

NCCARF Phase 2

Coastal Climate Change Risk Management Tool: Research Scoping Report



National Climate Change Adaptation
Research Facility
May 2015

The National Climate Change Adaptation Research Facility is supported through funding from the Australian Government.

Table of Contents

Executive Summary	1
1. Background	2
1.1 Purpose and scope of the Report	2
1.2 Structure of the Report.....	2
2. Sources of information to identify knowledge gaps and research needs	3
2.1 Stakeholder consultation meetings	3
2.2 Stakeholder engagement through the online survey	4
2.3 Input from NCCARF’s reference groups and Project Review Committee	5
2.3.1 End User Reference Group	5
2.3.2 Project Review Committee	5
2.3.3 Technical Reference Group	6
2.4 Feedback from the Adaptation Network Convenors.....	6
2.5 The <i>State-of-Play Report</i>	7
2.6 The NCCARF National Climate Change Adaptation Research Plans	7
2.7 Refereed journal literature	8
3. The Coastal Climate Risk Management Tool	9
3.1 Work to date on decision support	9
3.1.1 International initiatives	9
3.1.2 National initiatives.....	10
3.2 Framing the NCCARF Coastal Tool	12
3.2.1 Coastal climate, physical, social and economic datasets	13
3.2.2 Research outputs.....	14
3.2.3 Information Manuals.....	14
3.2.4 The user interface and decision support system.....	15
3.2.5 Information including Policymaker Summary	16
3.2.6 User manuals	16
3.2.7 Dissemination program	16
3.3 Stakeholder engagement and the Coastal Tool.....	17
4. Knowledge needs for the Coastal Tool.....	18
5. Research projects to support the Coastal Tool	23
5.1 A set of targeted research projects	23
6. Next steps	27
References.....	28
Appendix 1: Research gaps and research scoping from the Adaptation Networks	29
A.1.1 Vulnerable communities (including human health)	29
A.1.2 Natural Ecosystems Network.....	30
A.1.3 Social Economic and Institutional Dimensions of Adaptation	33
A.1.4 Australian Climate Change Adaptation Research Network for Settlements and Infrastructure	34
Appendix 2: Summary of relevant information in the <i>State-of-Play Report</i>	39
Appendix 3: High priority research questions identified in the National Adaptation Research Plans from NCCARF Phase 1	42
A.3.1 Settlements and Infrastructure.....	42

A.3.2	Terrestrial Ecosystems	43
A.3.3	Marine Ecosystems	44
A.3.4	Freshwater ecosystems	45
A.3.5	Social economic and institutional dimensions of adaptation.....	45
A.3.6	Human health	46
A.3.7	Emergency management	47
A.3.8	Indigenous communities.....	48

Executive Summary

This Report begins the process of identification of the research projects which need to be carried out to ensure that NCCARF has the necessary information to design, develop and implement the Coastal Climate Risk Management Tool (called the Coastal Tool) as part of its Phase 2 activities.

NCCARF has accessed many sources to understand the knowledge needs of its end users:

- national and regional stakeholder consultation meetings held by NCCARF in late 2014 and early 2015
- the online survey of stakeholders carried out by NCCARF in early 2015
- NCCARF's Phase 2 governance committee and advisory groups
- Adaptation Network convenors
- the *State-of-Play Report*
- National Climate Change Adaptation Research Plans prepared in NCCARF Phase 1
- relevant peer reviewed literature.

NCCARF has also carried out an inventory of the steps required to build the Coastal Tool, and has inspected these steps to identify any knowledge needs required in Tool construction.

In this scoping of research needs, we have identified 12 potential topics, as follows:

1. Integration and visualisation of datasets
2. Methodologies for vulnerability, impact and risk assessment, including methods to identify at-risk hotspots
3. Building a business case for adaptation
4. Systematic review of valuation methods with advice on their application to adaptation
5. Review of financing mechanisms for adaptation, including consideration of insurance, disaster preparedness and recovery, betterment and innovative financial instruments
6. Use of decision pathways to map out adaptation strategies, choice points, trigger points and thresholds for action, to support understanding of when and where to adapt
7. Ecosystem analysis, including information on ecosystem goods and services and methods to value ecosystem goods and services
8. Case studies of practice, in Australia and overseas, with a comprehensive synthesis to understand what does and doesn't work, and the determinants and predictors of success
9. Guidance on community engagement and consultation
10. Moving from assessment to implementation
11. Monitoring and evaluation in adaptation
12. Working with stakeholders in Tool development

Over the next weeks, research projects will be prioritised based on their value to the development and uptake of the Coastal Tool, the availability of appropriate experts, and the resources (both time and financial) required to carry out the projects. It is likely that some of the identified projects can be handled through the production of an Information Manual, rather than requiring research. Given the budget available, optimally we consider that between six and eight projects could realistically be undertaken. The process of scoping projects and identifying researchers must be complete by end July 2015 with delivery of final products and incorporation into the Coastal Tool due by the end of December 2016.

1. Background

The Australian Government has committed funding for the National Climate Change Adaptation Research Facility (NCCARF) to undertake a Phase 2 Program to support national capacity development and deliver guidance that helps local decision-makers manage climate risks. The funding has been provided for three years from 2014 to 2017, and to a value of \$8.8 million. Project activities will take place under four headings in order to deliver the project outcomes. These are, in brief:

- Key Activity 1: Governance, management and operations
- Key Activity 2: Preparing the Australian Coastal Climate Change Risk Management Tool
- Key Activity 3: Synthesis and communication
- Key Activity 4: Managing four Adaptation Networks

Further detail is available in the Phase 2 Project Plan, available from www.nccarf.edu.au

This Report relates to Key Activity 2. The Project Plan states that Key Activity 2 should develop a framework for understanding and managing climate risks, including sea-level rise in the coastal zone, in order to provide local governments and associated stakeholders with the skills, information and tools to support effective decision making.

