation action should be initiated. Defining a trigger is essentially a five step process.

Step 1: Obtain or develop projections for the threshold variable

Projections are required to gain an understanding of the rate (or speed) of changes occurring and therefore the likely timing of the threshold being reached. In the case of physical and environmental thresholds (e.g. sea level rise, coastal recession), these will most likely be derived through analysis undertaken for the hazard assessment (see Stage 4). In the case of economic or social thresholds, historic trends may need to be considered when developing projections (see Box 30). It is equally likely, however, given that many of the changes relevant to economic or social thresholds will be driven by climate change impacts, that climate change projections will need to be considered when establishing projections for those thresholds.

Based on projections, an approximate point in time when the threshold will be reached can then be extrapolated. This point in time will provide an indication of how long the primary objective for the area can continue to be met, without further intervention being required (i.e. new adaptation actions). This point in time will only be an approximation though. An ongoing monitoring program will be required to provide a clearer picture, over time, of when the threshold is likely to be reached (see section 6.4).

While thresholds and consequently triggers will vary depending on the issue at hand and the specific circumstances of the organisation, standardised projections should be used, where possible, to ensure consistency across the region. For example, where state wide projections for physical threshold variables (e.g. sea level rise) are available, or if service levels are determined by state or national guidelines, these should be utilised. In other cases the threshold itself may be standardised, but the projections may depend on local circumstances. An example is increases in salinity levels, which pose a threat to certain species once a particular level is reached. The projections however, depend on the location and other factors.

Step 2: Establish time required for the response

During this step, the answer to the question *"How long will take to make a decision and/or identify, assess and implement adaption options?"* needs to be established. Depending on the location along the decision pathway this may include the time required to:

- decide on a broader adaptation strategy (e.g. protect, retreat);
- identify adaptation options (e.g. consultation with stakeholders and filtering of options to determine short list);
- assess adaptation options (e.g. conducting a cost benefit analysis); and
- implement adaptation options (e.g. construction of a seawall, decommissioning of a sewage treatment plant, relocation of a recreational centre), which may include time required for preparation (e.g. funding, planning approvals, etc.).

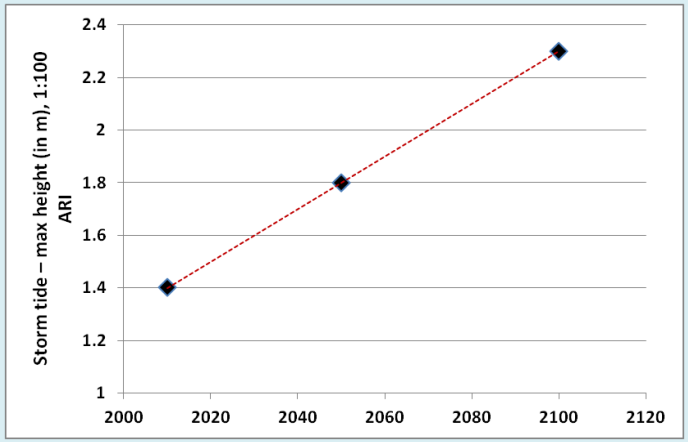
If thresholds and triggers are used to initiate actions in relation to new developments (e.g. to trigger development restrictions for residential dwellings) the life of the asset may need to be included in the response time. For example, the threshold indicates when current floor heights will no longer be above the 1:100 year flood level. The trigger point is used to determine when a development restriction, requiring higher floor levels, needs to put in place. In this case, the life of the assets affected - residential dwellings - needs to be included in the response time to ensure that the housing stock in place at the time the threshold is reached is built with sufficient floor heights.

Box 30: Developing projections – interpolation and extrapolation

Interpolation is used to construct new data points within the set of known data points. Linear interpolation is the simplest method and creates new data points by connecting the two closest existing data points.

For example, climate change projections may only be available for certain points in time (e.g. 2030, 2050, 2070, 2100). Interpolation can be used to establish the likely values of the climate variable within these points in time. The example shown in Figure 31 uses three data points (2010, 2050 and 2100) for the interpolation.

Figure 31: Interpolation of storm tide projections



Extrapolation creates new data points at the end of known data points. This method will be particularly useful for economic and social thresholds, when no projections for the future are available. For example, where insurance premiums or increases in operating costs are used as a threshold, the actual premium or costs over the last five to ten years can be used to extrapolate data points in the future. The following examples use data from the previous 7 years for the extrapolation.

Figure 32: Linear extrapolation

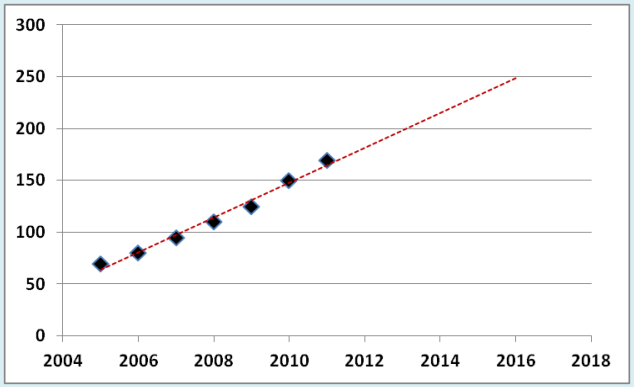
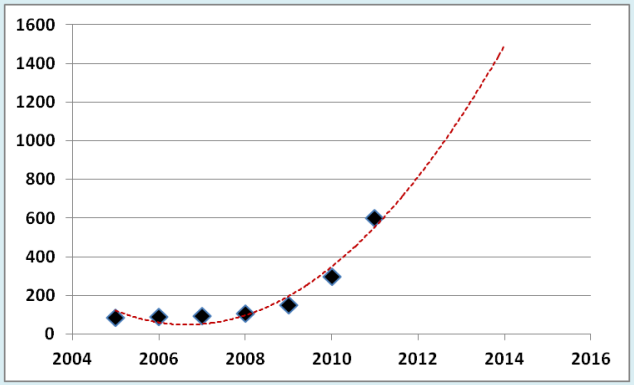


Figure 33: Polynomial extrapolation (2nd degree)



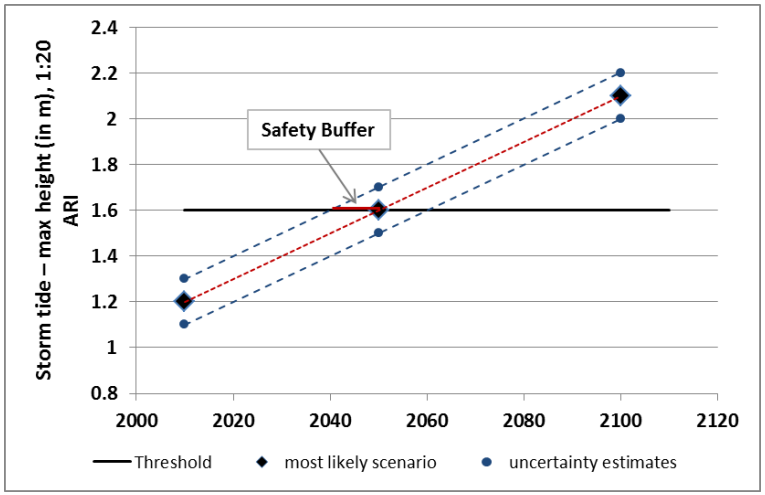
Which method of interpolation or extrapolation (e.g. linear, polynomial, exponential) is most suitable depends on the known data points. If these form an approximately linear function, linear extrapolation is an appropriate method. MS Excel's function 'add trend line' in charts is helpful to graphically display trends in data and can be used to predict future values.

Step 3: Determine an appropriate 'safety buffer'

Due to the uncertainty prevalent in coastal decision-making, the exact point in time when a threshold will be reached is unknown. A safety buffer or safety margin allows for unforeseen events, such as an acceleration in the direct or indirect effects of climate change or a delay in the decision-making process.

The length of the safety buffer will vary depending on the specific circumstances. For some thresholds uncertainty estimates may be available and can be used to determine a safety buffer (Figure 34). In the case of climate change, a best case scenario may be accompanied by additional scenarios, which can then be used to determine a safety buffer.

Figure 34: Establishing a safety buffer using uncertainty estimates



Depending on what is at stake, the willingness to go near the limit may vary. The safety buffer is therefore not just a statistical variable, but needs to be set within the particular social or ecological context, taking into account the appetite for risk among the stakeholders and communities. In general, the greater the risk (e.g. loss of life), the larger the safety buffer should be.

The safety buffer can be expressed in different units, such as time (e.g. an additional 5 years), as a percentage (e.g. an additional 10 percent of maintenance costs) or in the unit of measurement of the threshold variable (e.g. centimetres of sea level rise, dollar value, number of complaints or properties at risk).

Step 4: Set the monitoring interval

This issue is discussed in section 6.4.

Step 5: Determine the trigger point

The trigger point will initiate further action, such as deciding on an appropriate adaptation strategy, identifying and assessing specific adaptation options or implementing adaptation options. The trigger point is determined by subtracting the response time (Step 2), safety buffer (Step 3) and monitoring interval (Step 4) from the point in time when the threshold will be reached. The trigger point in Figure 35, for example, is 2021. This has been estimated by working backwards (i.e. subtracting the response time, a safety buffer and monitoring interval) from a hypothetical threshold value of 1.4 m. This threshold value expected to be reached in 2030 is, in turn, based on the modelled 1 in 20 year storm surge height (taking into account standard sea level rise projections), a value (again hypothetically) that is considered to result in an unacceptable frequency and level of damage to local residents.

Box 31: Principles for setting triggers

Triggers should be:

- Simple and easily understood.
- Based on data that can be consistently gathered and interpreted.
- Measurable or readily collectible without significant additional cost.
- Comparable over the affected area.

Box 32: Timing of decisions on assets nearing the end of their useful life

When considering upgrades or replacement of existing infrastructure, decision-makers will need to take into account the remaining asset life of the existing asset before setting the trigger. If an asset reaches its useful life **before** the trigger point (determined in Step 5) is reached then the remaining asset life could become the trigger point or at least an additional trigger point in the decision-making process.

In this situation decision-makers need to weigh up:

- the additional capital costs (and other costs such as operating costs) associated with upgrading or replacing the asset earlier than required; **against**
- the cost of writing-off a redundant asset if the asset is replaced like-for-like, but subsequently needs to be replaced before the end of its useful life (when the trigger point determined in step 5 is reached), minus the benefits of deferring investment in the upgraded asset.

For example, a major road servicing a coastal settlement is expected to require major upgrade or replacement by Council in 5 years from now. Based on a hazard assessment though, Council has determined that the road will need to be raised significantly or rerouted in approximately 20 years from now (the estimated trigger point) to ensure that it can continue to service the coastal area. That is, if Council replaces the existing road like-for-like in 5 years from now, within a further 15 years it will need to be replaced (i.e. resulting in the asset being written off 15 years before the end of its useful life of 30 years).

Council therefore needs to weigh up the additional capital costs of building a raised or rerouted road in 5 years' time (i.e. 15 years earlier than required) against writing-off the upgraded (but not raised) road after 15 years.

The costs associated with these alternative options need to be examined as part of the option assessment describe in detail in Stage 7.

Box 33: The use of thresholds and triggers in regulating new developments

Thresholds and triggers may also be used to regulate development in areas vulnerable to climate change. For example, Wellington Shire Council in Victoria requires development proponents to prepare a Climate Change Response Plan as a condition of the approval of a planning permit for development in areas vulnerable to flooding. This plan will be attached to the property title via a Section 173 Agreement and will therefore apply to the current and future owners of the property.

This plan examines climate change impacts on the site (e.g. flooding or a breach of the dunes), risks to the occupants and property, and includes a written Response Plan, which incorporates triggers for action, such as inundation levels, and action responses to these triggers.

An example for the use of triggers is in the decision to require site clearance in the worst case scenario, e.g. a potential permanent inundation of the property. In this case, the owners should remove the dwelling according to the site clearance plan, if certain triggers have been reached. These include:

- *The probability of periodic hazardous flooding has become unacceptable (possible trigger – flooding deeper than 300mm has 10% or greater Annual Event Probability (AEP)).*
- *Unacceptable likelihood of dangerous conditions e.g. probability of a marine erosion event threatening property or essential infrastructure, being assessed at greater than 1% per year, at any time over the following ten years.*
- *Essential public infrastructure becoming impractical or uneconomic to maintain.*

The need for regular monitoring is recognised by Council. It requires land owners to review, and if necessary update, the climate change response plan, at least every 10 years.

Box 34: Example – defining triggers

Following on from the previous example (Box 29), Council defined a trigger for each of the two thresholds identified following the five steps outlined below.

Step 1: Obtain or develop projections for the threshold variable

Council utilised projections for sea level rise provided by the State Government for 2050 (40 cm) and 2100 (90 cm), and used linear interpolation to determine SLR values for other years.

To construct projections for the maintenance costs for the coastal road, council utilised the cost incurred in the previous 5 years and applied a linear extrapolation.

Step 2: Establish time required for the response

Council expects that in the worst case it would be required to either elevate the existing road or construct an alternative road. It estimates that 5 years should be allowed for the development and implementation of adaptation options, including amongst others identifying alternative routes, planning, design and construction of the new road, and the community and council consultation required to determine and implement the preferred option.

Step 3: Determine an appropriate 'safety buffer'

Council decided to allow for an additional 10cm of sea level rise as a safety buffer. As a sea level rise of 1cm per year is expected beyond 2050, the corresponding safety buffer timeframe is set at 10 years.

The safety buffer for the maintenance cost threshold was set at 1 year based on the yearly monitoring interval and because the data is easily accessible.

Step 4: Set the monitoring interval

The monitoring intervals for sea level rise projections depend on the publication of revised projections by the State Government.

The next revision is expected in 2014 and a review of the trigger has been scheduled to coincide with this. Council expects a five year monitoring interval afterwards.

However, this may be revised if new information from State Government becomes available. The development of maintenance costs will be reviewed annually in line with the financial reporting cycle of council.

Step 5: Determine trigger point

Based on current projections and the established timeframes for response, safety buffer and monitoring, the sea level rise trigger point was set at 33cm, expected to be reached in 2040.

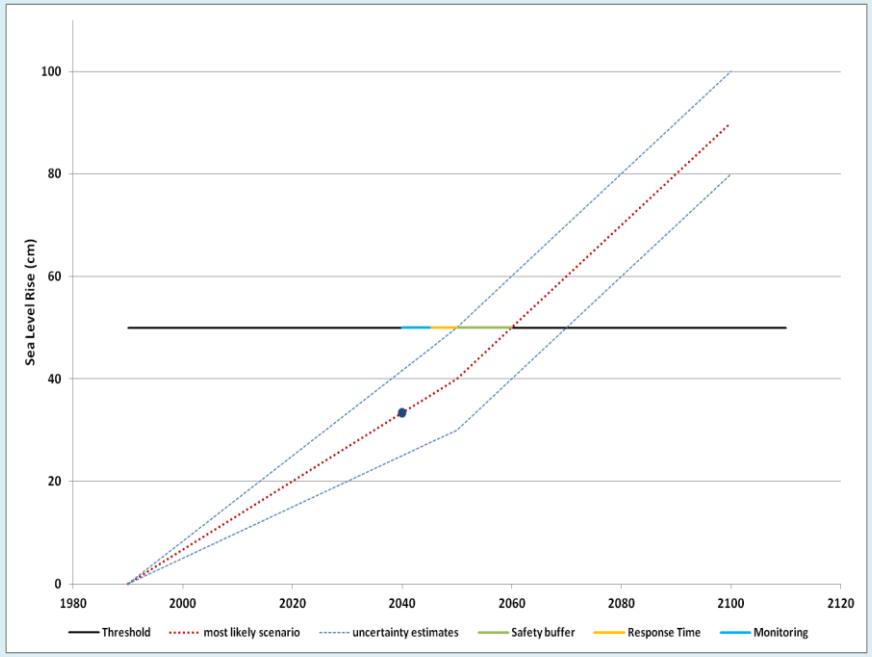
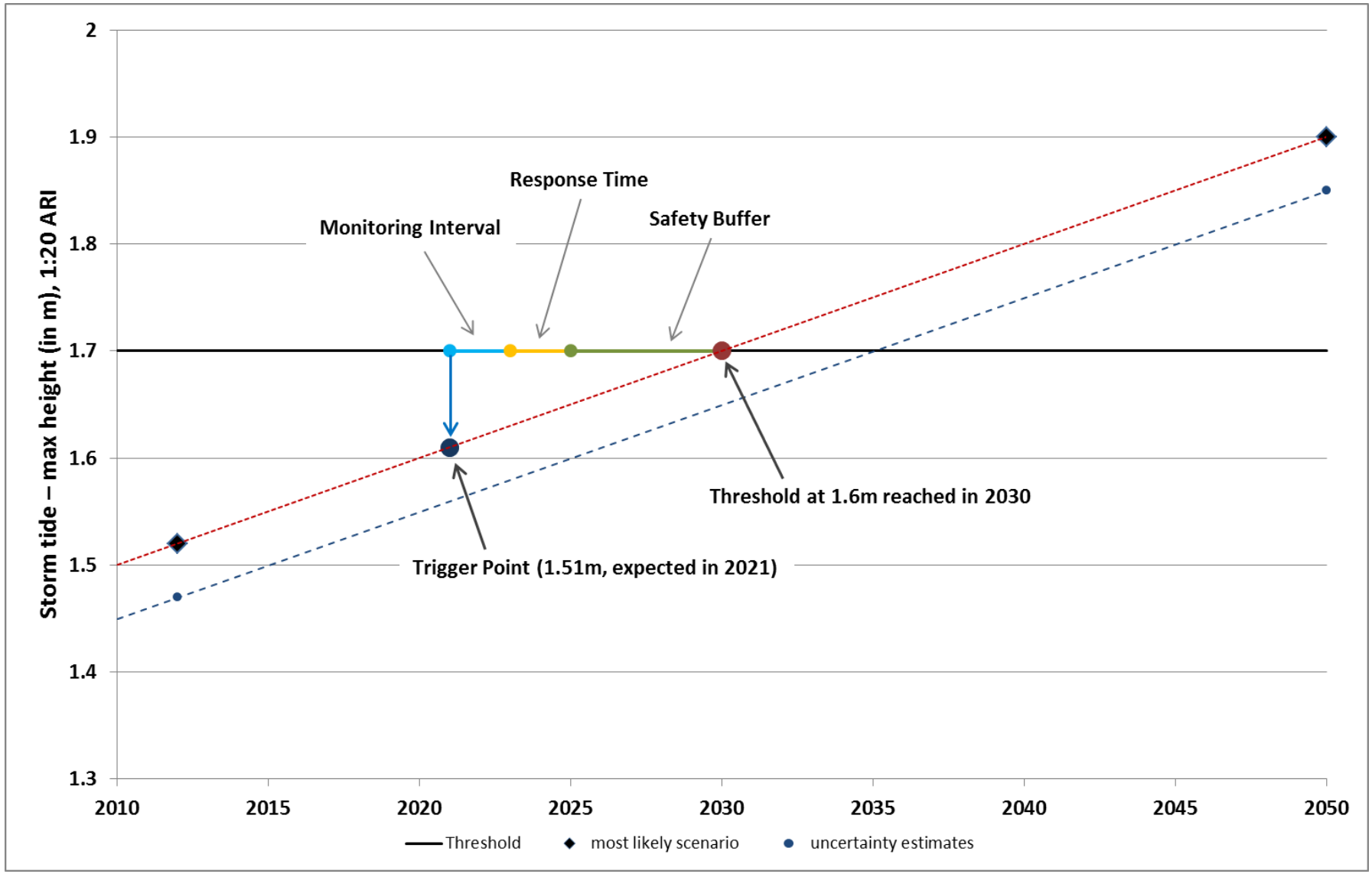


Figure 35: Determining the trigger point



6.4 Monitoring of thresholds & triggers

Observation of thresholds and triggers is unlikely to be continuous or straightforward. Thus a monitoring regime will need to be put in place. In the context of thresholds and triggers monitoring can be defined as 'being aware of the current magnitude or rate of change of the threshold variable(s)' (e.g. sea level rise, salinity levels, insurance premiums, maintenance costs or community complaints).