1.1 Purpose and scope of the Report

The Funding Agreement between Griffith University and the Australian Government, which brings Phase 2 into existence, states:

“NCCARF should deliver a detailed science and regulatory *State-of-Play Report*, which will:

- Assess jurisdictional planning processes to understand the jurisdictional policy and regulatory frameworks within which the coastal risk management tool will need to operate
- Identify relevant and existing coastal/climate information products and datasets
- Identify any research gaps, and the contribution that additional research would make to the development of the online tool.”

The first two points are addressed in the accompanying *State-of-Play Report*. This report addresses the third point, regarding research gaps and how additional research could contribute to the development of the Coastal Tool.

1.2 Structure of the Report

This Report is presented in six sections. Section 2 reviews the sources of information used to identify knowledge gaps and research needs. These include the national and regional stakeholder consultation meetings, the online survey, NCCARF’s reference groups and Project Review Committee, the Adaptation Network convenors, the *State-of-Play Report*, the National Adaptation Research Plans prepared in NCCARF Phase 1, and peer-reviewed journal articles on adaptation.

Section 3 then sets out and explores NCCARF’s current understanding of the Coastal Climate Risk Management Tool, its structure and components. Section 4 brings this understanding together with stakeholder knowledge needs, as identified in Section 2, to identify what research is required in order to ensure that the Tool can fully and effectively address the knowledge needs of stakeholders. Sections 5 and 6 briefly scope twelve projects to address these knowledge needs and discuss the next steps. They make the point that the optimal number of projects, given the resources available, is probably between 6 and 8. Therefore an early next step is to understand which projects truly fall into the category of research, and which can be handled by other mechanisms, for example as Information Manuals.

2. Sources of information to identify knowledge gaps and research needs

We accessed a diverse range of sources to identify knowledge gaps and research needs for the Coastal Tool. Principally, these are (together with the numbers of the sections where they are described):

- 2.1 Stakeholder engagement through consultation meetings
- 2.2 Stakeholder engagement through an online survey
- 2.3 Input from NCCARF's reference groups and Project Review Committee
- 2.4 Input from NCCARF's four Adaptation Networks
- 2.5 The *State-of-Play Report*, which is a detailed assessment of existing science and regulatory frameworks in which the Coastal Tool will operate
- 2.6 The NCCARF National Climate Change Adaptation Research Plans, prepared in Phase 1 with the primary goal of identifying research needs, but across a much wider spectrum of adaptation activity than is the focus of Phase 1
- 2.7 The refereed journal literature.

We report briefly on these activities here, with cross-reference to detail in other Reports prepared by NCCARF in the set-up phase for the development of the Coastal Tool.

2.1 Stakeholder consultation meetings

At the time of delivery of this Report, we will have held eight regional stakeholder consultation meetings, as well as the national meeting in Melbourne. In date order, these are:

- National Kick-off Meeting, Melbourne
- Hobart
- Adelaide
- Cairns
- Darwin
- Ballina
- Sydney
- Melbourne
- Perth

The national Kick-Off Meeting was held in Melbourne in late November 2014. It brought key stakeholders in government, the private sector and the research community together to discuss NCCARF's plans for Phase 2, with the emphasis on the Coastal Climate Change Risk Management Tool. Around 60 people were invited, drawn from all tiers of government, with state and local government representatives from all jurisdictions, data providers, technical experts and researchers, and industry peak bodies.

Following on from this initial meeting we organised and ran the series of regional consultation meetings in state and territory capitals and regional centres in early 2015 (refer to the *Analysis of End-User Needs Report* for more details).

The discussion at these meetings was guided by four questions:

- Q1: What are the key problems for coastal managers caused by sea-level rise and climate change?
- Q2: In addressing these problems and thinking about adaptation planning – what do you need to support coastal zone management under climate change and sea-level rise? How might a 'tool' help and what would it look like?

- Q3: Is NCCARF’s conceptualisation of the Tool fit-for-purpose?
What amendments would make it more useful?
- Q4: Will the tool address Australia’s knowledge needs for coastal zone adaptation?
Are there any clear knowledge gaps? How should we involve stakeholders going forward?

There were a number of consistent messages from the stakeholders regarding their knowledge needs across all meetings, and these can be summarised as follows:

- Stakeholders generally lack confidence and certainty about future projections of sea-level rise and climate change, and as a result are unsure of their ability and capacity to make robust decisions.
- They are unconvinced by their ability to persuade their own stakeholders (senior management and the community) of the need to act and make potentially unpopular decisions.
- They are concerned about legal liability and are seeking ‘court-defendable’ knowledge and a level of indemnity for decision-making.
- They are seeking a national standard for sea-level rise planning that includes endorsed information, case studies and benchmarks.
- They require support from a tool that is flexible enough to support different levels of expertise and need-to-know.
- They would like support for adaptation action – how to take the next step after vulnerability assessment.

Detailed information on these meetings and their outcomes is provided in the *Analysis of End User Needs Report*, Section 3.2.

2.2 Stakeholder engagement through the online survey

Although comprehensive in scope, the program of stakeholder consultation meetings did not necessarily reach everyone across Australia who might wish to have a voice and express an opinion about the plans for Phase 2. We therefore decided to run an online survey to give a broader audience the opportunity to contribute. A full analysis of the survey is available in the *Analysis of End-User Needs Report*.

Respondents to the online survey were asked to identify the topics or areas of information or guidance that were most important for coastal organizations (Question 12), any knowledge gaps that prevent the best possible decisions being made about present and future climate-related risks (Question 13) and any barriers to progress on planning (Question 8) and what could be done to overcome these barriers (Question 9).

Question 12: The topics or areas of information or guidance that more than a third of respondents were looking for were:

1. Understanding coastal hazards, sea-level rise and climate change
2. Costs and benefits of adaptation – methods of assessment
3. Community engagement and participation
4. Risks to ecosystems and biodiversity
5. Building a business case for adaptation/long term decision making in coastal based organisations.