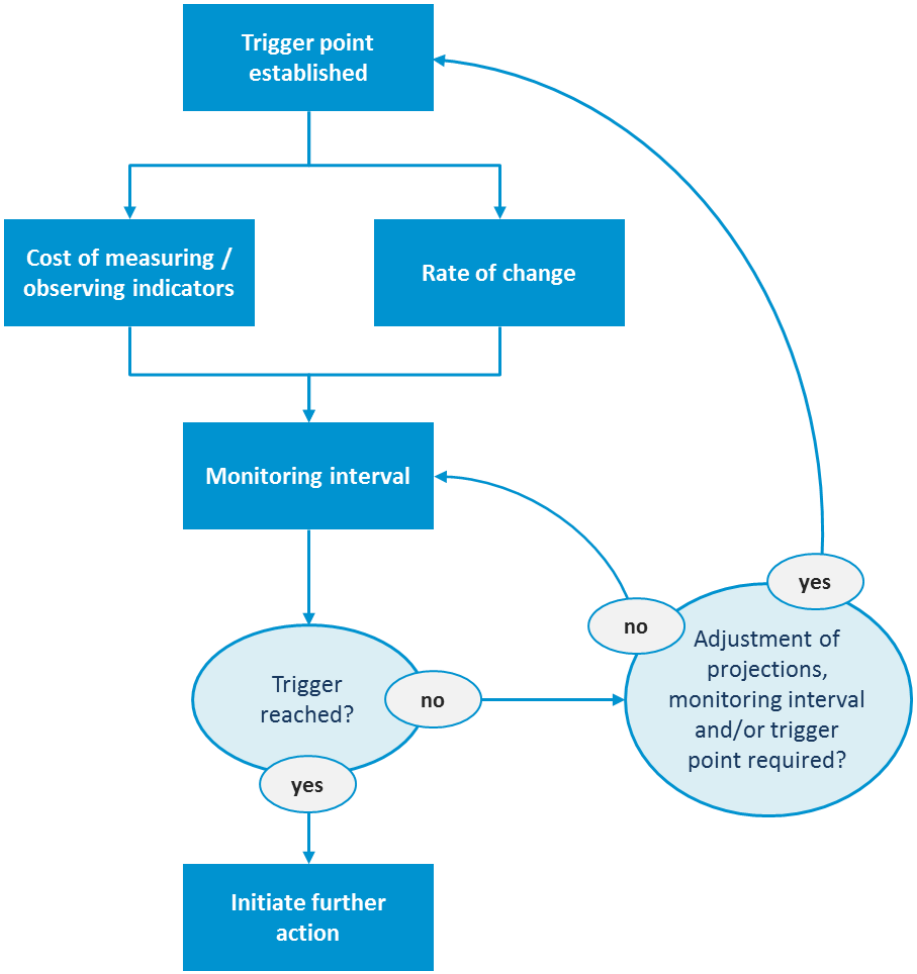
A well designed threshold monitoring program is critical to the effective application of triggers for two reasons (Figure 36):

1. To assess if the trigger point has been reached; and
2. To revise and adjust projections, and possibly the trigger point, as more information becomes available.

Without monitoring change in the threshold variable it is not possible to determine if the trigger point has been reached and if further action needs to be initiated.

The process of regular monitoring helps to reduce potential errors, based on limited or insufficient information. It provides a mechanism to update and revise triggers for reducing potential errors, as more information becomes available and knowledge increases. A monitoring regime for threshold variables should be initiated as soon as possible after thresholds and triggers have been established.

Figure 36: Decision pathways associated with monitoring of triggers



6.4.1 Monitoring process

Monitoring interval

An important aspect of the monitoring regime, which has implications for setting the trigger point (see section 6.3), is the monitoring interval.

The monitoring interval will be determined by both the rate of change and the time, effort and thus costs involved in measuring the indicator.

Some indicators will change relatively rapidly, whereas other indicators will change slowly over time. Still other indicators may experience fluctuations around a trend. This 'behaviour' of the trigger variable should be taken into account, when setting monitoring intervals.

For example, the rate of increase in sea levels over the last century has been approximately 1.7 mm per year over the period 1900 to 2009 (Church and White 2011). Based on this long term trend, if a sea level rise trigger of 30cm from 2000 were to be set, a relatively long monitoring interval (e.g. 5 years) may be adequate. However, based on more recent satellite altimeter data (1993-2009) the rate of increase has accelerated to about 3.2 mm per year, suggesting that the monitoring interval may need to be shortened over time.

Relatively short monitoring intervals (e.g. annual or even biannual) could be necessary for indicators that change at a relatively fast pace, such as rapidly retreating beaches, with additional monitoring scheduled after an extreme event.

Other indicators may come with an inherent monitoring interval as the change can be observed at a certain reporting date. This is likely to be the case with economic indicators in particular, or for example, insurance premiums that are paid at regular intervals. Reports on economic indicators, such as operating and maintenance costs, and also social indicators, like visitation numbers or complaints, are published quarterly, half-yearly or yearly. In these cases reporting cycles are most likely to be the determinant of monitoring intervals.

Table 13: Examples of monitoring intervals

Monitoring Interval	Trigger
> 1 year	▪ sea level rise ▪ probable maximum flood level ▪ annual exceedance probability ▪ number of lives at risk ▪ people and properties at risk ▪ property values
Annual	▪ extent of coastal erosion/ recession ▪ salinity level ▪ number of species / decrease in population ▪ public and political appetite for risk ▪ number of days areas need to be closed (e.g. recreation facilities, reserves, roads) ▪ remaining life of existing assets ▪ operating and maintenance costs ▪ insurance premiums
< 1 year	▪ frequency of disruptions to businesses (e.g. closure of areas, transport / shipping routes) ▪ community outrage / customer satisfaction / attitudes ▪ number of complaints

Another point that needs to be taken into account when setting the length of the monitoring interval is the time and cost involved in observing and measuring the change.

The cost of measuring the indicator needs to be in proportion to both the benefits that are expected from the adaptation action and the pace at which the indicator is changing.

For example, comprehensive flood modelling is required to determine changes in maximum flood heights. This is both costly and time-consuming. Decision-

makers will need to weigh up the costs of measuring the maximum flood height against both the damages expected from a severe flood and rate at which the maximum flood height is increasing (this may be based on past observations).

Another example is the change in community outrage or the community's, perception and appetite for risk. To measure the change in these indicators, a survey will be necessary, asking community members to apply ratings on scale from 1 to 10 for example. The monitoring interval is constrained in this case by both the costs and participation rates of the surveys, which would be expected to drop, if surveys are undertaken too frequently.

Consideration of the monitoring interval will also help to confirm whether or not the selected threshold is appropriate. If a suitable monitoring interval cannot be identified (and if a suitable monitoring regime cannot be established), it is likely that this threshold will not meet all of the selection criteria discussed in section 6.2 - for example, because the threshold is not quantifiable and measureable or because it does not follow a trend.

Other aspects of the monitoring process

Other important aspects of the monitoring regime will need to be established. In particular, decisions will need to be made about:

- how the threshold variable is to be monitored;
- who will have responsibility for the monitoring (agency, department etc.);
- data compilation and reporting; and
- resource allocation.

6.4.2 Monitoring of the trigger variable

As noted earlier in this section, regular monitoring allows for adjustments to projections and trigger points when new information (e.g. on the magnitude and rate of change occurring) becomes available. This information can then be used to refine projections of future change. Trajectories of threshold and trigger variables will most certainly change over time and might require the trigger point to be revised. For example, if sea level rise occurs at a faster rate than originally anticipated, the trigger point will need to be lowered to allow for sufficient time for the implementation of the adaptation option.

At the end of the first monitoring interval, results of the initial monitoring should be compiled, with this information being used to determine:

1. whether the trigger point been reached or is close to being reached and the adaptation action therefore needs to be implemented; or
2. given the additional information that has become available through monitoring, whether adjustments necessary to:
    - projections of the variable into the future;
    - the length of the monitoring interval; and/or
    - the trigger point.

The same process should be completed at the end of each subsequent monitoring interval.

Stage 6 checklist

Step 1. Determine timing

- What is the estimated response time of the shortlisted option or bundle (i.e. how much time is required to make a decision and /or identify, assess and implement the adaptation action(s))?
- Considering the estimated response time do options/bundles need to be implemented immediately or can they be delayed?

Step 2. If the action can be delayed, establish adaptation threshold

- Have potential thresholds been identified for each option or bundle?
- From the potential thresholds that have been identified, what is the most appropriate one (considering criteria such as whether the threshold is: quantifiable; can be readily measured or observed; follows a trend; and data can be readily obtained)?

Step 3. Define trigger

- Have projections for the threshold variable been developed or obtained?
- Has the response time required to identify, assess and/or implement the option been established?
- Has a reasonable safety buffer been established?
- Has the trigger point relevant to the selected threshold been calculated?

Step 4. Monitoring of thresholds and triggers

a. ***Establish monitoring process for trigger variable***

- Taking into account the projections obtained for the threshold variable, at what rate is change occurring / projected to occur?
- Is regular reporting on the trigger variable already available? Is the reporting interval appropriate considering the rate of change?
- If regular reporting is not available (or the reporting interval is too long and therefore not appropriate), what data is required for the monitoring? Is the cost of collecting this data proportionate to the scale of the issue?
- Given the rate of change, the data required and the associated costs, what is the proposed monitoring interval?
- Have other important aspects of the monitoring regime been established?

b. Monitoring of trigger variable (note this takes place at end of first monitoring interval)

- Based on results of the monitoring, has the trigger point been reached or is close to being reached and does the adaptation action need to be implemented?
- Are adjustments necessary to projections of the variable into the future; the length of the monitoring interval; and/or the trigger point.

7. Assess options

Questions addressed in this section

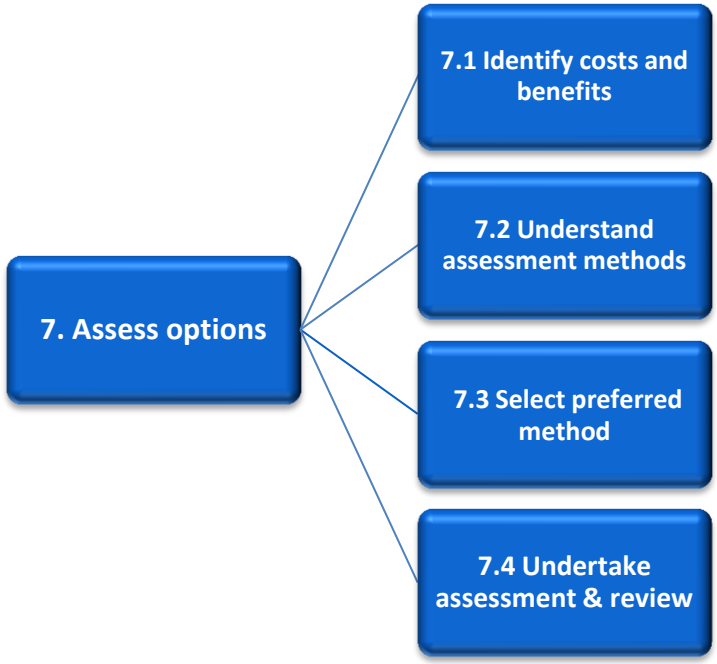
- What information is required for the options assessment?
- What methods are available to assess adaptation options?
- What are the main characteristics of the methods and how are they applied?
- What information or expertise is required for the application of a given method?
- What are the factors influencing which method is suitable for the assessment?

Overview

Options assessment is at the core of the decision-making process, with many of the stages and steps discussed in the preceding sections being geared towards ensuring that assessment of options is soundly based. This section introduces and discusses methods that can be employed to assess options for addressing a nominated coastal planning or infrastructure issue (Step 7.2) and explores the factors that may influence a decision-maker's preference for one assessment method over another (Step 7.3). A useful step to undertake prior to consideration of methods is preliminary identification of the costs and benefits that will need to be quantified (or otherwise considered) in the assessment (Step 7.1).

As discussed at the conclusion of Stage 5, the detailed assessment of options will often, in fact, be an assessment of 'bundles' (groups of options) or 'pathways' (bundles of options implemented over different timeframes) rather than individual options.

Figure 37: Steps in assessing options



Note that much of the discussion in this stage is geared towards medium or macro scale issues that have multiple dimensions. For smaller or more straightforward issues it may not be necessary to go through a detailed process of understanding and selecting the preferred method. A Cost Effectiveness Assessment (CEA) or Cost Benefit Analysis (CBA) with qualitative assessment of benefits will generally suffice for decisions on discrete infrastructure projects. Application of the 'rules' and good practice principles will often suffice for discrete planning/ development approval decisions (see Figure 40).

7.1 Identify costs and benefits

Economic assessments typically seek to measure a full range of costs and benefits associated with the change being explored. 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.

Prior to the selecting the options assessment method it is useful to identify the range of potential costs and benefits associated with the various adaptation options, bundles and pathways. As previously noted, this is a particularly useful step where the issue is macro in scale and multi-dimensional, involving a range of option bundles that are likely to be implemented over different timeframes. Identification of costs and benefits will assist with two subsequent steps:

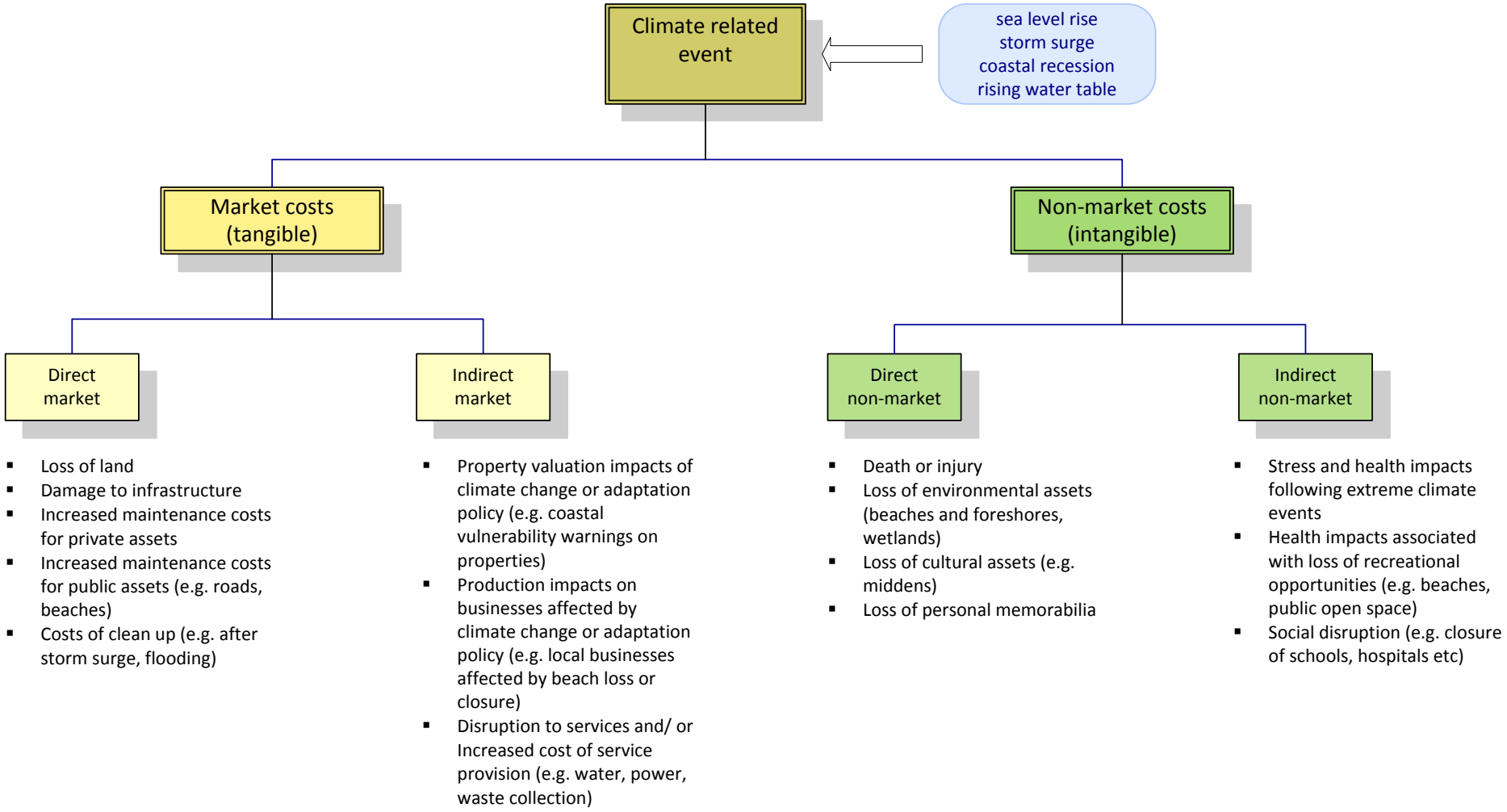
- it will assist with selecting the assessment method (Step 7.3), since the choice of method will often come down to consideration of whether or not the various options/ bundles/ pathways will deliver substantially different benefits; and
- it will assist in preparing for and framing the actual assessment (Step 7.4).