Question 13: In identifying knowledge gaps that prevent the best possible decisions being made about present and future climate-related risk, the top responses were:

1. Management options through defending against, retreating from and accommodating these risks

2. Future climate change in the local area
3. Laws, planning and building regulations as these affect management of the risks
4. Effects of sea-level rise and climate change in coastal morphology and beach dynamics
5. Future risk of flooding.

Questions 8 and 9: There was clear agreement amongst respondents over two classes of barriers: first those that contribute to failure to act because of perceived or real inadequate data and methodologies; second, those related to failure to communicate to important stakeholders, especially in the community and amongst senior management. These have clear solutions that could form the focus of targeted research.

Detailed information on these survey results is provided in the *Analysis of End User Needs Report*, Section 3.1.

2.3 Input from NCCARF's reference groups and Project Review Committee

NCCARF Phase 2 has two advisory groups and a review committee, as follows:

1. A *Project Review Committee* that includes representation from each relevant state and territory government, local government, and business associations.
2. A *Technical Reference Group* with a diverse range of expertise, including planners, legal experts and engineers. This Group provides guidance on technical aspects of NCCARF's activities.
3. An *End-user Reference Group*, with representatives from a geographically-spread diversity of local governments across Australia, and business associations.

2.3.1 End User Reference Group

The End User Reference Group met on 24 February 2015 and, as part of its discussions, made useful recommendations around topics that needed to be incorporated in the Coastal Tool. They recommended that the Tool should:

- provide access to data and resources
- incorporate a decision support system
- include methods of valuation including cost benefit analysis and methods to value ecosystem goods and services
- include methods of risk assessment
- consider the costs of inaction as well as different action pathways, and provide scenarios of the future under different decisions
- include case studies of good practice
- be relevant to decision makers dealing with legacy development as well as new developments, including worst-case legacy development
- set out innovative funding models for adaptation including shared cost arrangements (the example of San Francisco was cited).

2.3.2 Project Review Committee

The Project Review Committee met on 25 February 2015. In particular it stressed the vital importance of making sure that the Coastal Tool complements on-going coastal reform processes in states and territories, and the need to stay away from policy.

2.3.3 Technical Reference Group

The Technical Reference Group met for the first time on 9 May 2015. Members identified the following areas as important knowledge gaps:

- guidelines based on the National Committee on Coastal and Ocean Engineering Guidelines series, produced by Engineers Australia
- information on legal risks given as case studies (based on case law);
- case studies, including ones that identify failures
- information on the basic physical data to support adaptation planning in the coastal zone, e.g. understanding the range of sea-level rise projections, understanding the range of climate change projections
- guidance on using new approaches based on coastal geomorphology to assist decision making.

The Group considered it would be worth writing a short ‘introductory’ information manual that would set out some basic statements around what matters and what doesn’t in coastal zone management under climate change and sea-level rise. This might include, for example, consideration of the range of sea-level rise projections and the significance of the differences between them.

2.4 Feedback from the Adaptation Network Convenors

In Phase 2, NCCARF has engaged four Adaptation Networks, in:

1. Natural ecosystems;
2. Settlements and infrastructure;
3. Social, economic and institutional dimensions of adaptation; and,
4. Vulnerable communities (including human health).

We asked the Network convenors, in much the same way we asked other stakeholders, to poll their Network members to identify research and knowledge gaps they would identify in their sector. They were asked to address three questions:

Question 1: What are the key issues (impacts, barriers, options) for adapting in the coastal zone for your sector?

Question 2: Thinking about these issues, what are the key research questions that need to be addressed that would help support adaptation in the coastal zone?

Question 3: What ‘tools’ or aspects of a ‘tool’ might help support adaptation in the coastal zone for your sector?

Their full responses are provided in Appendix 1. Each of the Networks was clear that knowledge gaps exist in their sector, and that the utility of the Tool could be improved for users from these sectors if research was commissioned to address these gaps. Some examples are given below.

- In the Vulnerable Communities sector, there is distinct lack of knowledge and research on how to effectively increase community resilience through use of warnings and public alerts.
- The Natural Ecosystems Network looked separately at marine, terrestrial and freshwater ecosystems. For example, they identified knowledge of the influence of extreme events on coastal areas as a key issue.
- The Social, Institutional Dimensions Network identified three key issues, one of which is understanding what social processes are required to transition between adaptation pathways over time.
- The Settlements and Infrastructure Network identified understanding of the relative importance of sea-level rise and wave climate changes.

However, the Networks did not make a substantial effort to prioritise, or to identify key questions relevant to Tool construction (and nor did we ask them to carry out this step). NCCARF will work further with the Networks during the preparation of the Development Plan to undertake this prioritisation exercise.

2.5 The State-of-Play Report

The *State-of-Play Report*, currently under preparation as part of the NCCARF Phase 2 deliverables, and due for submission on 1 April 2015, is designed to provide a detailed assessment of the existing science and regulatory framework in which the Coastal Tool will need to operate. The structure of the *State-of-Play Report* follows a basic adaptation framework as follows:

- **Establishing the context.** In this section we considered available physical data, climate projections, resources and stakeholders.
- **Analysing the problem and making decisions.** In this section we considered the available tools for decision-making and risk assessment.
- **Implementation, monitoring and evaluation.** In this section we looked at resources and examples of putting these tools into practice and at available resources and examples of monitoring and evaluation. We also looked at case studies of existing adaptation strategies and plans.

Appendix 2 provides more information on the content of the *State-of-Play Report*.

Under *Establishing the Context*, the Report sets out the available datasets. There are gaps, for example, a lack of tide monitoring gauges in South Australia, but these could not be addressed by NCCARF with the resources available for Phase 2. However, NCCARF will work with Technical Reference Group members during the preparation of the Development Plan to understand whether there is research on approaches to understanding the physical environment, such as beach erosion, that could usefully be carried out.

The Report is clear that further work on the role of insurance is required – stakeholders have identified this as a knowledge gap that needs to be addressed, with the findings incorporated in the Tool.

Under *Analysing the Problem and Making Decisions*, the State-of-Play Report did not identify any obvious knowledge gaps that could usefully be addressed by NCCARF in the construction of the Tool.

Under *Implementation, Monitoring and Evaluation*, a number of areas are inadequately researched, including such topics as synthesising across case studies to understand the determinants of successful adaptation, and how to carry out consultation and engagement in order to achieve community support for adaptation. Potential research topics identified from the State-of-Play Report are included in Table 4.1.

2.6 The NCCARF National Climate Change Adaptation Research Plans

A National Climate Change Adaptation Research Plan (NARP) was written for each of nine key sectors during NCCARF Phase 1. The purpose of a NARP is to provide a national blueprint for research investment in climate change adaptation by research organisations and knowledge user stakeholders. Each NARP identified critical information gaps and priority research questions for the most urgent and important climate change adaptation issues for the relevant sector. Development of NARPs involved the active participation of both the research community and adaptation stakeholders.

NCCARF updated each NARP after two years, meaning that the six NARPs that had been completed earliest, and their associated implementation plans, were updated in phase one. The nine NARP sectors and their publication date are:

1. Marine biodiversity and resources (2010, updated 2012)
2. Terrestrial biodiversity (2011, updated 2013)
3. Freshwater biodiversity and resources (2011, not updated)
4. Primary industries (2010, updated 2013)
5. Settlements and infrastructure (2010, updated 2012)
6. Human health (2009, updated 2012)
7. Emergency management (2010, updated 2012)
8. Adaptation in Indigenous communities (2012, not updated)
9. Social, economic and institutional dimensions of adaptation. (2011, not updated)

The high priority research questions for each sector are listed in Appendix 3.

2.7 Refereed journal literature

A search was made of the adaptation research literature in Web of Science using the terms (i) “coast* AND climate change adaptation AND Australia” and (ii) “coast AND sea level rise AND adaptation AND Australia”. The searches provided more than 90 journal articles, and these are listed, together with their abstracts, in Section 4 of the *State-of-Play Report*. These journal articles cover all aspects of adaptation, from the underlying physical environment (changes in sandy beach erosion rates, for example) through to legal contexts and explorations of the application of adaptation pathway approaches. A first-pass assessment was carried out and did not identify any clear knowledge gaps. A systematic analysis of the journal papers will be performed as part of the preparation of the Development Plan for the Coastal Tool, and for the report on planned synthesis activities, to identify any clear knowledge gaps.

3. The Coastal Climate Risk Management Tool

NCCARF will deliver a Development Plan for the Coastal Climate Risk Management Tool (the Coastal Tool) on July 1 2015. In this section, we summarise our thinking to date, based on two sources of information:

- Work to date on the development of tools to support climate change adaptation. NCCARF intends to build on existing work in this area to date, and to not ‘reinvent the wheel’.
- Feedback from stakeholder engagement. Clearly, the Coastal Tool must address and support stakeholder needs in adaptation, especially local councils and other stakeholders in the coastal zone who seek to manage the effects of sea-level rise and climate change.

The *State-of-Play Report*, which accompanies this Report, looks in detail at current work in the area of decision support. The outcomes from stakeholder engagement are summarised in the *Analysis of End User Needs Report*. Below we summarise this information with respect to identifying research needs for the Coastal Tool.

3.1 Work to date on decision support

Here and overseas, numerous reports and online support tools have been produced in the last ten years. Some of these relate directly and usefully to what NCCARF plans to develop and implement under Key Activity 2. The most notable of these are highlighted below.

3.1.1 International initiatives

One initiative that has informed NCCARF’s thinking around the Coastal Tool is the framework supporting good decision making to address climate change risk, developed by Willows and Connell (2003). They take a standard risk management framework, applied in areas where risk is an issue, and make it relevant to the climate change adaptation case. There are eight steps in their framework, and the authors lead decision makers through these: from identifying the problem and the objectives of the exercise, through to monitoring the outcomes. The eight steps are shown in Figure 3.1.

Many subsequent efforts in the area of climate change adaptation decision support use this approach, adapting it as necessary to their particular case. The appeal of the framework lies in its simplicity and logic, and also in its characteristics which make it particularly appropriate to the case of climate change adaptation: because it is circular, tiered and iterative, it is responsive and adaptive. These are characteristics essential in decision support for adaptation, when timescales are long, there is uncertainty surrounding the outcome, and decisions may apply to long-lived infrastructure with high sunk-costs.

Examples of international projects that have used this approach, sometimes modified to their particular situation, include:

- ‘Adapting to sea level rise: a guide for California’s coastal communities’ (2012) uses a six-step process under three headings - Assessment, Planning and Implementation.
- ‘Five steps to managing your climate risks’ (2013), developed by Adaptation Scotland.
- ‘Adapting to coastal climate change: a guidebook for development planners’ (2009), produced for USAID.
- ‘Coastal adaptation to climate change: pathways to change (2011), produced by NIWA (New Zealand).

These and others are detailed in the *State-of-Play Report*.

As mentioned, a particular strength of the Willows and Connell framework is that it is adaptive. Adaptive management approaches, as illustrated in Figure 3.2, are attractive to resource-constrained decision-makers, because they allow decision making and implementation to be staged according to levels of risk, so that there are clear and objective criteria that identify when expenditure, whether of financial or human resources, is required. The adaptive management approach has led to the development of decision pathways, or adaptation pathways, exemplified by the Thames Estuary 2100 report, TE2100, a real-life example of adaptation decision making under uncertainty applied to planning for a piece of long-lived infrastructure with very high sunk costs (see Figure 3.3). Challenges in applying this approach have been identified (Wise et al. 2014) and will be considered in our planning for Tool development.