Figure 39 sets out a typology of potential costs associated with a range of coastal hazards. This provides an indication of the sorts of costs (benefits of adaptation) that may need to be considered in an assessment. Principles underpinning welfare economics require that the full range of market and non-market (environmental and social) costs and benefits should be considered in cost benefit analyses and other types of assessments.

Figure 38: Ongoing maintenance and emergency repairs costs associated with 'business as usual' need to be factored into the assessment

Source: SECCCA

Figure 39: Typology of potential costs associated with coastal hazards[9]



[9] Note adaptation actions will aim to deliver **benefits** in the form of a reduction in some or all of these costs.

7.2 Understand option 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. Doing so would ignore the complexities, interplay between priorities and objectives of any given situation and could lead to selection of a method that is not the most appropriate for the decision at hand. Therefore, judgment is required in the selection of an appropriate method and the following sections provide information about different methods that should be used to inform this judgment.

7.2.1 Cost Benefit Analysis (CBA)

Cost-benefit analysis (CBA) is a method that compares monetary costs and benefits associated with alternative options. The scope of CBA is on social costs and benefits as opposed to the private cost and benefits assessed in a financial evaluation. This broad scope makes it well suited to measuring coastal adaptation options from a community perspective[10], as will often be the basis for decision-making by councils. CBA enables comparison of alternative options to determine which options will provide net benefits to society and the option that will contribute the greatest benefit. The method can also be used to compare projects of different scales and timeframes.

[10] That is, the benefits and costs experienced by the whole of society, as opposed to just the proponent or one part of society. For example, environmental costs values should be included in a CBA, something that may not be of interest to a specific project proponent.

Financial assessment operates under the same principles as CBA, but explores only financial costs and benefits from the perspective of the proponent (e.g. council). In some cases, such as infrastructure appraisals, financial analysis can be used as the primary building block for a cost-benefit analysis. But because CBA has a broader societal focus, it takes account of the benefits of protecting and enhancing environmental, cultural and social values. A financial analysis does not do this unless there is a commercial benefit from protecting those values.

Principles underpinning CBA

CBA is directly concerned with identifying and measuring costs and benefits to enable the calculation of the net economic worth of project options. Principles underpinning CBA include:

- a common measurement (dollars) is used to compare all options against a base ('without project') / Business As Usual case;
- all costs and benefits related to projects or alternatives are within the scope, regardless of to whom those benefits accrue;
- CBA is interested in changes attributable to a project (or projects) - 'marginal' net benefits and costs;
- future costs and benefits are 'discounted' back to a common year, to allow for meaningful comparison of projects over different timeframes (Box 35);
- CBA provides a 'decision rule' that recommends whether a project's benefit exceeds its costs, or which of a range of options produces the highest benefits relative to its costs.

Frequently, the full range of costs and benefits cannot be quantified in dollar terms. Those that cannot be quantified or monetised are then described to complement the quantified assessment.

Box 35: Discounting and discount rates

Discounting is the usual method employed to add and compare costs and benefits that occur at different points in time. Discounting involves summing across future time periods net costs (or benefits) that have been multiplied by a discount rate, typically greater than zero. If the discount rate is zero, then equivalent costs (or benefits) in each time period are valued equally. If the discount rate is infinite, then only the current period is valued. Thus, the higher the discount rate, the less the value attached to future costs (or benefits). The rationale behind discounting is that individuals and businesses attach less weight to a benefit or cost occurred in the future than they do to the same benefit or cost incurred now.

In the case of the individual, impatience or 'pure time preference' is the main reason the present is preferred to the future. In the case of business, since capital is productive, a dollar's worth of investment now will generate more than a dollar's worth of capital in the future. Hence, a business will be willing to pay more than a dollar in the future to acquire a dollar's worth of capital now. The rate at which businesses are willing to discount future capital is referred to as the 'opportunity cost of capital' or market discount rate. A third way to value time preference is the 'social time preference rate' (or social discount rate), which attempts to measure the rate at which welfare for society falls over time. The social discount rate is often linked to the pure time preference rate. An argument against this link, particularly for issues spanning generations, is that public policy should reflect collective interests (including intergenerational equity) rather than private interests.

Where there are no intergenerational issues other than dollars, it is generally appropriate to apply a high discount rate, reflecting the opportunity cost of capital. When there are intergenerational issues however, particularly those involving potentially irreversible environmental impacts, then society arguably has a 'duty of care' to future generations to avoid those adverse consequences. In this circumstance, it may be appropriate to apply a low discount rate to future benefit streams (e.g. the avoidance of coastal impacts).

Cost benefit analyses and cost effectiveness assessments are based on discounted cash flow analysis. The selection of discount rate can therefore be critical to the estimate of overall worth of an option, bundle or pathway. This is especially true of options that have long time horizons or large capital costs, as is likely to be the case for many coastal adaptation strategies.

Thus rigorous consideration of discount rates will be important for the assessment of many coastal adaptation options, especially those associated with macro scale, multi-dimensional issues. In practice, if the issue is likely to be assessed from the perspective of what is best for the wider community then a low social discount rate could be appropriate, especially if options and pathways being assessed cut across a number of generations. If, on the other hand, the primary consideration is the financial bottom-line for council, then a market discount rate would be appropriate. In all cases sensitivity analysis should be undertaken to assess the implications of different discount rates for the assessment (see Step 7.4).

Types of decisions for which CBA is useful

CBA provides a rigorous and defendable framework for the comparison of alternative projects or options, or for assessing if one project is a cost-effective investment (can its benefits be demonstrated to exceed its costs?).

It is especially useful when benefits and costs are easily quantified and data is readily available. When data is not readily available or significant benefits are difficult to quantify, CBA becomes more challenging and potentially expensive (creating datasets or value estimates for specific benefit streams).[11]

In cases involving significant data shortages, alternative methods relying on economic principles may be preferred (threshold analysis, cost-effectiveness assessment), or those that rely on expert judgment instead of data (Multi-Criteria Assessment).

CBA relies on relatively advanced technical economic skills, often requiring the contracting of consultants with specific experience in the subject matter. This contracting, plus the data requirements of CBA, results in it being a relatively expensive method. As such, CBA is useful for larger decisions for which a budget is allocated and relatively complete data sets exist.

Strengths and weaknesses of CBA

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;
- incorporates non-market values using established methods (e.g. travel cost method, contingent valuation, choice modelling – see Box 36).

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;
- non-market valuation can be very expensive and time consuming.

A broadly scoped CBA will require significant (and often expensive) data collection and analysis.

[11] If a key benefit cannot be estimated (due to expense or difficulty), sometimes a 'threshold analysis' can be used, in which the difference between the costs and benefits forms a threshold for the missing benefit. If the un-estimated benefit can be assumed to be greater than the gap between the estimated benefits and costs, the project is deemed to be worthy.

Steps involved in a CBA

CBA involves the following general steps:

1. **Define objectives**: what is the question the CBA is assessing? This must be clear and consistent with the issue and primary objective determined in Stage 3.
2. **Identify options**: clearly define all the realistic options for comparison including the base ('no change') case. While many options may be originally identified, a small number of 'most likely' options will need to be chosen for assessment
3. **Identify benefits**: the full range of benefits accruing to each option including the base case is determined and quantified where possible over the period of assessment
4. **Identify costs**: the full range of costs associated with each option is determined and quantified where possible over the period of assessment
5. **Identify qualitative factors**: those costs and benefits that can be identified but not quantified are understood and described.
6. **Assess net benefits**: the benefits and costs of each option are tallied and compared with the base case
7. **Sensitivity analysis**: the sensitivity of results to key assumptions are tested by varying those assumptions and revealing the impact on the results.

Box 36: Non market valuation

Many important values in coastal areas are non-market in nature, such as a thriving ecosystem within a national park that provides recreational use as well as habitat for significant indigenous species. For decisions that involve significant non-market values, it may be useful to estimate the extent of values affected by the decision, using a range of economic methods. Importantly, these methods are technically sophisticated and therefore expensive to employ, so any decision on whether to use them must be carefully weighed. Broadly, they may be considered when significant non-market values are anticipated and a larger budget exists for the assessment.[12]

Techniques for valuing non market values include market-based approaches such as:

- **preventative expenditure**: an asset is valued at the cost that would be incurred to prevent significant damage to it;
- **replacement cost**: an asset is valued at the cost that would be required to replace it or restore it should it be lost or damaged.

Often, market-based approaches are not used because data does not exist or the assets are simply irreplaceable (significant ecosystems, for example). In such cases, 'revealed preference' methods can sometimes be used:

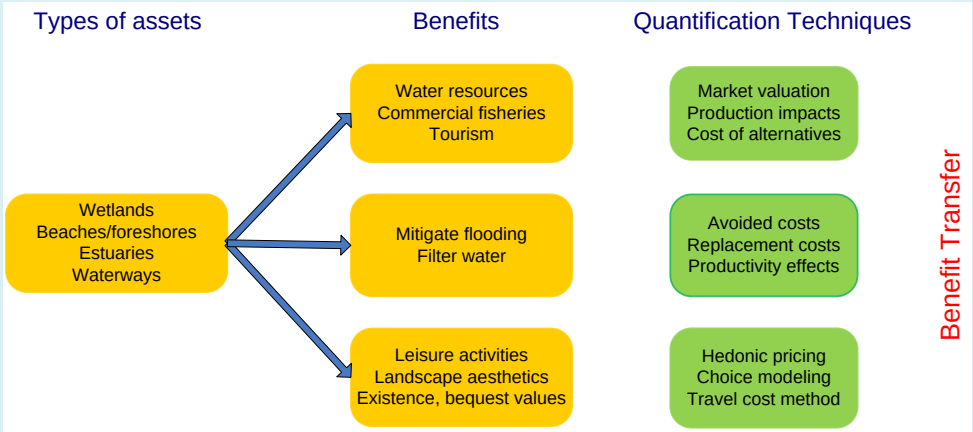
- **travel cost method** is used to estimate the recreational use of natural areas, using the actual costs incurred by people travelling to the site and the number of trips made to the site.

hedonic pricing is used to value environmental or aesthetic attributes and their impact on housing prices, using econometric analysis to estimate the implicit price of the environmental or aesthetic attributes of an area.[13]

These techniques require existing data, based on actual decisions made by people. For situations for which revealed preferences do not exist, 'stated preference' methods are ways of eliciting information on what people would be willing to pay for specific assets:

- **contingent valuation** is a survey method that describes a scenario and asks participants whether (and how much) they would pay to retain an environmental asset, or be paid compensation for its loss;
- **choice modelling** is another survey method in which respondents are asked to evaluate and choose between different sets of options, with associated costs – thus eliciting the value of the asset in question. It is generally considered the most robust of the stated preference methods.

Stated preference techniques are quite contentious. Therefore, considerable care should be taken with decisions on how and whether to apply them.



[12] Non-market valuation typically involves significant data collection, and can be expensive to undertake.

[13] For example, an econometric analysis of a housing market may consider variables such as block size, house size, number of bedrooms, and the aesthetic views of an area of natural beauty. This information can elicit data on the positive contribution the views make to housing prices.

7.2.2 Cost-Effectiveness Assessment (CEA)

CEA is an alternative to a full CBA, which considers only the direct costs attributable to meeting a specified outcome. CEA can be used when the outcome is fixed, and what is of interest is the relative cost effectiveness of different adaptation options for achieving that outcome.[14] It is often used to assist decision-making when estimation of all key benefits is not possible.

Because CEA makes no attempt to value the benefits of adaptation options (it assumes that all options will achieve an equal level of benefit), unlike CBA the method cannot be used as a measure of the inherent economic worth of different adaptation options. The method also cannot be used to value gains in economic welfare to society. It is, however, a useful and relatively simple approach to determine the most financially efficient option to deliver a predetermined outcome (e.g. protection of a highly valued coastal area). In practice, a CEA can be completed with various levels of sophistication. A simple approach would be to identify a set of discrete options and then undertake a CEA to determine which is the most cost effective. Another approach would be to define the problem using dynamic programming software[15] to find the optimal (most cost effective) solution.

Principles underpinning CEA

The principles underpinning CEA are the same as those for CBA. The key difference is that CEA does not attempt to estimate benefits, and therefore cannot be used to determine the net worth of a project.

Types of decisions for which CEA is useful

CEA is a useful method to assist decisions for which key data is lacking or a budget cannot be provided to fill key data gaps. It is especially useful for decisions in which the outcome is predetermined, and alternatives are being explored for achieving that outcome.

While not as complex as a full CBA, it operates under the same economic principles and may require advanced technical economic skills (potentially involving economic consultants).

Strengths and weaknesses of CEA

CEA's strength is in using a rigorous economic framework to assist decision-making in the absence of key data sets. As such, it provides cost-effective advice supporting some types of decisions, especially where outcomes are predetermined.

CEA's main weakness is that, in the absence of estimating benefits, it cannot be used to produce a decision rule on whether a project is a worthy investment. For decisions requiring this justification for an investment, the difference between a project's costs and those benefits that can be measured can be used as a 'threshold' beyond which those benefits left un-estimated must be assumed to exceed for a project to be justified.

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14 For example, if a political announcement has been made that a foreshore area will be protected from sea level rise, a CEA may be used to determine the most cost effective way to achieve this outcome. A CBA, in contrast, might evaluate whether protecting the foreshore is worth investing in, as well as establishing the preferred method of doing so.

15 Dynamic programming is a method for mathematically defining a problem and finding an optimal solution to the problem. Applying it requires an advanced level of skill and is not covered in detail in this Guide.

Steps involved in a CEA

CEA involves the following general steps:

1. **Define objectives**: what is the question the CEA is assessing? This must be clear and consistent with the issue and objective determined in Stage 3
2. **Identify options**: clearly define all the realistic options for comparison. While many options may be originally identified, a small number of 'most likely' options will need to be chosen for assessment
3. **Identify costs**: the full range of costs associated with each option is determined and quantified where possible over the period of assessment
4. **Identify qualitative factors**: those costs and benefits associated with each option that are identified but not quantified are understood and described.
5. **Assess cost-effectiveness**: the relative cost-effectiveness of achieving the outcome by each option is determined
6. **Sensitivity analysis**: the sensitivity of results to key assumptions is tested by varying those assumptions and revealing the impact on the results.

7.2.3 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. Especially useful for projects with critical considerations that are considered too difficult to quantify in dollar terms, MCA allows for these to be introduced as rankings, ratings or other non-monetised inputs.

MCA presents as an alternative or a complement to the economic framework of CBA. CBA can involve expensive and technically demanding non-market valuation of significant environmental considerations, which MCA can avoid with subjective judgments and assumptions.

Principles underpinning MCA

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 validity and transparency of these weightings become critical to the analysis.

The result is typically a score that can be used to compare options.

Types of decisions for which MCA is useful

MCA is useful for decisions in which some critical benefits (e.g. environmental or social amenity) are difficult to quantify, and for which expert opinion can be trusted to inform the decision.

Strengths and weaknesses of MCA

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.

Steps involved in a MCA

MCA follows the following general steps:

1. **Establish the decision context**: What are the aims of the MCA, and who are the decision-makers and other key players?
2. **Identify the options**: clearly define all the realistic options for comparison.
3. **Identify the objectives and criteria** that reflect the value associated with the consequences of each option.
4. **Describe the expected performance** of each option against the criteria. (If the analysis is to include steps 5 and 6, also 'score' the options, i.e. assess the value associated with the consequences of each option.)
5. **'Weighting'**. Assign weights for each of the criteria to reflect their relative importance to the decision.
6. **Combine the weights and scores** for each of the options to derive and overall value.
7. **Examine the results**.
8. **Conduct a sensitivity analysis** of the results to changes in scores or weights.

7.2.4 Regional economic impact assessment (EIA)

Regional economic impact assessment is concerned with regional changes in financial flows or economic activity, associated with a decision, policy or other change. These changes may be positive or negative, however if a policy has a positive effect on direct users of a natural resource, then the regional economic impact will generally be positive and vice versa.

Economic impact assessments demonstrate the direct expenditure and valueadded to a sector, plus economic flow-on effects to the economy from expenditure on inputs and consumption.

Economic impact assessment is useful in assisting understanding of some of the economic implications of an asset or decision. For example, economic impact assessment could reveal how many visitors come from outside the region to visit a particular asset (such as a high profile beach), and how many local jobs are supported by that visitation.

It is often combined with social or environmental impact assessments, to inform decision-makers about the broader social, environmental and economic impacts of decisions.

Principles underpinning impact assessment

Economic impact assessment seeks to identify the economic dimensions of an asset by measuring the economic flows associated with that asset. Continuing the above example, measuring the number of visitors to a destination beach and their associated expenditure can provide insight into the regional economy's reliance on the health of that beach.

However, while EIA can inform as to the economic importance of an asset, unlike more rigorous methods like CBA it does not measure the marginal value of the asset – if the beach was no longer there, would all of the associated activity disappear, or would it simply move to other parts of the regional economy? Would visitors simply go to another beach in the region, or would they visit a different region? As such, EIA lacks a 'decision rule' for whether a project should proceed or not.

There are two principal economic impact assessment methodologies, both based on national accounting principles: computable general equilibrium (CGE) modelling, and input-output (I-O) modelling. Both methodologies attempt to quantify the broad (direct and indirect) impact of a change in expenditure in the economy attributable to a project. Typically, CGE modelling is used to measure the impact of very large projects on the economy. CGE models are rarely available at a regional scale. I-O modelling is more typical for assessing the regional impacts of projects, and thus is more relevant to local council decision-making on coastal adaptation.

Types of decisions for which EIA is useful

While EIA does not provide decision-makers with a 'decision rule' on whether a project is worthy of investment, or which project is more worthy, it does provide decision-makers with information about the scale of economic activity associated with specific assets. For example, it can inform about how many regional jobs are linked with the health of an asset, providing information (if not a decision rule) on how significant that asset is to regional economic health.

As such, it is useful to inform decisions that may impact upon assets of significant regional importance, or in establishing the regional importance of assets upon which decisions are made.

As noted, impact assessment does not provide a measure of a project's net overall worth. Impact assessment should therefore not be used to appraise whether a project should be undertaken or not.

Strengths and weaknesses of EIA

EIA's main strength is its flexibility – an assessment can be provided based on the data at hand, using scenarios to fill gaps.

Its main weaknesses are in its corresponding lack of rigor and its lack of a decision rule. It can be used to provide information to assist a decision, but not to strongly inform a decision rule.

Steps involved in an EIA

EIA involves the following general steps:

1. **Define objectives**: what is the question the EIA is assessing? This must be clear and consistent with the issue and objective determined in Stage 3
2. **Define the area of interest**: usually undertaken at the regional level, the 'region' must first be defined in the context of the decision and the available data
3. **Prepare a social and economic profile** for the region: compile all relevant data from available sources
4. **Conduct a preliminary assessment of the asset of interest**: understand the social and economic data relating to the asset of interest, in the context of the social and economic profile
5. **Estimate the future potential impacts** of the proposal: estimate changes to the social and economic data that would result from the decision
6. **Analyse the impacts**: interpret the implications of these changes in the context of the social and economic profile
7. **Document conclusions**: describe these conclusions

7.2.5 Conditional and qualitative assessments

Decisions constrained by legislative or policy requirements

Some decisions could be constrained by requirements or conditions established in key legislation, guidelines or policies. These constraints could relate to legislated planning requirements, for example, or minimum service level requirements. In these circumstances, it may still be possible to apply the options assessment methods described above except that the decision rule – the basis on which the preferred option is identified through the options assessment process – will be conditional. In other words, the option will only be selected if:

3. it meets the decision rule; **and**
4. it meets the planning or service level requirements.

Generally speaking, options that do not meet legislative or policy requirements should be ruled out of the assessment process early in the process, for example through a preliminary filtering process (see Step 5.2). However, the initial filtering process may identify some options that rate quite highly and the only constraint is an administrative or legislative one. It may be useful to complete the assessment on the assumption that it may be possible to advocate for legislative or policy reform to remove this barrier.

Non-discretionary and qualitative decisions

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, because demonstration of compliance with the legislative or policy requirement is essentially the **only** consideration; or
- they 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 coastal 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.*** Individuals or entities who are in a similar situation 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.

7.3 Select assessment method

The relevance and applicability of a specific assessment method depends upon a number of factors. Issues around whether and how to assess the benefits of adaptation options are perhaps the most significant factors. Other factors include the nature and scale of the issue, budget and time available to assist decision-making and data availability. These factors are discussed below.

7.3.1 Do benefits need to be assessed?

Assessing the benefits of adaptation options can be a resource intensive exercise, and a highly contested aspect of the decision-making process, especially if the assessment seeks to value benefits in market terms (i.e. dollar values). It is important therefore to carefully consider whether valuing the benefits of adaptation actions will enhance the decision-making process. There are two reasons why this may ***not*** be the case.

- First, if all adaptation options, bundles or pathways are all likely to deliver substantially similar types of benefits then there may be no need to assess the benefits of those options. This situation will often arise where the objective for an issue or area is focused on achieving a specific, agreed outcome (see Stage 3) - for example, 'protect settlement X from coastal flooding and erosion'.
- In this situation, cost effectiveness assessment (CEA) could be the most appropriate options assessment method. If different options are likely to achieve the same types of benefits but potentially at different levels then cost effectiveness may need to be assessed in relative terms (see Step 9.2).
- A second circumstance where it may not be useful for the decision-making process to value benefits is when monetary valuation will not help explain the benefits of alternative options or pathways to the

community because most of the key benefits are not priced in the market (e.g. social and environmental values), are difficult to quantify and/or could be highly contested.

- In this situation, either a CEA or a restricted CBA may be the most appropriate options assessment method, but perhaps incorporating 'threshold analysis' to add to its sophistication (see Box 37).

Box 37: Example - deciding on an assessment approach

In an earlier example, discussed in Box 26 (Stage 5), Council identified five potential adaptation pathways (A to E) for an area that is under increased threat in the future from storm surges and coastal flooding. Three of those pathways (A, C, E) have planning controls (increased floor levels and time limited consent) as the main short and medium term options (in various permutations), with retreat as the eventual outcome. The remaining two pathways have a levee as the main medium or long term option respectively (B, D).

In one scenario, Council decides to rule out the levee option due to the likely significant capital cost. In this case, the assessment will focus on assessing the short and medium term phases of Pathways A, C and E. Cost effectiveness assessment (CEA) is likely to be a suitable assessment method in this case because both pathways will achieve broadly the same outcome, i.e. partial protection of the area, focussing on new developments in the medium term, but with retreat being the long term outcome. However, the cost stream of the different pathways will vary significantly.

In an alternative scenario, Council decides that it is important to consider protecting the area more broadly in the long term through construction of a levee. The difficulty for Council in this situation is that the levee pathways will lead to very different outcomes from the planning control pathways and it will be very difficult to quantify the inherent values associated with those disparate outcomes.

One way around this could be to still assess the costs of the alternative pathways using CEA, but build threshold analysis into the assessment (see Step 8.2). The threshold in this particular case would be the maximum amount that affected residents are willing to pay (e.g. through rate payments or special levies) to protect their settlement. This amount could be determined through a survey of residents (see Step 9.1). Undertaking a survey will entail costs, but those costs are likely to be less than would be involved in undertaking a full valuation of benefits and the results are likely to be less contested. In this case, the protect option would be selected provided the cost of this option is below the threshold.

A restricted cost benefit analysis (CBA), combined with a threshold analysis, could also be a suitable assessment method for the second assessment, with the CBA including only market benefits that can be readily quantified.

7.3.2 Other factors

Nature and scale of the issue

The nature and scale of a decision essentially influences the decision to employ more sophisticated, time consuming and expensive assessment methods. For small investment decisions, such as replacing inexpensive play equipment in a local park due to a one in one hundred year storm, a rigorous quantifiable assessment may be deemed unnecessary. Judgment by staff may be sufficient, or a financial assessment at most. A detailed Cost Benefit Analysis, Multi-Criteria Analysis or even Cost Effectiveness Assessment would be disproportionate in this context.

However, for larger infrastructure investments such as wastewater treatment facilities, or strategic decisions such as choosing between locations for residential expansion, expert judgment or simple financial assessment may be insufficient. A rigorous and detailed assessment may assist the decision-maker, or be required in a business case for investment.

Available budget and time

The budget available to assist decision-making would logically be related to the scale of the decision. Technical expertise in applied economics is frequently contracted in the development of business cases for large decisions, requiring funds of between $20k and $100k or higher depending upon the complexity of the decision and the number of options assessed. Expert assistance for specific non-market valuation studies could feature the same order of magnitude price. Using a tender process can help ensure the achievement of a desired outcome at the lowest market price.

For significant decisions being made with limited budgets, decisions may be aided with less detailed methods such as Cost-Effectiveness Assessment or Financial Assessment. Smaller decisions may also be assisted by these methods should the budget allow.

The timeframe required to deliver a project is generally related to the sophistication of the method used. Timeframes can be reduced if higher budgets are available, allowing for more resources to be applied to delivering an outcome. Where significant data collection is required as part of the project, a proportionate timeframe must be allocated.

Data availability

The existence of readily available data is another factor in choice of assessment method. The more sophisticated methods that have been discussed are relatively data intensive. In the absence of data sets, especially data involving valuation of non-market costs or benefits, a full CBA may not be possible (or may require significant expenditure or time to develop). If realistic assumptions cannot be made to overcome data shortfalls, CEA might be a useful alternative. Expert opinion, in the form of MCA, is sometimes used when no statistical evidence exists.

For significant decisions, data collection may be required to overcome data shortages, including non-market valuation.

7.3.3 Which method?

The choice of method must be made in the above context, subject to the question of whether or not valuing the benefits will enhance the assessment, the nature and scale of the issue and availability of resources and data.

Figure 40 depicts the types of issues that must be considered in choosing an appropriate method to aid decision-making. Firstly, a rules-based decision is unlikely to be aided by any of the economic methods described above, while expert judgment and the employment of best practice principles could assist such a decision.

The choice of economic method will usually be guided by one or more key constraints. The steps running down the left hand side of Figure 40 are not procedural steps, but instead reflect considerations that are required in choosing an assessment method. For example, if no resources can be allocated to the decision support method, this constraint dictates that more expensive methods are out of scope (e.g. a full CBA with non-market valuation). In this context, all other considerations become somewhat secondary.

An important consideration for decision-makers is the minimum information and level of expertise required to implement a method. This is outlined in Table 14 and influences when a method can be applied in-house with existing information or where additional costs with respect to acquiring information or engaging external consultant expertise is required. This aspect is implicitly considered as part of the budget and time (as shown in Figure 40) but may also be a limiting factor if there is a strong preference for in-house assessment.

Similarly, if a decision must be made within a very short timeframe, methods requiring longer timeframes (for example, those requiring non-market valuation or residential surveys) may not be reasonable.

Figure 40: Selecting the options assessment method

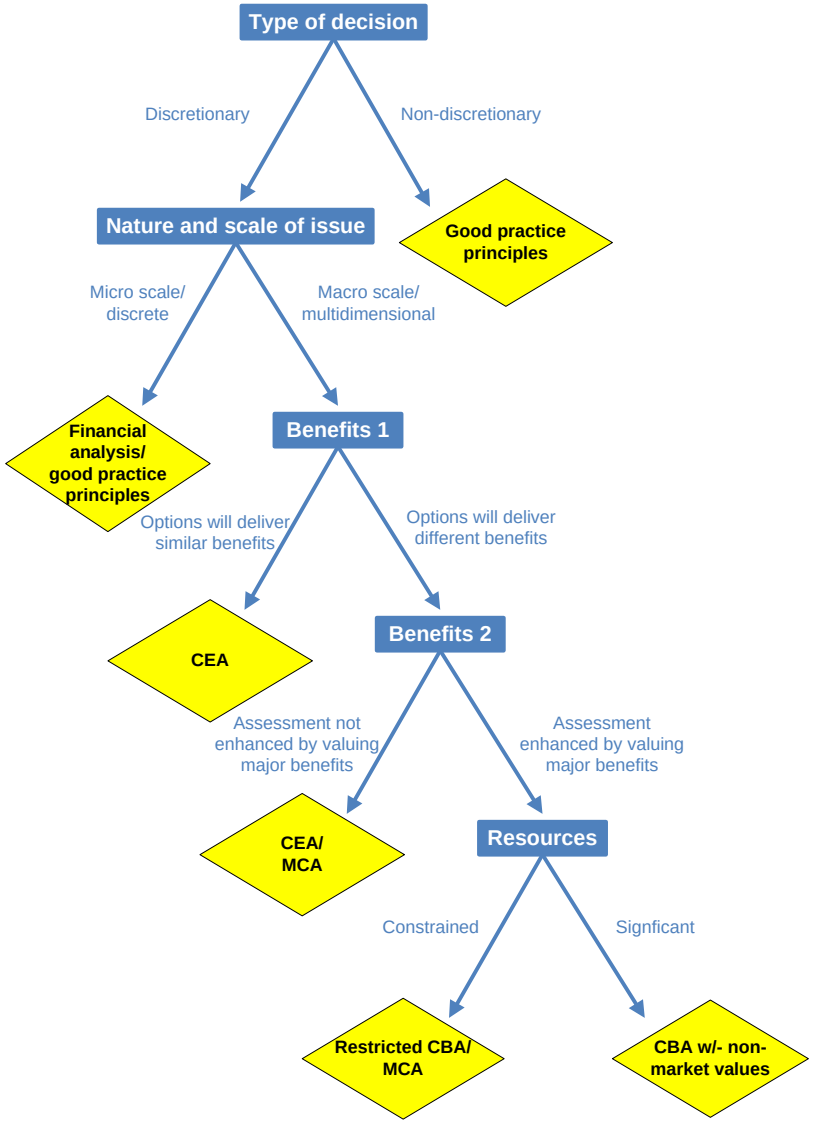


Table 14: Key attributes of options assessment methods

Method	Scale of decision	Budget required	Time required	Data requirements	Level of expertise required	Strengths	Weaknesses	Example
CBA	Medium, Macro	Significant	Medium to Long	Monetary values for full range of major benefits/costs including values for environmental and social benefits/costs (with the exception of a few qualitative benefits/costs where not possible to monetise but can complement the analysis)	Advanced understanding of welfare economics Advanced financial and economic modelling	Provides a decision rule Robust, defendable Transparent Rigorous comparison of alternatives Incorporates non-market values	Data-intensive Technically demanding Expensive Time consuming Difficult where benefits are un-quantified	Decision on whether to protect or move/abandon a township or large, highly valued natural area
CEA	Micro, Medium, Macro	Small to Moderate	Medium	Direct costs attributable to meeting a specific outcome	Basic financial modelling	Rigorous, defendable Transparent	No decision rule	How best to protect a highly valued beach and foreshore from sea level rise
MCA	Micro, Medium, Macro	Moderate to Significant	Medium to Long	Quantify full range of costs and benefits but not necessary to have monetary values for these	Expertise in the importance and rating of these major considerations	Avoids CBA quantification problems Less expensive than CBA Can incorporate nonmarket benefits through expert opinion and ranking	Less rigorous and transparent than CBA Less recognised by funding bodies than CBA	Decision on whether to protect or move/abandon a township or large, highly valued natural area – used to assess non-market benefits
EIA	Medium, Macro	Moderate to Significant	Medium	Expected changes in financial flows or economic activity associated with each option -	Understanding of macro-economics Economic modelling	Flexible Details the context of a decision	Lack of objective and decision rule	Assess impact of beach closure on surrounding businesses and local community
Rules based	Micro, Medium	Small to Moderate	Short	Service level standards (if relevant) of each option	Understanding of the relevant policies, legislation, regulations and guidelines	Simplicity	Potential to produce perverse outcomes if the policies or legislation are poorly designed	Approval of a building extension in an area vulnerable to sea level rise

7.4 Undertake assessment and review

There are a number of publications that provide guidance on good practice economic and financial assessment of policies, programs and projects, through the application of cost benefit analysis (CBA) or cost effectiveness assessment (CEA). The most pertinent for councils and government agencies in Victoria is the Australian Government publication *Handbook of Cost-Benefit Analysis* (Department of Finance and Administration 2006). This provides detailed, step by step guidance on undertaking economic and financial analysis. The *Victorian Guide to Regulation* (Department of Treasury and Finance, Victoria, 2011) also provides guidance of some aspects of CBA.

Good practice multi criteria analysis (MCA) is less well established and documented. *Multi-criteria analysis: a manual*, a publication of the UK Department of Communities and Local Government (2009), provides perhaps the best readily accessible overview of approaches to MCA.

Given availability of these guidelines and manuals, detailed discussion of approaches to assessing adaptation options, bundles and pathways is not provided here. Some general principles that should be considered regardless of the assessment method are outlined below however.

First, having identified the preferred assessment method, the assessment process itself should be documented. This will cover:

- general approach to the assessment;
- who is to undertake the assessment (e.g. internal or external);
- assessment budget and timeframe;
- the business as usual case (or base case);
- information required from the hazard and risk assessment;
- other information requirements;
- key costs and benefits to be assessed for each option/ bundle/ pathway and how they will be assessed (see Step 7.1);
- proposed approach to assessing cost and technical feasibility and cost of options;
- proposed approach to assessing benefits of options (where relevant);
- proposed approach to dealing with risk and uncertainty – this is discussed at length in the following section (see Stage 8); and
- proposed approach to considering distributional impacts and cost sharing (i.e. identifying which segments of the community will benefit from a decision, who may be adversely impacted and given this, who should pay for the costs of implementation)[16].

Second, technical and feasibility assessment of options will be a key input to the assessment process, especially for infrastructure based options. Again, a number of manuals and guidelines are available to assist with technical and lifecycle assessment of infrastructure options, the most relevant perhaps being the *International Infrastructure Management Manual* (IPWEA 2011).

Third, It is important that the assessment itself includes detailed documentation of key assumptions and how changes to those assumptions affect outcomes of the assessment (e.g. through sensitivity analysis).

Finally, a post assessment review of methods, parameters and assumptions used in the assessment should be undertaken. The depth of the review process will depend on significance of the assessment. It is desirable that the review is undertaken independently of the assessment.

[16] Note, consideration of distributional impacts and cost sharing is an important aspect of the decision-making process, but should be separate from the options assessment itself – see Stage 9, Step 9.1.

Stage 7 checklist

Step 1. Identify major potential costs and benefits

- Have major market and non-market benefits been identified for each bundle?
- Have major market and non-market costs been identified for each bundle?
- Has the section of the community who will gain (or lose) from the benefit (cost) been noted?

Step 2 and Step 3. Consider assessment methods and select preferred method

a. Do benefits (of options) need to be assessed?

- Will all options/ bundles/ pathways be likely to deliver substantially similar benefits?

b. Other factors influencing selection of method

- (i) Will the options assessment be enhanced by attaching monetary values to major non-market benefits?
- (ii) Are substantial budget, resources and time available to undertake the options assessment?
- What is the most suitable method considering these other factors?

Step 4. Undertake assessment and review

a. Pre-assessment

- Has the proposed approach to the assessment been fully documented?
- Does the proposed approach to the assessment align with good practice?
- Has the business as usual case been established?
- Has the technical feasibility of options been assessed?

b. Post assessment

- Have uncertainties around key parameters and assumptions been documented and the effects of changes to these assumptions on outcomes been assessed (see Stage 8)?
- Has the assessment been reviewed?