3.1.2 National initiatives

Many state governments have produced guidance for their adaptation decision makers (see Section 2.2.2.1 in the *State-of-Play Report*). These include:

- The Queensland government has published a set of guidelines for preparing a coastal hazard adaptation strategy as well as a *Climate Change Risk Management Matrix* that steps users (the primary target being farmers) through a process of risk and vulnerability assessment.
- The South Australian government funded the production of *Climate Adaptation Planning Guidelines* (2014), see Snapshot 7 in the *State-of-Play Report*.
- The *Victorian Coastal Hazard Guide* was produced by the Department of Sustainability and Environment (DSE in 2012).
- The Western Australia government produced the *Coastal Hazard Risk Management and Adaptation Planning Guidelines* in 2014.
- New South Wales produced the *Guide to Climate Change Risk Assessment for NSW Local Government* in 2011. The government is now moving to publish a statutory Manual as part of its Stage 2 Coastal Reforms that will include decision support for risk assessment.
- Tasmania: ClimateAsyst is a climate change analysis, risk assessment and communication tool supporting management of Tasmania's built assets and infrastructure under climate change.

There have been initiatives at the regional and local council level, and by NRM groups. Some are guidance documents in themselves, and others are examples of the application of risk management and decision pathways analysis methods. These include:

- The Hunter and Central Coast Regional Environmental Management Strategy (HCCREMs) *Decision Support for Adaptation – The Handbook* (2013), see Snapshot 6 in the *State-of-Play Report*, as an example of a guidance document
- *Regional Climate Change Adaptation Plan for the Eyre Peninsula* (Siebentritt et al., 2014), as an example of the application of the application of these approaches.

Amongst business and industry, the AdaptWater tool (Climate Change Adaptation Tool for the Australian Urban Water Sector) from Sydney Water takes into account uncertainty, time, spatial and technical information through a systems analysis approach. It provides a comprehensive picture of the complexity of modern water utilities' direct and indirect climate change risks that need to be considered in decision making processes. AdaptWater provides flexible adaptation pathways and plausible estimates of the cost-effectiveness of these adaptations.

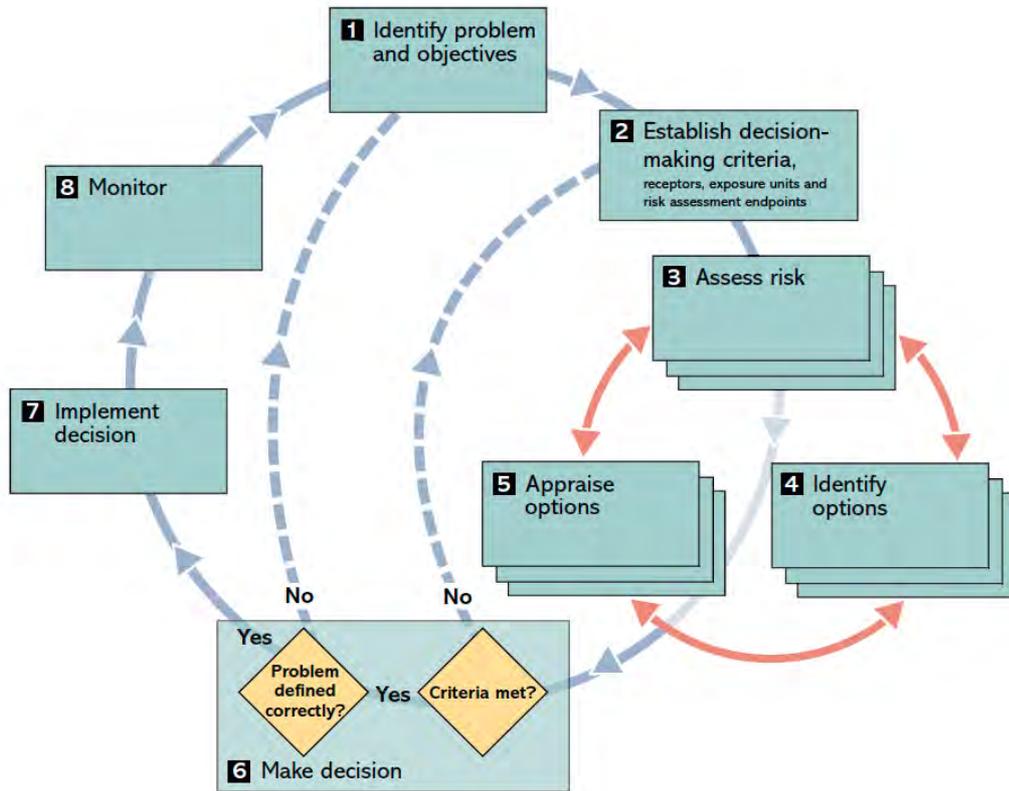


Figure 3.1: A framework to support good decision-making in the face of climate change risk (Willows and Connell, 2003)