8. Manage risk and uncertainty in the options assessment

Questions addressed in this section

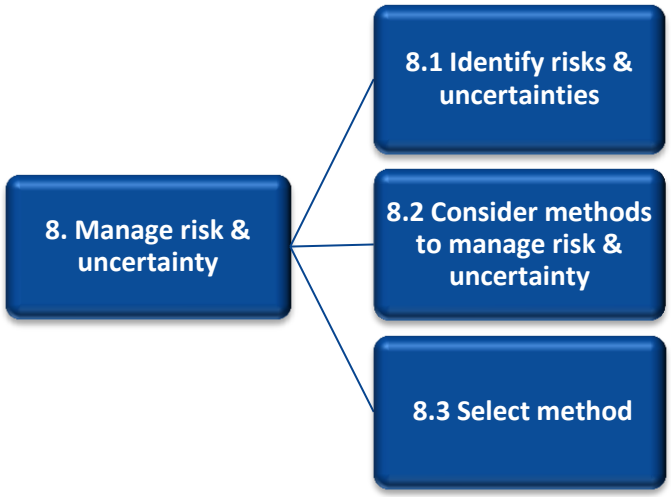
- What is uncertainty? What is risk?
- What methods are available for managing uncertainty and risk in the options assessment?
- Which of these methods should be used?
- What information and expertise is required for the application of a given method?

Overview

Decision-making, whether in business or government, almost always involves dealing with uncertainties, and making the best decision in light of those uncertainties. In this respect, decision-making on coastal adaptation options and pathways is not fundamentally different to other types of decisions. Nevertheless, the nature and range of uncertainties associated with coastal adaptation means that it warrants careful attention in the options assessment process (Stage 7).

Decision-makers have a range of methods to choose from to handle these uncertainties. In order to determine the most appropriate method it is useful to go through a number of steps (Figure 41): first understanding the nature of the uncertainties; next considering the different methods available for managing the uncertainties; and finally, selecting the most suitable method given attributes of the different methods and the nature of uncertainties.

Figure 41: Steps in managing risk and uncertainty



8.1 Identify risks & uncertainties

Uncertainty and risk defined

'Risk' and 'uncertainty' are two widely used terms in decision-making but are often used interchangeably and mean different things to different people.

In this Guide, the term **'uncertainty'** is used to refer to a factor in the decision-making process that cannot be predicted with a high degree of confidence. Uncertainty can come in many forms.

Often it is possible to place bounds on and/or estimate probabilities for the uncertainty that is ultimately driving the decision-making criterion being evaluated (e.g. a minimum value and maximum value for the degree of sea level rise that in turn affects the extent of social, environmental and financial damages). When it is possible to quantify the uncertainty and the impact it

may have on council, it is referred to as a **risk.** This definition is broadly consistent with the prevailing literature on the subject of risk in climate change, with a risk being a concept that combines the likelihood of a potential damaging event occurring together with its consequence/impact (refer to the introductory section on risk and uncertainty in Part A of this Guide).

This distinction is important because more can be done to manage and protect against a risk. Unquantifiable uncertainties are more difficult to manage and protect against but nevertheless there are methods to understand the impact they could have and test the robustness of options to possible outcomes. The other important characteristic about a risk is that it can be reduced. However, reducing risk often (but not always) comes at a cost. An intuitive example is the cost of purchasing insurance against property damage.

The other distinction to make is with a concept often referred to as variability, which is a measure of how 'spread out' possible values for the uncertain variable are. For example, the range of possible values for temperature rise might be a lot more close together than values for cost of water supply in the future. It could then be said that the future cost of water supply has greater variability. Generally speaking, and holding all else equal, the greater the variability, the more costly a risk is to protect against.

Range of outcomes, probabilities and impacts

The first step in dealing with uncertainty is to understand it as much as possible. If it is a *risk* (i.e. an uncertainty that can be quantified) then this involves defining or estimating:

- the range of possible outcomes;
- where possible, the probabilities that each possible outcome could eventuate; and
- the impact that each possible outcome could have on the attractiveness of any option being assessed (e.g. the impact that different degrees of sea level rise and consequent social, environmental and economic impacts could have on the attractiveness of a given land management policy).

Each of these three characteristics can later be captured in the assessment method employed (e.g. in a CBA model) and will therefore assist in the decision-making process.

If it is an *uncertainty* that cannot be quantified then it is still useful to define as much about the uncertainty as possible, for example:

- a set of *plausible* outcomes (outcomes that are believable and widely agreed *could* occur); and
- the *likely* impact that these outcomes could have on the attractiveness of any option being assessed.

In some cases it may be possible to quantify or estimate one aspect (e.g. bounds for possible outcomes) but not the other (e.g. the impact on the attractiveness of the option). In general, the more that can be quantified or estimated about an uncertainty the more that can be done to manage it.

It is sometimes the case that there is a broad range of views on the possible or plausible values for an uncertain variable. When this situation arises, it will be important to ensure that the full range of relevant stakeholders' views are represented when presenting results of sensitivity or scenario analyses (see Step 8.2).

Assessing whether a risk is acceptable

If the uncertainty is a definable risk, and if enough information is available, steps can then be taken to assess whether a risk is acceptable. This can be done in a qualitative manner (that is, a judgment based on the outcomes, probabilities and impacts), but if the *variability* of the risk is known, then it can also be done in a quantitative manner using a method known as Value at Risk (VaR). An example is provided in the following box.

Box 38: Value at risk

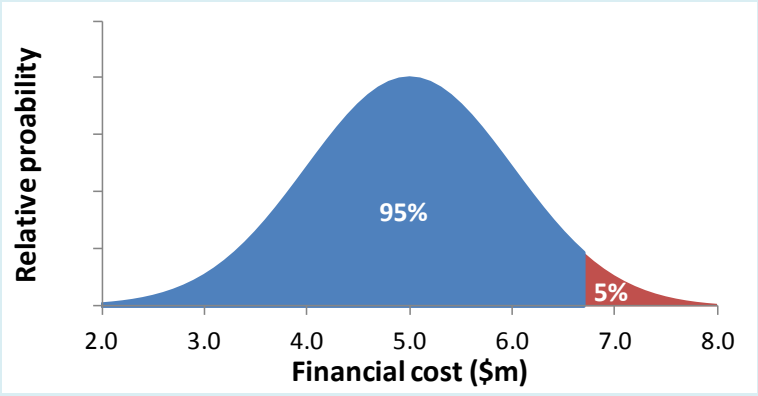
Value at Risk (VaR) is a method that can help decision-makers quantify risk into dollar terms and makes it possible to make statements such as *'there is a 95% chance that the amount of loss from this risk is less than $5m'*.

Take for example the potential financial exposure a council may have to sea level rise (SLR). If the probabilities that SLR can turn out to be any value in a range of possible values is known (say between 0.2m and 0.8m) and the financial damage resulting from any given SLR can be estimated, a VaR assessment can be undertaken. The steps involved include:

1. Define probability distribution for SLR (i.e. range of possible values and the probability of SLR being any given value)
2. Establish the link between SLR and financial cost
3. Chart the probability distribution for financial cost by combining steps (1) and (2)
4. Define the required 'prediction interval' (i.e. the point where the area in the chart to the left of that point covers x% of the whole area where x is the level of confidence, e.g. 95 in the statement at the beginning)
5. This point is the value at risk with x% confidence

Assuming the financial cost is $1m for every 0.1m of SLR and that the spread of possible values for SLR is defined by a certain type of 'normal probability distribution'[17] then the chart from step (3) showing area for step (4) could be as follows:

Figure 42: Value at Risk with 95% confidence



From this chart, it is possible to say that there is a 95% chance that losses are less than $6.7m

[17] A detailed discussion of the normal and other common probability distributions and their use is outside the scope of this Guide but is generally included in any literature on applied statistics, one of which has been included in the references section

If a risk is considered unacceptable then there are different types of mitigating actions that can be taken to reduce the exposure to a risk. Some actions can reduce the likelihood of the risk occurring (e.g. barriers against sea water inundation), others the consequence from the risk occurring (e.g. protection of infrastructure) or a combination of these. However, reducing exposure to a risk almost always comes at a cost and therefore judgment is required as to whether exposure to a risk can be tolerated.

8.2 Methods to manage risk & uncertainty

In this section, guidance on using a variety of methods is provided. The appropriate method to assess any given uncertainty will depend on the nature of that uncertainty.

In general;

1. a risk is assessed using sensitivity analysis (in one form or another). A **sensitivity analysis** is used to test how a result can change *based on a change in one or more factors*.
2. an *uncertainty that cannot be quantified* is assessed using **scenario analysis**. A scenario analysis is used to test how a result can change based on *plausible* alternative states of the future without having to specify the likelihood of that outcome occurring or specify what all possible outcomes could be.

While these are general rules of thumb, the appropriate method for any given situation will depend on the context and circumstances of that situation and therefore judgment should be used considering the merits and drawbacks of each of these methods and these are discussed in the following sections.

It is also important to note that these methods are not mutually exclusive. That is, they can and often are used in combination with each other. For example, a Real Options analysis can be conducted in a number of different ways, a common way is through Monte Carlo simulation which is a method in its own right.

Sensitivity analysis

It is often useful to understand how results change when an uncertain variable in the analysis changes. As Table 16 indicates, it is most useful to apply a sensitivity analysis when the bounds for values of the uncertain variable can be estimated (i.e. it is a risk). To provide an example, if the effect of sea level rise on the maintenance costs of infrastructure needs to be estimated, the reasonable minimum and maximum possibilities for sea level rise can be used to answer the questions:

> *What would maintenance costs be if sea levels rise to the upper end of what is to be expected? and*
>
> *What would maintenance costs be if sea levels rise to the lower end of what is to be expected or do not rise at all?*

It is apparent from the above that sensitivity analyses generally answer questions phrased as *'What-ifs'*. Additionally, it is also apparent that these bounds represent 'worst case' and 'best case'.

This is not to say that a sensitivity analysis is *not* useful in circumstances where the lower and upper bound of the range cannot be used. It can still provide insight in situations, for example:

> *What-if sea levels rise by X? and*
>
> *What-if sea levels don't rise at all?*

A sensitivity analysis can be applied with varying degrees of complexity. The examples that have been provided so far are quite simple. 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?

Table 15: Overview of methods to assess risk and 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 sea level rise can be estimated
Scenario analysis	A range and probabilities of outcomes cannot be estimated but a set of *plausible* outcomes can be constructed.	A plausible estimate of rise in maintenance costs due to sea level rise can be estimated
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 seawater inundation and consequent rise in level and salinity of groundwater can be estimated
Threshold Analysis	It is useful to understand at what point/value for an uncertain variable does the best course of action change	The degree of sea level rise where the best strategy against coastal erosion changes from protect to retreat needs estimation
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 probability distribution of extreme rainfall events is known.
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 sea level rise over time

The rest of the methods in this section are specific cases where generally two or more of the uncertain variables are changed together.

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.

There are likely to be quite a few applications of this method in the coastal adaptation area because of limitations with estimating some variables with any confidence. For example, the possible long term policy and regulatory landscape often needs to be considered when making decisions on climate change adaptation. Where this policy landscape makes a material impact on the decision at hand, a scenario analysis might be useful. In such a situation a plausible scenario (in this case communicated as a story) could be as set out as in the box below.

Box 39: Example of a scenario

Scenarios are often communicated as a story of what a possible state of the future might look like.

> *There is a successor to the Kyoto protocol that imposes legally binding emissions reduction targets on developed countries in 2013 and major developing nations (namely China and India) shortly after in 2015, effectively constraining atmospheric concentration of greenhouse-gases and potentially constraining sea-level rise to 0.5m.*

Once a scenario is defined, the consequence that this has on the subject of the decision (e.g. council assets and residents) is also defined.

It may or may not be possible to precisely estimate the impact of a 0.5m sea level rise. However, this is not necessary for a scenario analysis to be useful, as it can still be insightful to understand what is a possible outcome resulting from the uncertain variables (sea-level rise and extreme weather event frequency) identified values.

Sensitivity analysis with correlations

Like a scenario analysis, a sensitivity analysis with correlations involves assessing how the result changes if two or more uncertain variables change simultaneously. However unlike a scenario analysis as described in the previous section (where there need not be a link between the various uncertain variables), in this form of sensitivity analysis it is recognised that if one of the uncertain variables is higher (or lower) than the expected/central value then it is likely that the other uncertain variable will also be different to its expected/central value (either higher *or* lower).

When two uncertain variables are correlated and this relationship needs to be captured in the analysis it can be done in many ways. One way is to define a *'linear relationship'*. This is done by a specifying a factor (say ß) where if one uncertain variable is two times higher than its expected/central value then it is likely that the related uncertain variable is 2ß times higher than its expected/central value. A good example could be the link between sea level rise and groundwater level rise due to seawater inundation. Note that a linear relationship is the simplest form of relationship and other more complex forms can be defined.

It is important to note that there might be a correlation between two uncertain variables but this does not necessarily mean that one is a result of the other (sometimes the phrase 'correlation does not imply causation' is used to express this). It could be that both are the result of some other factor that influences the two at the same time, for example, that groundwater level rise coincides with groundwater salinity, but this is because both are due to seawater inundation.

Once all the relationships are established, the decision-making model is typically set up so that adjusting (often referred to as 'flexing') one variable/ uncertain variable automatically adjusts related uncertain variables and the net effect on the end result can be measured.

Threshold analysis

A threshold analysis is used to understand how and when an end result (e.g. that an option to protect an existing residential development is more attractive than the option to retreat altogether) reverses due to the value of an unknown (e.g. sea level rise). It specifically determines the value of the uncertain variable (i.e. 'threshold value') where the crossover occurs.

This can be thought of as another form of sensitivity analysis and can be particularly useful when a judgment can be made about whether the uncertain variable is more likely to be *above* or *below* this threshold value, therefore supporting the case for one side of the decision as opposed to the other. This intuitiveness makes threshold analysis a useful method and it is often visually presented as shown in the following example.

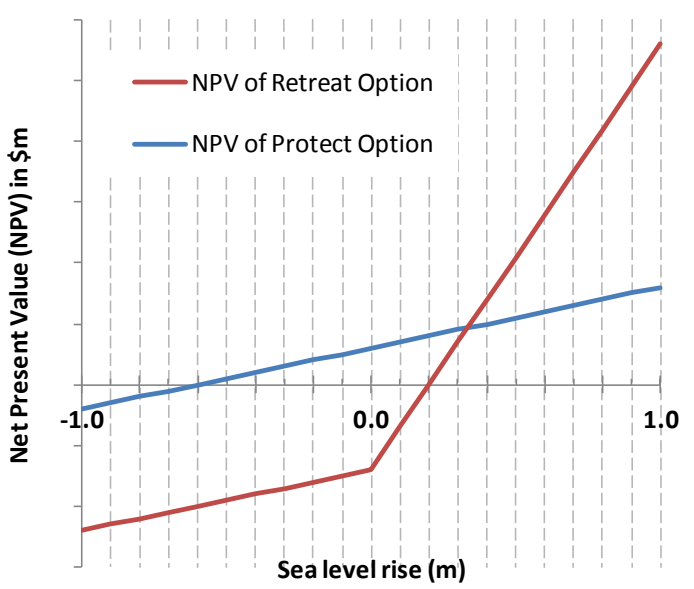
A conceptually similar method (but used for different purposes) is that of trigger points, which is discussed in Stage 6.

Box 40: Identifying a threshold point

Identifying a threshold point

In the hypothetical situation illustrated, a threshold analysis is used to assess at what point it makes sense to abandon and retreat from an existing residential development, an understandably high cost option. The threshold point being determined is the level of sea level rise where the result of the cost-benefit analysis will change. Note this is a highly stylised and simplified example and not meant to indicate the actual point of sea level rise where the decision cross-over would or should occur.

Figure 43: Chart used to identify threshold value



From this example it appears more attractive to retreat than to protect when sea levels rises by about 0.3m. In this context a threshold value is used to determine whether one decision would be more attractive than another.

Monte Carlo simulation

In some cases, the probability that uncertain variables can turn out to be any value within the range of possible values is known and there are numerous inter-related uncertain variables. In these cases, a Monte Carlo simulation is particularly useful. In the methods discussed so far the impact on the end result of a change in one or more uncertain variables is estimated using a manual process, that is, by applying one sensitivity analysis at a time or one scenario analysis at a time. In a Monte Carlo simulation, computer software is used to repeatedly (referred to as 'iteratively') test the impact on the end result by selecting possible random values of the uncertain variables. Furthermore, while values for the uncertain variables are selected at random, they are based on the probabilities defined by the Monte Carlo modeller. That is, in each iteration, the probability that an uncertain variable will have any given value within its possible range of values is pre-defined. This definition is referred to as the uncertain variable's 'probability distribution'.

A simple example is as follows. Assuming it can be estimated that there is a 30% chance of a global coordinated policy response to climate change setting legally binding emissions reductions targets on all major emitting countries, developed or developing, by 2015, then the probability distribution for the uncertain variable 'Global policy response' is 30% TRUE, 70% FALSE.

This is one of the simplest forms of probability distribution. Another, more complex, form is a 'normal probability distribution'[18], commonly encountered in many fields, including in nature. When drawn as a two dimensional chart (with the x-axis representing possible values and the y-axis representing the

[18] A detailed discussion of the normal and other common probability distributions and their use is outside the scope of this Guide but is generally included in any literature on applied statistics.

probability of the uncertain variable taking on that value), the distribution has a 'bell shape'. This probability distribution is defined by two parameters:

- *mean* – the expected/central value of the uncertain variable; and
- *standard deviation* – a measure of how spread out the possible values of an uncertain variable are in terms of their probabilities (where a higher standard deviation means less likelihood of the uncertain variable having a value close to the mean)

Once probability distributions for uncertain variables are defined, each iteration will yield a random but plausible set of values for the uncertain variables. This is not unlike a scenario analysis, although the obvious difference is that the scenarios (random set of values for the uncertain variables in each iteration) are selected automatically and iteratively by the Monte Carlo simulation software.

The outcome of this process is a set of values for the end result. The number of values will equal the number of iterations run in the simulation and is usually represented as a chart known a 'frequency histogram'.

These types of probability distributions are the typical outputs of a Monte Carlo simulation. The example presented in this subsection (Box 41) was relatively simple and actual simulations can take on more complex forms. For example, Monte Carlo simulation software typically allows the user to define correlations between uncertain variables, that is, the likelihood of an uncertain variable being a certain value, based on the value of another uncertain variable. In the example above, defining a correlation between 'Global policy response' and 'Sea level rise' would be an appropriate and sensible correlation.

Again, more detailed and comprehensive discussion on Monte Carlo simulations is usually provided in applied statistics literature. Additionally, a number of computer simulations software tools are available. A comprehensive review/ trial of the software, matching requirements and budget should be undertaken before selecting a specific tool though.

Figure 44: Some coastal hazards are known but impacts can be hard to predict

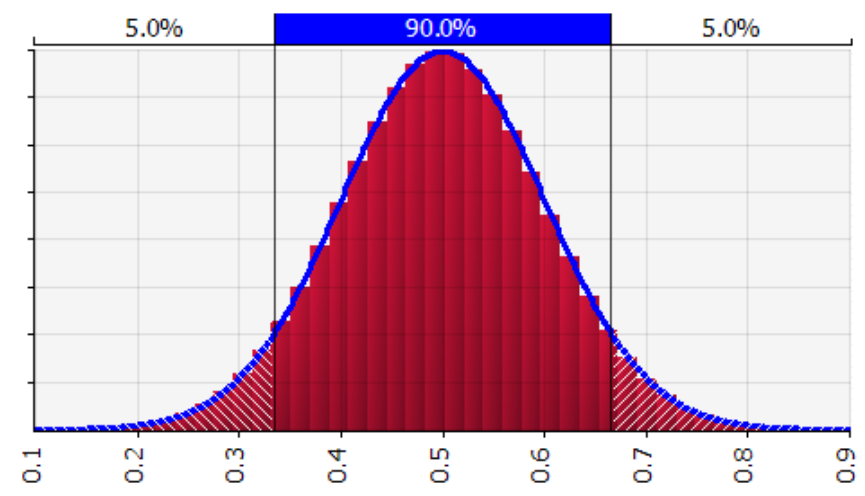
Source: SECCCA

Box 41: Application of Monte Carlo simulation

Defining sea level rise with a normal probability distribution

An uncertain variable that could be represented with a normal probability distribution is 'Sea level rise', as illustrated in Figure 45 below:

Figure 45: Probability distribution of sea level rise



Source: MJA

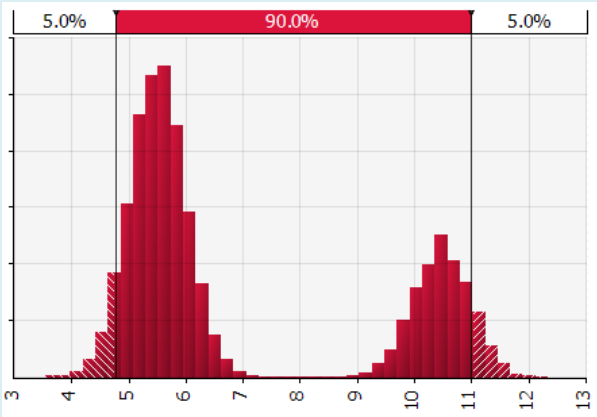
In this case, the mean is 0.5 and the standard deviation is 0.1 and there is approximately a 90% chance that sea level rise will be between 0.34 and 0.66.

Frequency histogram of results

The frequency histogram is a bar chart that shows the number of times the end result has taken on a certain value (or a value within a band where the total range is split into equally sized bands). This frequency histogram can, and often is, interpreted as an estimate of the probability that the end result can have a certain value.

Assuming the end result being measured is the Net Present Value (NPV)[19] of a 'Protect strategy'. More probable values for NPVs will have higher bars on the histogram. This is illustrated in Figure 46. Note that according to this example, there is approximately a 90% probability that the NPV of the protect option is between $5m and $11m but NPVs closer to $5.5m and $10.5m are more probable than NPVs close to $8m.

Figure 46: Probability distribution of 'Protect Strategy' NPV ($m)



[19] Net Present Value entails expressing the net benefits (benefits less costs) that could be derived from a project with later years benefits 'discounted; (i.e. worth less) than benefits from earlier years due to the interest or 'discount' rate that is applied to amounts in the future (see Box 35).

Real options

Real Options is a useful way to deal with risk and uncertainty in climate change because it provides a way to incorporate the expectation that uncertain variables will gradually become more certain and that in this context, decisions that are flexible (e.g. reversible, alterable etc.) and can respond when things become more certain, are more valuable than ones which cannot. While it is just one of many methods available to the decision-maker it is more complex conceptually and in application and therefore warrants a greater level of explanation than the other methods discussed. This explanation is provided below.

Overview of Real Options

In Cost Benefit Analysis (CBA) projects 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 expected or central case is just one (usually the average, most likely, median or some other 'middle' case) 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 actually quantify this value.

This subsection set outs when a RO analysis would be beneficial and different methods available to undertake the analysis. RO has been included in this Guide because it is particularly useful to apply in the context of climate change, where there is a high degree of policy, regulatory, market, technology and demand uncertainty and therefore a strategy that can adapt and respond as new information comes to light can be much more valuable than one that cannot.

The language of Real Options Analysis

In this section, the term 'option' in the context of RO Analysis refers to the ability to change the type, scale or use of investments after the initial investment decision, project, or strategy has commenced and not options in the sense of *alternative* investments, projects or strategies. 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.

It is important to recognise that these options may exist in adaptation actions but may also exist in the base case or the 'do nothing' case. The reason this point is important is that if the benefits of an adaption action are compared with 'do nothing', to be consistent the option value inherent in both of these alternatives should be assessed.

When to apply a Real Options approach

RO should 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 beaches, foreshores and estuarine areas as environmental assets may be reversed as and when more information about the effects of climate change are understood. In this instance it may be (relatively) cost effective to rezone parcels of land down the track and this would represent an option to *alter production*. What is important to recognise is that there might be a cost associated with this change and that this cost needs to be taken into account in the RO analysis.

An example where RO may not be useful is for the evaluation of a large scale 'sunk' infrastructure asset like a waste water treatment plant. It is unlikely that the capital used to construct the plant can be recovered after it is already built and there may not be any alternative uses for the plant other than the treatment of waste water.

Utilising Real Options Analysis

There are different methods that may be used to value options in a project, these include but are not limited to:

- ***Decision Tree[20] Analysis (DTA),*** this is probably the most intuitive and straight-forward method to use where a tree with branches is used to calculate the value of a project, with branches representing either possible outcomes (with corresponding probabilities) or alternative decision paths that may be followed and the optimal path is the one that maximizes expected benefits; and
- ***Monte Carlo Analysis,*** where a computer simulation is run iteratively to estimate a probability distribution of possible returns on investment using probability distributions of possible values for the uncertain variables in the analysis

There are also other more sophisticated methods such as the 'Black-Scholes' mathematical formula, however it is unlikely that the level of precision this provides will be beneficial for council investment decisions.

Due to its simplicity and transparency, the Decision Tree approach is recommended and is illustrated in the case study example in the next subsection. However, in situations where the underlying probability distribution of possible outcomes (e.g. rainfall) is important, and can be estimated and supported with a strong base of evidence, a Monte Carlo Analysis may be used.

[20] The term decision tree is used in this section refers to a technique for applying Real Options analysis and does not refer to the Decision Tree that council decision-makers may use to guide their overall evaluations of climate change adaptation projects

Box 42: Example – Application of Real Options

The following example is a highly stylised and simplified scenario which involves the decision on whether to allow development on an area of coastal land. The development is expected to deliver economic benefits to the local government area (LGA). However there is a risk that sea level rise will eventually render the development unviable, resulting in economic losses to the LGA in the long term.

A Real Options analysis using the decision tree analysis (DTA) method would be recommended in this instance providing:

- the probability of sea levels rising to an extent that renders the development unprofitable can be estimated and this estimate can be supported with an appropriate evidence base; and
- there is an embedded option where council may either take the decision now or take the decision in the future and there is a benefit to deferment due to more information being available that allows prediction of a sea levels rise with more certainty.

The analysis requires a series of steps set out below.

Step 1: Specify possible outcomes, payoffs, decision points and probabilities

The first step entails specifying what the possible outcomes are, what the payoffs are in the event those outcomes eventuate, probabilities for each outcome and decisions that can be taken at given points. In the stylised example:

- The economic benefits (payoff) from development are worth **$100m** (expressed as a Net Present Value (NPV) in today's dollars);
- There are no economic benefits (**$0m**) if the development does not proceed;
- There is a **70%** chance that sea levels rise to an extent that renders the development unprofitable incurring economic losses of **$50m**
- It is possible to defer the decision to allow development for another 10 years;
- In 10 years' time the scientific community is expected to predict with high degree of certainty (**90% probability**) whether sea level rise will be significant or not;
- Based on today's information there is a **75%** chance that the scientific community will predict sea life rise as opposed to **25%** that it will not; and
- If development is deferred by 10 years the economic benefits are expected to be **$80m** if sea levels do not rise and **-$40m** if they do.

Step 2: Draw decision trees for each alterative

Based on step 1, there appear to be 3 alternatives:

1. Disallow development (also equivalent to a base case or 'do nothing' case).
2. Allow development without waiting.
3. Defer the decision by 10 years until the scientific community has predicted sea level rises to a greater degree of certainty.

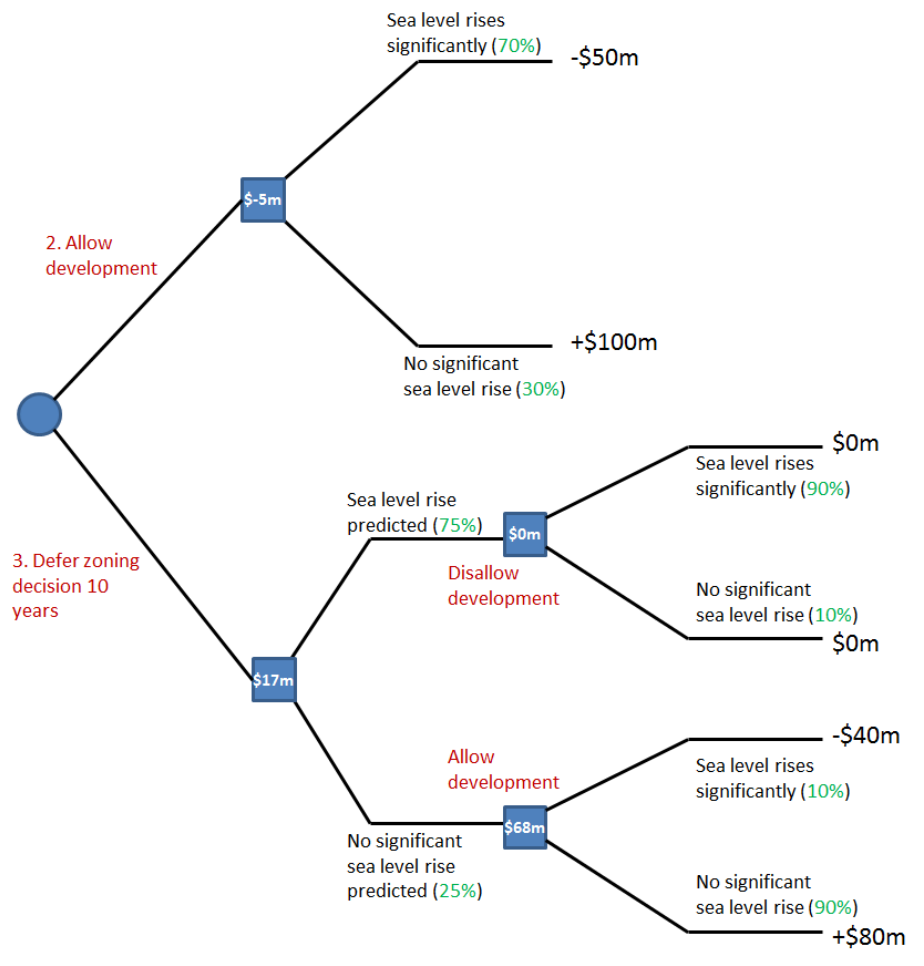
Alternatives which have embedded uncertainty and/or decision points require the construction of a decision tree. These decision trees are then 'solved' (Step 3) to determine the value of that alternative.

Alternative 1 does not required a decision tree and can be said to have an economic value of $0m.

The decision tree for alternatives 2 and 3 is depicted in the figure following.

The tree uses a common convention for DTA, which is to represent decision points as circles, branching of possible outcomes as squares and payoffs as NPV values at the right hand side at each end point of the tree.

Figure 47: Decision tree for a development decision (Alternatives 2 and 3)



Source: MJA

Step 3: 'Solving' the tree

The tree is solved by working backwards from the right hand side to the left and calculating the 'probability weighted' values at each point of branching in the tree. The sub steps for this tree would be:

1. Starting from the top right, the probability weighted value at the square following 'allow development' is (70% x -$50m + 30% x $100m) = **-$5m**.
2. Therefore allowing development immediately is an alternative that is expected to payoff **-$5m** (that is, incur $5m worth of economic losses)
3. The two end points in the centre right of the chart are then probability weighted so that the probability weighted value at the square following 'Sea level rise predicted' is (90% x $0m + 10% x $0m) = **$0m**.
4. The two end points in the bottom right of the chart are then probability weighted so that the probability weighted value at the square following 'No significant sea level rise predicted' is (90% x $80m + 10% x -$40m) = **$68m**.
5. Moving again from right to left, the probability weighted value for the square following 'defer zoning decision 10 years' can be calculated as (75% x $0m + 25% x $68m) = **$17m** (note that the $0m and $68m used in the formula come from the previous two sub-steps 3 and 4).

Step 4: Identifying the optimal strategy

By following the previous steps 1 to 3 the following payoffs have been estimated:

1. Disallow development (also equivalent to a base case or 'do nothing') yields **$0m** in economic benefits.
2. Allow development without waiting yields **-$5m** in economic benefits.
3. Defer the decision by 10 years until the scientific community has predicted sea level rises to a greater degree of certainty yields **$17m** in economic benefits.

Therefore, the optimal strategy based on the RO analysis using DTA is to defer the decision by 10 years.

Points to consider when applying Real Options analysis

The example in the previous subsection provides a very simplistic case. In practice, the number of decision points, degree of uncertainty and branching may be greater, making the decision tree more complex. However, a balance is required between sufficient complexity in the DTA to properly represent the problem at hand and transparency and ease of analysis.

If sufficient data were available to define probability distributions for the key variable (sea level rise) then a Monte Carlo Analysis could have also been applied. The steps of the Monte Carlo Analysis would be:

1. Setting up a valuation model that estimates payoff in a given scenario;
2. Defining probability distributions for one or more key variables (sea level rise in our case); and
3. Running a Monte Carlo simulation utilising appropriate software to estimate a probability distribution for the result (i.e. payoff in the example above)

In summary, Real Options is way of capturing the effect of embedded uncertainty and options. However, it is a method that is used in conjunction with other methods such as CBA or CEA. Real Options enhances the results for a CBA, CEA or other method by recognising that expected benefit and cost streams have underlying uncertainties and can in some circumstances be influenced through decision-making or 'options'.

8.3 Select method

Again, there are no hard and fast rules for which method should be applied to which situation and judgment is required. The following tables summarise the list of methods discussed in this Guide that may be used to deal with risk and uncertainty. They provide guidance on which circumstances applying a given method would be useful after considering the characteristics of the problem and the information and expertise required.

Table 16: Rules of thumb for when application of a method is suitable

	Sensitivity analysis	Scenario analysis	Sensitivity analysis with 'correlations'	Threshold Analysis	Monte Carlo simulation	Real Options
A set of plausible outcomes for the uncertain variable can be constructed	✓	✓	✓	?	✓	✓
The range for the uncertain variable can be bounded, either precisely or a reasonable range can be estimated	✓	?	✓	?	✓	✓
Probabilities of the uncertain variable turning out to have certain values can be estimated	?	?	?	?	✓	✓
There is flexibility to change tack following the implementation of the decision and/or a multi-layered decision is being evaluated	?	?	?	?	?	✓
It is useful to understand at what point/value for an uncertain variable the best course of action changes	?	?	?	✓	?	?
Interactions between two or more uncertain variables can be estimated (what happens to the value of one uncertain variable due to a change in the value of another)	?	?	✓	?	?	?

Source: MJA

The matrix above provides for each method a list of characteristics the problem should have before judging whether that method is suitable:

- Where there is a tick it is recommended that the problem has that characteristic for the method on the left hand side of the matrix to be suitable.
- Where there is a question mark that characteristic does not necessarily need to be present for the method to be suitable.

For example, generally speaking, to undertake a Monte Carlo simulation it is recommended that a set of plausible outcomes for the uncertain variable can be constructed, the range for the uncertain variable can be bounded, either precisely or a reasonable range can be estimated and probabilities of the uncertain variable turning out to have certain values can be estimated. Again, these are rules of thumb and judgment is always required when selecting the most appropriate method(s) for the problem. The following sections are designed to provide more detail about the methods to assist with this judgment.

Table 17: Information and level of expertise required for implementation of risk and uncertainty methods

Method	Information Required	Level of Expertise Required	Type of external expertise that may be required if not available in-house
Sensitivity analysis	▪ Range of possible values for uncertain variable(s) ▪ How end result (e.g. cost of physical damage) changes due to change in value of the uncertain variable(s)	▪ Basic modelling	▪ Generally not required
Scenario analysis	▪ Stories of plausible futures ▪ How end result (e.g. cost of physical damage) could change in light of these possibilities	▪ Basic modelling ▪ Understanding of the domain in which scenarios are being developed	▪ Expertise in the domain in which scenarios are being developed
Sensitivity analysis with 'correlations'	▪ Range of possible values for uncertain variable(s) ▪ Relationship between uncertain variables ▪ How end result (e.g. cost of physical damage) changes due to change in value of the uncertain variable(s)	▪ Basic modelling	▪ Expertise in understanding the links between uncertain variables
Threshold Analysis	▪ How end result (e.g. cost of physical damage) changes due to change in value of the uncertain variable(s)	▪ Basic modelling	▪ Generally not required
Monte Carlo simulation	▪ Probability of possible values for uncertain variable(s) ▪ How end result (e.g. cost of physical damage) changes due to change in value of the uncertain variable(s)	▪ Advanced modelling and statistics	▪ Probability distributions for uncertain variables ▪ Expertise with Monte Carlo simulation
Real Options	▪ Alternative decision-making paths ▪ Probability of possible values for uncertain variable(s) ▪ How end result (e.g. cost of physical damage) changes due to change in value of the uncertain variable(s)	▪ Advanced modelling and statistics ▪ Advanced financial theory	▪ Expertise in the application of Real Options theory

Table 18: Compatibility of methods to deal with risk and uncertainty with options assessment methods discussed in section 7

Options assessment method	Risk and uncertainty methods that could be used for options assessment method
Cost benefit analysis (CBA)	All risk and uncertainty methods can be applied and are common in CBAs.
Cost effectiveness assessment (CEA)	All risk and uncertainty methods can be applied and are common in CEAs.
Multi-criteria analysis (MCA)	Typically for a MCA a simple sensitivity or scenario method would apply given that the focus of an MCA is on the weightings or priority of different factors rather than on precisely defining characteristics of each uncertain variable.
Economic impact assessment (EIA)	All risk and uncertainty methods can and are applied and are common in EIAs.
Rules/ principles based	Risk and uncertainty methods are typically not used in rules based assessments because this method is usually prescriptive and often does not leave factors (e.g. possible values of uncertain variables) open to judgment or opinion. However in some instances, it is possible that a simple scenario or sensitivity analysis can be used.