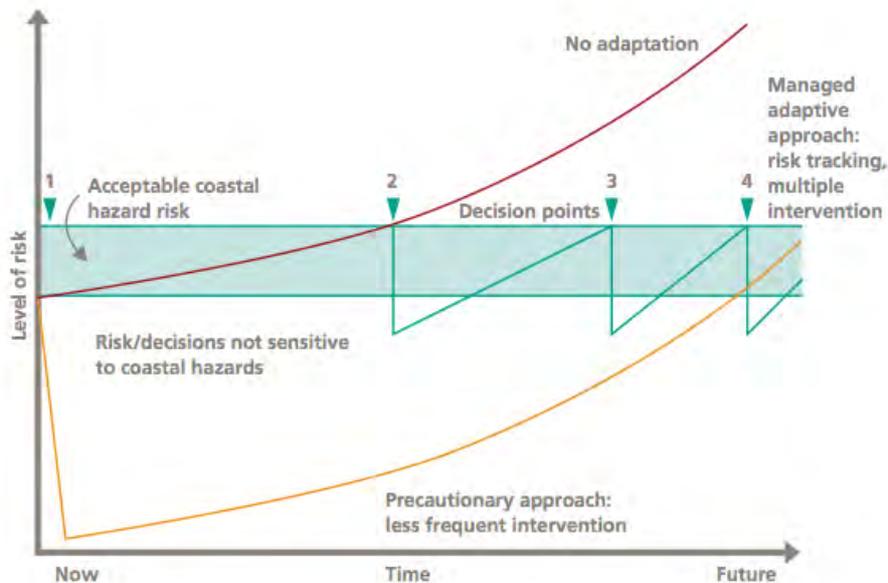


Figure 3.2: Approaches to adaptation and their effect on the level of risk over time. Source: *Victorian Coastal Hazards Guide*, Victorian Government Department of Sustainability and Environment, Melbourne, 2012.

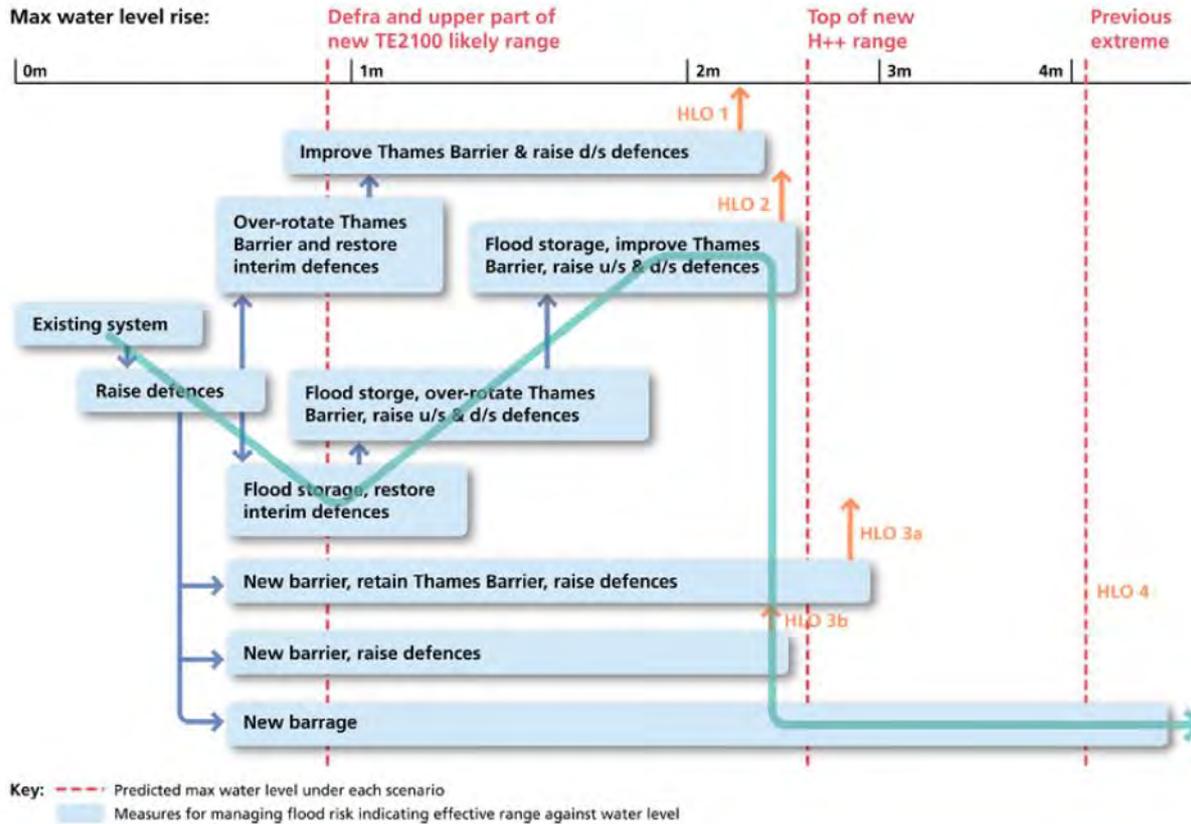


Figure 3.3: High-level adaptation options and pathways developed by TE2100 (on the y-axis) shown relative to threshold levels increase in extreme water level (on the x-axis). The blue line illustrates an imaginary pathway where a decision maker switches at a point when sea level is found to be increasing faster than predicted. Source: Reeder and Ranger (undated) www.worldresourcesreport.org

3.2 Framing the NCCARF Coastal Tool

Building on the thinking identified in the initiatives described in Section 2.1, NCCARF has begun to frame the Coastal Tool. The first two identified characteristics are that it will:

- include guidance and support for decision makers wishing to take an adaptation pathways approach
- be based around a risk management framework, such as that proposed by Willows and Connell (2003).

These two characteristics are compatible and can be used in parallel. The pathways approach introduces another dimension to the adaptation decision-making framework: that of time. It requires decision makers to establish a series of thresholds and trigger points (such as storm surge of a specified severity occurring more frequently than a defined threshold value each year) which, once exceeded, require some action to take place, or some decision to be finalised. As noted, it has particular appeal for decision makers working with constrained resources, whether human or financial.

The Willows and Connell (2003) approach has been used successfully to underpin analysis of case studies of good practice in adaptation, and in the provision of guidance for natural resource management planners (Rissik *et al.* 2014). The risk assessment framework is consistent with the coastal zone management frameworks used by most state-level jurisdictions, which ensures the Coastal Tool will be compatible with State and Territory practices.