Source: MJA

Stage 8 checklist

Step 1. Identify and understand the key potential uncertainties that could affect the decision

a. Identify uncertainties

- Which hazards are uncertain?
- Which variables associated with exposure to the hazards are uncertain?
- Which impacts and risks associated with exposures are uncertain?
- Which costs associated with adaptation are uncertain?
- Which of these uncertainties are likely to have a significant effect on results of the analysis?

b. Understand the uncertainties

- (i) Can plausible ranges of values (bounds) be placed on all or at least most of the **key** uncertain variables?
- (ii) Can plausible probabilities (or likelihoods) be estimated for different values within ranges of uncertainty for the key uncertain variables?
- (iii) Is there a link between two or more of the uncertain variables?
- (iv) Is it useful to understand the value or point (for a key uncertain variable) at which the best course of action changes?
- (v) Is there benefit in trying to value the flexibility associated with one or more of the bundles/ pathways?

Step 2 and Step 3. Select an appropriate method for dealing with risk and uncertainty based on characteristics of the uncertainties

- Which method(s) is most appropriate given what is understood about the unknowns?
- Are the necessary expertise and/ or resources available to implement the method?

9. Select options and implement

Questions addressed in this section

- What is an appropriate decision rule for selecting the preferred option?
- Who should pay for the cost of implementing the option?
- What is an implementation schedule and what should it include?
- What are the barriers to implementation?

Overview

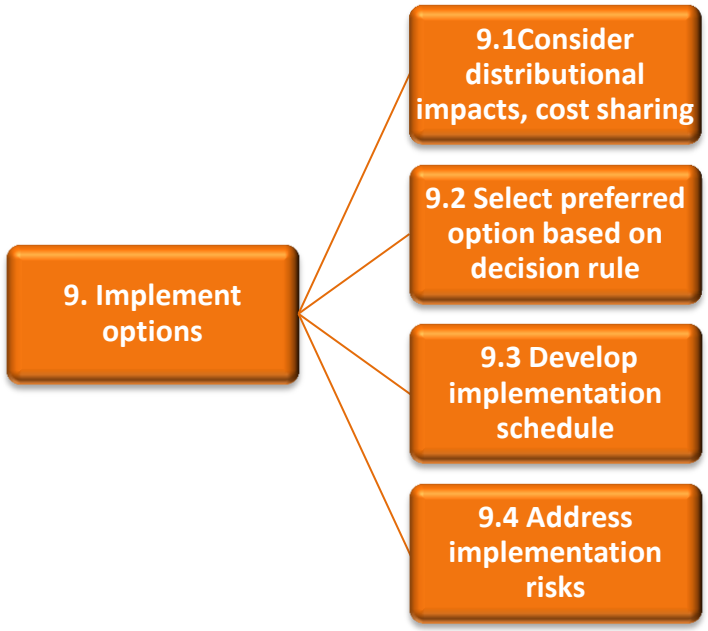
Once options have been identified and assessed, council and other decision-makers need to select the preferred option, noting that for most multi-dimensional issues the preferred option will actually be a bundle of options or a pathway constituting multiple bundles to be implemented over time. A key factor influencing the selection of the preferred option of bundle is the 'decision rule', which in turn is influenced by the assessment method (Stage 7) as well as the objective and constraints (Stage 3).

A key to be considered prior to options selection is 'distributional issues' covering:

1. Who benefits from the adaptation strategy?; and therefore
2. Who should pay?

Once the preferred option or bundle has been selected an implementation schedule should be developed and potential impediments to the implementation and operation of the option identified and mitigated.

Figure 48: Important steps in implementing options



9.1 Consider distributional impacts, cost sharing and cost recovery

Distributional impacts

Selection of an adaptation option by councils and government agencies will generally be based on the objective of maximising net benefits to the community or 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 – usually referred to as 'attemporal distributional impacts'.

Ideally, a comprehensive assessment of options, especially of larger macro scale issues, will include an appraisal of distributional impacts. This appraisal will usually involve three steps that are completed in conjunction with the options assessment, although separate from the options assessment itself (Campbell and Brown 2007):

1. Identification of an option's gainers and losers (noting that in some circumstances all members of the community could be assessed as benefiting from an action in roughly equal measure).
2. Classification of the gainers and losers (e.g. based on income levels, or property values).
3. Assessment of gains and losses. This could be done quantitatively (e.g. impacts on incomes or property values of the action) or qualitatively (e.g. Group A stands to gain most from the action, Group B will also benefit but less then Group A, Group C will not benefit at all).

A 'distributional incidence matrix' (Table 19) , which shows costs and benefits on one axis and the affected groups on the other axis, is a useful means of identifying distributional impacts unless these impacts are sufficiently straightforward to make this unnecessary - for example, where there is only one group in each of the two (benefits and costs) categories.

As with other aspects of the options assessment process, the level of detail of the distributional impacts appraisal should be commensurate with the nature and scale of the issue being assessed. In the example presented in Table 19, for example, quantification of the distributional impacts between the different groups would be warranted for an assessment of macro scale issues.

Table 19: Simplified example of a distributional matrix

Benefits and costs (Bundle A incl. coastal protection works, road raising)	Whole of community	Residents living in vulnerable area	Residents adjacent to vulnerable area
Benefits			
Protection of dwellings		✓✓	
Protection of beach and foreshore area	✓	✓✓	✓
Maintenance of access		✓✓	✓
Maintenance of property values		✓✓	
Costs			
Capital and operating costs of infrastructure	XX (if cost borne by Council)		
Adverse impacts on coastal wetlands	XX		

As a general rule, consideration of the distributional impacts will not change a decision on adaptation options. One exception is where two or more options are more or less equally weighted against the decision rule. In this circumstance, distributional impacts could influence the decision (i.e. in favour of the option producing the most equitable distribution of benefits). Another exception is where the implementation of options will lead to a perverse distributional outcome (e.g. all of the benefits will go to wealthy groups in the community at the expense of the less well off).

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.

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 (Stage 2).

If however, specific sections of the community benefit from the action (as per the example in Table 19) 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 will result in very different cost recovery outcomes.

With regards to coastal adaption actions the 'beneficiary pays' principle is most relevant[21]. The 'beneficiary pays' principle states that those who benefit from an action or the provision of a service should contribute to the cost of that service. These benefits may result from their own use of the service or, indirectly, in the form of reduced damage to their interests. In the latter case the beneficiary is sometimes referred to as the victim. The 'beneficiary pays' principle seeks to allocate costs to different individuals or groups in proportion to the benefits that each individual or group stands to derive from the costs being incurred.

Under the 'beneficiary pays' principle therefore, members of the community who benefit from an adaptation action would be required to contribute to the cost of an action up to the extent that they benefit. Where benefits of the action are shared between the private landholders and the broader community

[21] Attributing the costs of adaptation actions to those who have caused the problem, based upon the 'polluter pays' principle, is highly problematic for two reasons: 1) it will often be difficult to disentangle human causes of the hazard and associated impacts from possible natural causes; and 2) to the extent that the impacts can clearly be attributed to human causes (i.e. greenhouse gas emissions) the 'polluter pays' principle is best applied at the national or international levels (e.g. through a carbon tax or emissions trading scheme).

or environment (e.g. if protection of a public beach is also involved), then the costs would be shared between the individual landholders and the community. For example, an action that prevents coastal flooding of residential or business properties and protection of a beach would be partially funded by those residences or businesses protected by the action and partially by the broader community (e.g. on a 50/50 basis).

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.

Rates

Generally, a council's main source of revenue is from rates. In Victoria, councils have autonomy to set rates at a level necessary for their local circumstances and demand for community services. Nevertheless, councils need to demonstrate that they are operating as efficiently as possible. This requirement means that councils need to demonstrate that they have assessed the cost effectiveness of options before implementing those options and (possibly) increasing rates to pay for them.

Grants

Commonwealth and State grants are a significant source of funds for local councils. Each year councils receive a financial assistance grant, which is paid by the Commonwealth Government through the State Government's Grants Commission. The financial assistance grant may be used for any council purposes.

Councils receive grants from other sources from time to time and may apply for specific grants for specific purposes or programs. These grants are usually through the State and Commonwealth Governments. In addition to grants for specific infrastructure requirements (e.g. transport), grant programs that may be of relevance include:

- programs delivered through the Department of Planning and Community Development such as the ***Community Works Program***; and
- programs delivered through Regional Development Victoria such as the ***Local Government Infrastructure Program***.

Levies or charges

In Victoria, councils have a broad power under section 111 of the *Local Government Act* 1989 to

> *make local laws for or with respect to any act, matter or thing in respect of which the Council has a function or power under this or any other Act.*

Further, in section 113 it is stated that a local law may provide that a council may by resolution

> *determine a fee, charge, fare or rent in relation to any property, undertaking, goods, service or other act, matter or thing.*

Baker & McKenzie (2011) suggest that this power may allow councils to levy funds to manage climate change impacts.

9.2 Select preferred option

Councils need to have a basis for selecting an adaptation option, bundle of options or pathway once assessment of options has been completed – a decision rule. It is important that the decision rule is well understood and agreed by decision-makers at the point of option selection to ensure that:

- there is a clear understanding and agreement on what is the best option(s) for achieving the objectives; and
- barriers to the implementation of the selected options are minimised.
- Cost benefit analysis and cost effectiveness assessment have established rules that are closely linked to the decision-making objective implied in the respective approaches ('maximise net benefit' and 'minimise cost' respectively). These are discussed below. If other methods have been applied to the options assessment then a decision rule will need to be developed considering the primary objective and associated constraints or conditions, set out during Stage 3 of the decision-making process.

Decision rules for cost benefit analysis

In cost benefit analysis (CBA), there are two ways to measure the net benefit of an option, providing alternative decision rules:

- net present value (NPV) is the present value of estimated benefits minus costs and is an *absolute* measure of net benefit; or
- benefit-cost ratio (BCR) is the present value of the estimated benefits divided by the present value of the estimated costs and is a *relative* measure of net benefit.

Coastal adaptation projects would generally be regarded as worthwhile (provide a net benefit) if they have a positive NPV and the BCR is greater than one. If two or more options meet these rules and only one option needs to be implemented then:

- the option with the **greatest NPV** will generally be selected **if** the focus of the options is on regulatory or planning decisions, since BCR can be sensitive to how the costs and benefits of an option are categorised;
- or
- the option with the **greatest BCR** will be selected **if** the options involve significant capital investment, especially if it is to be funded from a limited pool of funds, since BCR provides a better measure of return on dollars invested.

- Any constraints applied to the primary objective will condition application of NPV or BCR to selection of options.

Decision rules for cost effectiveness assessment

Cost effectiveness assessment (CEA) is focussed on delivering a defined outcome in the most cost effective way and therefore does not require monetary quantification of benefits. For this reason, decisions on preferred options arising from a CEA tend to be more straightforward than for CBA. Even so, as with CBA there are two ways to measure cost effectiveness, providing two alternative decision rules:

- an *absolute* measure of least cost, measured as the present value of costs over time; or
- a *relative measure* of least cost (often referred to as 'levelised cost'), measured as the present value of costs over time divided by a (non-monetary) unit of benefit (e.g. number properties protected, area of land protected, ecological value of land protected etc.), i.e.:
  - $ / property;
  - $ / hectare; or
  - $ / index of ecological value.

Selection of a relative measure of least cost will be dependent on availability of suitable benefit data and is particularly useful if the benefits of different options are similar but of a different magnitude.

As with CBA, any constraints applied to the primary objective will condition selection of options assessed through a CEA.

9.3 Implementation

Implementation schedule

An implementation schedule 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 Stage 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 (see Table 3).

9.4 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. For the implementation of larger adaptation measures it may be useful to conduct a risk assessment to identify potential impediments. Table 20 provides a list of potential barriers and strategic responses.

Table 20: Potential barriers to implementation and strategic responses

Potential barriers	Strategic responses
Lack of funding and resource constraints	Seeking State or Federal Government funding Raising additional revenue through levies
Lack of political will Lack of awareness and will amongst other stakeholders	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 Cross council / agency working groups to share knowledge and expertise
Organisational and professional inertia	Change management process Engaging Councillors and Senior Managers in the decision-making process
Short planning horizons of organisations compared to those of climate change	Design of flexible adaptation options, which can be scaled up or down as required Use of thresholds and triggers
Complications through different levels of decision-making (e.g. national, regional and local)	Stakeholder engagement and consultation; Integration in decision-making process
Public perception that there is no problem Perception by public that they cannot make a difference - difficulties in changing their behaviour	Education and awareness programs (possibly embedded in communication and engagement strategy) Well-designed enforcement and monitoring processes to ensure implementation and evaluate & report on effectiveness of local scale responses

Stage 9 checklist

Step 1. Select option based on decision rule

- Has the decision rule been defined and agreed upon, taking into account the primary objective (Stage 3)?
- Has the preferred bundle or pathway been selected based on this decision rule, taking into account any constraints on the objective?

Step 2. Ensure distributional impacts and cost sharing and recovery have been considered

a. Consider distributional impacts

- Which segments of the community will gain or lose if the preferred bundle or pathway is implemented?

b. Cost sharing and recovery

- Noting this, who in principle should bear the costs of the preferred adaptation bundle or pathway?
- Given these considerations, what are the potential funding sources for the adaptation options?

Step 3. Develop implementation schedule

- Has a timeframe for the implementation of the adaptation action been developed?
- Have roles and responsibilities for the implementation been defined?
- Is community and stakeholder engagement required? If so, who needs to be consulted and when?

Step 4. Address implementation risks

- Have implementation risks associated with the preferred option been identified?
- Have measure to mitigate these risks been identified?

10. Monitor and evaluate

Questions addressed in this section

- Why is monitoring and evaluation of adaptation actions important?
- When and how should adaptations actions be monitored and evaluated?
- How should the results of the monitoring and evaluation be used to improve either ongoing or future adaptation actions?

Overview

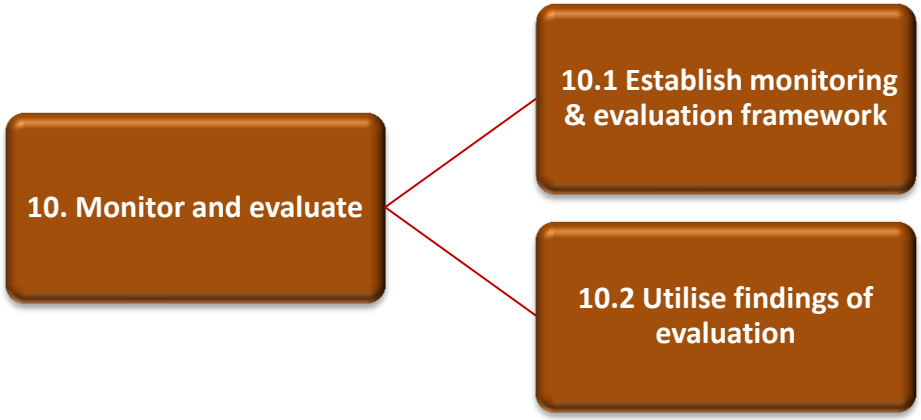
Climate change is a complex and long term issue, and the magnitude of change and impacts is uncertain. Adaptation to climate change is still relatively new for councils and communities. It is also, in many instances, a continuous and flexible process. It is therefore important to learn and improve over 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 the following two questions:

- *Are we doing things right?* and
- *Are we doing the right things?*

This section discusses monitoring and evaluation of adaptation actions, considering suitable approaches to monitoring and evaluation and how best to act on the results of the monitoring and evaluation so as to achieve a truly iterative approach to adaptation.

Figure 49: Important steps in monitoring and evaluation



10.1 Establish monitoring and evaluation framework

Regular monitoring and evaluation of adaptation measures is important, due to the uncertain and long term nature of climate change and the often flexible approach of adaptation.

By monitoring and evaluating adaptation projects or programs, 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 appropriateness, in particular their effectiveness and efficiency.

Monitoring means 'being informed about the status of a system and keeping track of progress being made'. Monitoring the implementation of adaptation measures reviews the progress against not only the objectives but also inputs, such as time and budget. It allows decision-makers to adjust and correct processes as new information becomes available to improve the outputs of the adaptation measure.

Evaluation systematically and objectively assesses the effectiveness of an adaptation measure with regard to its objectives.

In general, monitoring is undertaken by those responsible for the implementation of the adaptation measures. An evaluation is usually undertaken by independent experts, taking into account the findings of the monitoring.

Both monitoring and evaluation of adaptation measures is an important process to identifying the strengths and weaknesses of an adaptation measure and to:

- improve the adaptation intervention currently underway; or
- provide insights and lessons for other adaptation interventions immediately or sometime after completion (ex-post) of the project.

It is recommended that processes for the monitoring and evaluation of adaptation actions are set up during the implementation phase of the action.

Figure 50 illustrates a possible framework for monitoring and evaluating adaptation. In this context outcomes are the short and medium term effects of the adaptation measure, whereas impacts are long-term impacts, both positive and negative, on communities and systems.

The framework suggests that in addition to the effectiveness of the adaptation option other aspects, such as efficiency and its overall utility, should also be taken into account.

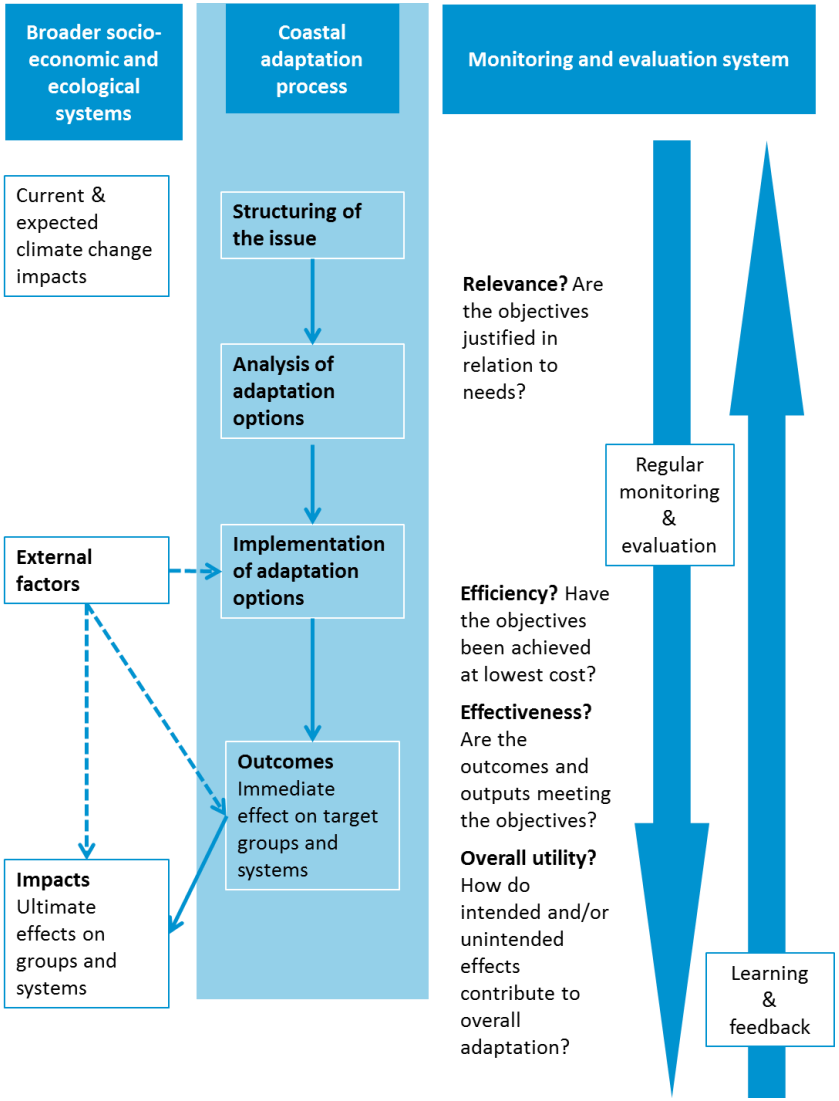
However, before setting out the monitoring and evaluation process, the purpose and scope of, and responsibilities for, the evaluation should be defined:

- What are the reasons for undertaking the monitoring and evaluation (e.g. improving adaptation measure, deriving lessons learnt for future adaptation)?
- What needs to be monitored and evaluated?
- Who monitors and evaluates the adaptation project or program?

Answering these questions will support the development of an appropriate monitoring and evaluation approach.

For example, an economic valuation method, such as cost benefit analysis, could be used if the focus is on assessing the efficiency and value for money of a project. Whereas assessing improvements in adaptive capacity and knowledge building will call for a different monitoring approach entirely, likely involving surveying or consultations with stakeholders and end users.

Figure 50: Framework for evaluating adaptation actions



Source: MJA after UN FCCC 2010

Box 43: Evaluation 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?

Timing of the evaluation

When to undertake monitoring and an evaluation of an action will depend on:

- the duration (or life) of the adaptation action, and
- the purpose of the monitoring / evaluation.

Monitoring is usually undertaken to establish ways of improving a project or program while it is underway. Hence, the monitoring will take place before completion of the project or program, for example at the mid-term of a project.

An evaluation assesses the performance and effectiveness of an adaptation intervention after completion (ex-post) of the project. In setting a time for an evaluation, it should be considered that in some cases there might be a time lag between the completion of the adaptation action and the benefits of the action being realised. The evaluation may therefore be best undertaken when the effects of the adaptation action can be, at least in part, observed.

Objectives and logic of the adaptation measure

At the start of every monitoring and evaluation it needs to be established what the primary objective of the adaptation action are (or were) (see Stage 3) and how the action was intended to achieve those objectives.

For large projects or programs in particular, it may be helpful to use a program logic approach (see Box 44) to outline the inputs, activities and outputs as well as the underlying assumptions and objectives of an action.

Box 44: 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

Defining a benchmarks and establishing evaluation criteria

In order to assess a specific adaptation action, a 'reference point' or benchmark needs to be defined against which to measure the adaptation action.

The mandatory reference point is the objective of the action or program itself (see above and Stage 3). The evaluation needs to examine, if the measure was able to meet the primary objective.

Assessing a project against its objective will help to answer the question "Are we doing things right?" However, it does not provide an answer to the question "Are we doing the right things?"

Assessing the adaptation action against good adaptation principles can help answer this second question and may provide supplementary evaluation criteria in addition to those flowing from the objectives of a program or project.

The performance of an adaptation intervention may also be assessed against a baseline. The baseline is most commonly defined as the condition of the system without the action. An assessment against a baseline will establish the additional benefits the adaptation measure has achieved. However, given the changing nature of the environment, it may be difficult to establish how the baseline would have evolved over time without the adaptation action in place.

The evaluation criteria will vary depending on the specific circumstances, the adaptation action in question and the 'reference point' selected. Evaluation criteria can be quantitative and/or qualitative in nature. It is likely that they will be similar to the decision criteria (filters) listed in Stage 5 but will now be applied retrospectively.

10.2 Adjust adaptation actions

Findings and lessons learnt

Having conducted monitoring or evaluation of an adaptation action should provide lessons learnt for future adaptation actions and may also initiate further actions to either improve or replace the existing adaptation action.

The evaluation should provide answers to the following questions, which can then be used to determine, if and what further adaptation actions are required:

- Has the problem been solved?
- Were the impacts as expected? Have unforeseen problems occurred? Did any other effects (positive or negative) occur that were not anticipated?
- Is action still required?
- Does experience with the measure suggest ways it can be improved to meet the objectives? (e.g. new technologies)
- Is this still the appropriate action to take or would another action now be more appropriate?

Stage 10 checklist

Step 1. Establish monitoring & evaluation framework

- Has the aim of the evaluation been established? Does the evaluation aim to improve the adaptation action while it is underway or provide lessons for other adaptation initiatives?
- Taking into account the answers to the questions above, when should the evaluation be undertaken?
- Have benchmarks been identified against which the adaptation action will be measured?
- Has an evaluation methodology been decided on?

Step 2. Utilise findings of evaluation and lessons learnt

- Has the problem been solved or is further action required?
- Did other positive or negative effects occur that were not anticipated?
- Could the adaptation action be improved in any way? Is it still an appropriate action or is a different adaptation action required?

Part C: Supporting information

Glossary

Useful materials and links

References

Glossary

Adaptation	Actions taken in response to actual or anticipated climate change impacts that lead to a reduction in risks or a realisation of benefits.
Adaptive management	An approach to adaptation that encourages strategies that are flexible, reversible and can achieve multiple objectives and synergies.
Bundle	A group of (adaptation) options that are implemented simultaneously so as to achieve synergies or enhance their collective benefits or minimise costs. See Option and Pathway.
Business as usual (BaU)	Policies, programs and actions that are currently in place to address a particular issue or problem. Often used as the base case in an options assessment.
Cost Benefit Analysis (CBA)	A method that compares monetary costs and benefits associated with alternative options. The scope of CBA is on social costs and benefits as opposed to the private cost and benefits assessed in a financial evaluation. Sometimes referred to as Benefit Cost Analysis (BCA).
Cost Effectiveness Assessment/ Analysis (CEA)	An alternative to CBA that considers only the costs attributable to meeting a specified outcome. Thus CEA can be used when different options are likely to deliver similar benefits. See Cost Benefit Analysis.
Decision rule	The basis for selecting an adaptation option or bundle of options once an assessment of options has been completed. The primary objective and associated constraints or conditions established in Stage 3 of the Guide will provide the basis for the decision rule.
Decision tree analysis (DTA)	A commonly used approach Real Options approach involving mapping of alternative (adaptation) pathways and assigning values at each step in the pathway depending on probability of the step eventuating.
Hazard	A condition, event, or circumstance that could lead to or contribute to an unplanned or undesirable impact or consequence. See Risk.
Hazard Assessment	The process of evaluating hazards, generally involving quantitative, technical analysis. It will often precede or be undertaken in conjunction with a quantitative risk assessment. See Risk Assessment.
Levelised cost	The present value of the total cost of an option converted to equal (non-monetary) units of benefit over time.
Monte Carlo Simulation	A computer model based process by which the impact on the end result of an assessment (of

	options) is tested by selecting random values for uncertain variables. Values for the uncertain variables are selected at random based on probabilities defined by the modeller.
Maladaptation	Adaptation strategies that adversely impact or increase the vulnerability of other systems, sectors or groups or close off other feasible options. See Adaptation.
Multi Criteria Analysis (MCA)	A method that allows for comparison of options considering several criteria. Often used as an alternative to CBA when costs and benefits of alternative options are difficult to quantify in dollar terms. MCA allows for these to be introduced as rankings, ratings or other non-monetised inputs.
Multidimensional issue	An issue characterised by having multiple aspects, needing to be addressed over different timeframes.
Objective	A clear statement of intent or preferred (long term) outcome for an area or community.
Option	A potential new or additional action that strengthens the resilience of communities, organisations or systems to impacts / issues arising from climate change. See Bundle and Pathway.
Pathway	The process of sequencing different options or bundles of options over time. See Bundle and Option.
Program logic	An approach to program planning, implementation, monitoring and evaluation.
Risk	The likelihood and consequence of a hazard. See Hazard.
Real Options	A method for dealing with risk and uncertainty in the options assessment by valuing the inherent flexibility (i.e. reversible, alterable) of some options or pathways compared with others. Real Options is not a stand-alone method but will be undertaken in conjunction with a CBA or CEA.
Risk assessment	The process of appraising risks by evaluating the likelihood (probability) of the hazard occurring and the consequences of that hazard for infrastructure, people, services or the natural environment. Risks can be assessed through a high level, qualitative process or through more detailed quantitative analyses. See Hazard Assessment.
Scenario analysis	The process of constructing plausible future states of the world, factoring in how all of the important uncertain variables in the analysis could change.
Sensitivity analysis	The process of measuring how results of an assessment (of options) changes when an underlying variable (or uncertain variable) in the assessment changes.
Sensitivity analysis with correlations	Sensitivity analysis assessing how the result changes if two or more uncertain variables change

	simultaneously.
Threshold	A point or minimum level at which a possibly irreversible change happens or risk reaches an unacceptable level. Used as the basis for setting a trigger for implementing an adaptation action. Not to be confused with threshold analysis (see following).
Threshold analysis	Used in CBA or CEA to define the point (usually expressed in $) at which an adaptation option will or will not be selected for implementation.
Trigger	An incident or occurrence that initiates other events. In the case of decision-making, a trigger is used to indicate when a management response is required and / or an option should be implemented.
Uncertainty	A factor in the decision-making process that cannot be predicted with a high degree of confidence. More specifically, poor knowledge of the likelihood or probability of a risk. See Risk.

Useful materials and links

Following is a list and brief description of support materials relevant to coastal adaptation generally or to specific stages and steps of the decision-making process. Direct links to the materials are provided where possible.

General

The Workbook accompanying this Guide provides checklists of the major steps to be completed in the decision-making process and worksheets to assist decision-makers step through the decision-making process and record key relevant information.

The Australian Government is partnering with decision-makers in the coastal zone to explore and demonstrate decision or investment pathways that can build resilience to the increasing risks from future climate impacts. Projects have a focus on the decision pathways that enable the transformation of business operations to prepare for longer-term climate change projections. A list of projects is available at the following link.
http://www.climatechange.gov.au/en/government/initiatives/coastal-adaptation-decision-pathways/projects.aspx

The Victorian Coastal Strategy sets out a long term vision for the Victorian coast and provides policies and actions to guide decisions about its management, including in relation to climate change.
http://www.vcc.vic.gov.au/page/victorian-coastal-strategy

More specifically, Practice Note 53, *Managing coastal hazards and the coastal impacts of climate change*, produced by the Department of Planning and Community Development, provides guidance on: managing coastal hazards; the decision-making process for assessing coastal hazard risk; and planning for development in coastal areas.
http://www.dpcd.vic.gov.au/__data/assets/pdf_file/0003/41727/53-Managing-coastal-hazards-and-the-coastal-impacts-of-climate-change-PN53.pdf

Stage 1 - Define the issue

The Citizen Science Toolbox reviews a range of tools that could be used to map and/or implement an engagement plan.
https://app.secure.griffith.edu.au/03/toolbox/

The International Association for Public Participation (IAP2) *Public Participation Toolbox* provides useful hints on the pros and cons of various community engagement techniques.
http://iap2.affiniscape.com/associations/4748/files/06Dec_Toolbox.pdf

Stage 2 - Clarify roles & responsibilities

The Department of Planning and Community Development Planning Toolkit: Statutory Toolkit provides relevant codes and guidelines, Victorian Planning Provisions and Ministerial Directions.
http://www.dpcd.vic.gov.au/planning/planningtoolkit

A report for the Department of Climate Change and Energy Efficiency, *Coastal Climate Change Risk - Legal and Policy Responses in Australia* (Blake Dawson 2011), provides information on current coastal climate change policies and how they are given legal effect.
http://www.climatechange.gov.au/publications/coastal-climate-change-risk/legal-policy-response.aspx

A report for the Australian Local Government Association (ALGA) *Council Risk of Liability in the Face of Climate Change – Resolving Uncertainties* (Baker & McKenzie 2011), includes discussion of Federal government, State government and Council responsibilities and key legal risks for coastal councils.
http://www.climatechange.gov.au/publications/local-govt/resolving-uncertainties.aspx

Stage 3 – Establish objective

The *Victorian Coastal Strategy* sets out management objectives for the Victorian coast. http://www.vcc.vic.gov.au/page/victorian-coastal-strategy

The Central Coastal Board sets out priorities for the Central Coast region consistent with the Victorian Coastal Strategy. http://www.ccb.vic.gov.au/publications.html

Stage 4 - Assess hazards & risks

The *Victorian Coastal Hazard Guide* outlines a five-stage coastal hazard risk management framework. http://www.climatechange.vic.gov.au/adapting-to-climate-change/future-coasts/victorian-coastal-hazard-guide

Melbourne Water provides guidance assessing development in areas prone to tidal inundation from sea level rise in the Port Phillip and Westernport Region in the publication on *Planning for sea level rise*. http://www.melbournewater.com.au/content/library/planning_and_building/information_for_developers/guidelines_for_developers/Planning%20for%20sea%20level%20rise.pdf

Climate change impacts and risk management: a guide for business and government (Broadleaf Capital & Marsden Jacob Associates, 2006), provides guidance on undertaking a preliminary, high level risk assessment. http://www.climatechange.gov.au/what-you-can-do/local-government/risk-management.aspx

The International Infrastructure Management Manual (IPWEA 2011, section 3.1) provides guidance on assessing risks to public infrastructure and assets.

Stage 5 – Identify options and pathways

The report, *Planning for climate change adaptation in Coastal Australia: State of practice*, includes a description of local climate adaptation initiatives being implemented around Australia http://www.seachangetaskforce.org.au/Publications/Planning%20for%20climate%20change%20in%20coastal%20Australia%20%20State%20of%20Practice.pdf

A number of software tools are available for producing decision trees similar to the approach used for mapping adaptation pathways. These include Palisade, SmartDraw and TreeAge.

Stage 6 - Establish thresholds & triggers

The International Infrastructure Management Manual (IPWEA 2011, section 2.2) provides guidance on developing and monitoring levels of service associated with public infrastructure.

Stage 7 - Assess options

The Australian Government publication *Handbook of Cost-Benefit Analysis* (Department of Finance and Administration 2006) also provides useful guidance on these methods. http://www.finance.gov.au/publications/finance-circulars/2006/01.html

Although it is a UK publication, *Multi-criteria analysis: a manual*, a publication of the (UK) Department for Communities and Local Government, provides perhaps the best readily accessible overview of approaches to MCA. http://eprints.lse.ac.uk/12761/1/Multi-criteria_Analysis.pdf

The *Local Government Asset Investment Guidelines* provide guidance on various aspects of infrastructure investment by local councils including investment appraisal analysis. http://www.dpcd.vic.gov.au/__data/assets/pdf_file/0006/38175/0806-24AssetInvestmentGuidelines.pdf

The International Infrastructure Management Manual (IPWEA 2011) provides guidance on technical, and lifecycle cost assessment of infrastructure.

Stage 8 - Manage uncertainty & risk

Scenarios Planning for Climate Adaptation is an online tool developed by the Victorian Centre for Climate Change Adaptation Research. It provides comprehensive guidance on developing climate change and impact scenarios. http://www.vcccar.org.au/files/vcccar/Scenario%20policy%20brief%20web%20version%20120711.pdf

The *Handbook of Cost-Benefit Analysis* (Department of Finance and Administration 2006) includes a discussion of sensitivity analysis. http://www.finance.gov.au/publications/finance-circulars/2006/01.html

A number of quite user friendly Monte Carlo computer simulations software tools are available at moderate cost. These include @RISK, Risk Solver and TreeAge. Some of these also apply techniques such as sensitivity and threshold analysis. A comprehensive review/ trial of the software, matching requirements and budget should be undertaken before selecting a specific tool. Software tools for undertaking Real Options Analysis are also available, but they are primarily geared towards market trading and business investment decision-making. However, there are a number of tools available for producing decision trees including Palisade, SmartDraw and TreeAge.

Stage 9 – Select options and implement

The *Handbook of Cost-Benefit Analysis* (Department of Finance and Administration 2006) includes guidance on the application of decision rules and assessing distributional effects. http://www.finance.gov.au/publications/finance-circulars/2006/01.html

The Australian Government Department of Finance and Deregulation has produced guidance on the use of decision rules. http://www.finance.gov.au/obpr/docs/Decision-Rules.pdf

Stage 10 – Monitor & evaluate

Developing and Using Program Logic in Natural Resource Management – User Guide provides step-by-step guidance for developing program logic in the context of natural resource management. Program logic is an approach to program planning, implementation, monitoring and evaluation. http://nrmonline.nrm.gov.au/catalog/mql:2164

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