A schematic of the Coastal Tool is shown in Figure 3.4. This was presented in the Phase 2 Project Plan and has been tested successfully at the national Kick-Off Meeting and at regional consultation meetings. NCCARF will use it as the starting point for full definition of the Coastal Tool in the Development Plan (due for delivery on 1 July 2015). We can consider each element of this schematic in turn.

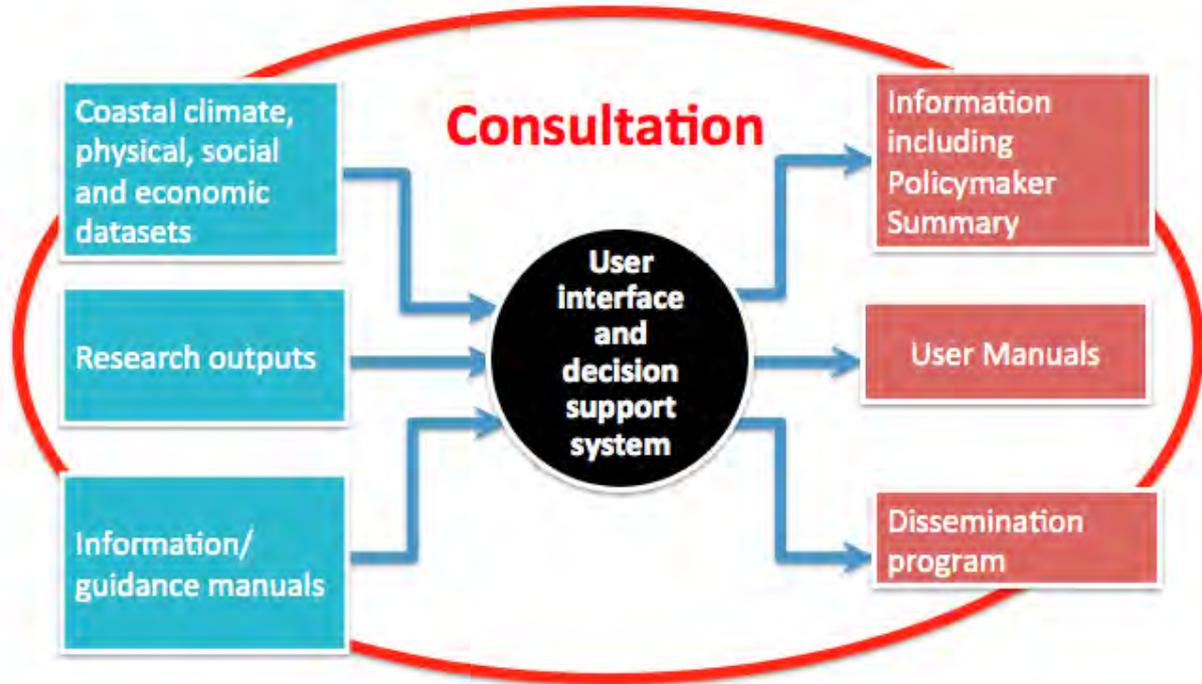


Figure 3.4: Schematic of the NCCARF Coastal Tool

3.2.1 Coastal climate, physical, social and economic datasets

NCCARF has already done extensive research into the datasets available to underpin the Coastal Tool. Climate and physical datasets include information on sea-level rise (Canute), on inundation risk (through OzCoasts and the National Elevation Data Framework), and climate change scenarios available from CSIRO and most state governments. These datasets are all resolved geographically and the owners provide visualisation tools that generate maps and/or spatial imagery using satellite data. Future sea-level rise and inundation risk can be viewed in the context of present-day residential, commercial and infrastructure development.

What remains a challenge, and may become a research question, is to understand whether these different datasets can usefully be brought together to support the NCCARF Coastal Tool, and hence adaptation decision-making in the coastal zone. And if the answer is yes, how can this best be done? What is clear to NCCARF from its stakeholder consultation is that, despite the efforts of the creators and owners to produce something that is useful, time-poor decision makers do not always find these datasets and data-based visualisation tools user friendly, and may struggle to understand how best to utilise them. Where resources are available, local councils may decide to employ a consultant to generate and interpret climate change and sea-level rise information that is precisely tailored to their needs. This is clearly wasteful of effort and may be counterproductive where geographically-adjacent councils are making decisions on the basis of information that is inconsistent.

Data are also available on future population projections from the ABS. However, these are not resolved geographically beyond the distribution of people in each state-level jurisdiction (except the ACT)

between the capital city and the rest. NCCARF could not identify any spatially-resolved datasets on future building and infrastructure distribution in the coastal zone. This is not necessarily a negative – we would expect coastal decision-makers to make their own decisions about where and when future development can and will take place, in the light of what they learn about future inundation and erosion risks.

These considerations raise a number of questions for NCCARF as it begins planning for the Coastal Tool. These include:

- How can these datasets be made more accessible and more useful to potential users?
- Do they need to be integrated to provide maximum benefit?
- Does NCCARF need to provide a portal to allow more straightforward and guided access to these datasets?

If NCCARF pursues the route of providing a portal, there will be a further set of questions around the extent to which we would seek to integrate the datasets. An example that we might follow is the Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S), which has been developed by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). This freely downloadable software allows users to view, classify, adapt and combine map layers.

3.2.2 Research outputs

In the development of the Coastal Tool, NCCARF may use \$750,000 to commission research projects to address knowledge gaps identified through stakeholder consultation. This short report begins the process of identifying the projects that could usefully be carried out, by making an assessment of where the gaps lie.

Timeframes are short. Research must be delivered within the timeframes of delivery of the Coastal Tool to enable outputs to be utilised effectively. Therefore we propose to adopt the model of the Synthesis and Integrative Research Program in Phase 1 of NCCARF. This program focussed on developing new knowledge from existing research products and literature, and by tapping into stakeholder’s knowledge and experience through analysis of case studies and through regular engagement. Projects were completed in less than 12 months and were delivered in ways that supported the needs of users. Project teams were closely guided by NCCARF. There were opportunities for researchers to engage, formally and informally, with stakeholders to ensure that projects remained on track to deliver useful outputs.

3.2.3 Information Manuals

NCCARF has explored with stakeholders, at its consultation meetings and in the on-line survey, the value, or otherwise, of producing information manuals as part of the Coastal Tool. We have further explored what would be the most useful format for stakeholders, and what topics are required.

The original concept for these information manuals, as described in the Project Plan, was that they would be freestanding compendia of information on topics of particular interest to coastal zone managers. The target audience for these manuals was very much the people charged with day-to-day management of the coastal zone, for example, local council officers with a planning, financial or infrastructure development portfolio.

The manuals will be provided on-line for download, and would be structured in such a way that they could easily be updated by adding and removing sections. This is essential given the dynamic character of the policy environment within which coastal management takes place. Although NCCARF would not update the manuals during Phase 2, this would be an essential step if the Coastal Tool is to continue to be useful in the longer term.

Stakeholders are supportive of the need for Information Manuals as a tool to deliver information. They have suggested that these should be provided in two formats: the first a detailed technical manual putting up-to-date essential information at the fingertips of decision makers; the second, a two page introduction to the topic that can be used as a tool for communication to senior management and, in local councils, elected representatives.

The current list of Information Manuals, compiled following extensive consultation, is as follows:

1. Understanding coastal hazards, sea-level rise and climate change
2. Available datasets and their application to adaptation decision making in the coastal zone
3. Methods and case studies for assessing costs and benefits of adaptation and making trade-offs
4. Planning instruments and approaches to enable adaptation to long-term climate risks (Australia and beyond)
5. Legal Case studies: a compendium of cases relevant to adaptation on the Australian Coast
6. Engineering solutions for coastal infrastructure: what the Engineering Australia Guidelines mean for non-technical experts
7. Coastal sediments, beaches and soft shores: understanding their importance for coastal resilience, and approaches for local and regional decision-making including use of sediment compartments
8. Community engagement and participation: guiding principles, case studies and current best practice
9. Ecosystems and the coastal fringe: approaches to ensure the long-term sustainability of the coast.

In addition, the *State-of-Play Report* will be restructured as an Information Manual.

NCCARF will commission external experts to produce the Information Manuals. We will prepare a full specification to ensure that the Manuals meet the requirements of the Coastal Tool. We plan to hold a meeting of authors before writing begins, to ensure they fully understand these requirements and can deliver on them.

3.2.4 The user interface and decision support system

The user interface.

Stakeholders have stressed the need to deliver a product that is attractive, straightforward and quick to use, and that does not create additional work for time-poor users. We have looked at a number of models for creating the user interface and will continue to pursue this inquiry as we begin the process of writing the Development Plan.

At the moment we favour an infographic approach, as the simplest approach to delivering potentially large amounts of information clearly, succinctly and effectively. Two examples of this approach in climate change are:

- the Adaptation Navigator (<http://adaptation-navigator.org.au/>), although this pilot project was never fully populated with content
- an example from the Ouranos team (http://www.ouranos.ca/en/scientific-program/impacts-adaptation/documents/Prog_IA.pdf), although in this case the end result is somewhat daunting.

The infographic enables the user to navigate their way through the available information, rather than forcing them onto a preordained pathway. They can dip in and out as time permits. A potential disadvantage is that (as in the Ouranos case) it can become overly complex. If NCCARF decides to take the infographic route, careful planning and structuring will be essential to avoid over-complexity.

The decision support system.

Our current thinking is that decision support will have two parts.

The first part is a step-by-step process to support decision makers to address the questions:

1. What are the risks from climate change and sea-level rise?
2. What adaptation measures are required to address these risks?
3. When should these measures be implemented?

So far as is possible, this decision-making framework will be based around a set of rules of thumb.

If we consider the risk management framework of Willows and Connell (2003), this has eight steps:

1. Identify problem and objectives
2. Establish decision-making criteria
3. Assess risk
4. Identify options
5. Appraise options
6. Make decision
7. Implement decision
8. Monitor

In this framework, Steps 1-3 are necessary to address Question 1 around understanding the risks, and Steps 4-8 provide the answers to Question 2. The adaptation pathways approach, when implemented as part of the risk management framework, provides the answers to Question 3.

The second part will be the information needed by decision makers as they step through the risk management framework. In Section 4, we summarise the results from stakeholder consultation to identify stakeholder knowledge needs.

3.2.5 Information including Policymaker Summary

Potential end users of the Tool have been clear that one of their requirements is support to engage with their communities around difficult questions to do with climate change and sea-level rise, and also to persuade their senior management and, in the case of local councils, elected representatives of the reality of climate change and the need for action.

To address this need, NCCARF will produce a series of high-level briefs on key topics addressed by the Tool, and on the Tool itself— its function and how it can support coastal zone decision-making. These are likely to be two-page documents attractively presented and using easily accessible language that engages stakeholders. We will pre-test these documents to ensure they are useful for their intended audience.

3.2.6 User manuals

The Coastal Tool should be largely intuitive to use. However, NCCARF plans to generate a user manual to fully document the thinking behind the creation of the Coastal Tool – who it is intended for, why it was created, what the context was at the time it was built, how it is expected to support decision making for coastal zone management under climate change, and what are the limitations of its application.

3.2.7 Dissemination program

NCCARF will carry out a full program of dissemination for the Tool. This will begin with the release of the beta version of the Tool for consultation and review, in the second half of 2016, and continue after the final Tool is released, on 28 February 2017, until the end of the current round of funding.

3.3 Stakeholder engagement and the Coastal Tool

The discussion in Section 3.2 focuses on the ‘mechanical’ aspects of Tool construction. What needs to be emphasised, however, is that continuing stakeholder engagement will be a key part of the Tool. Stakeholders have been very clear to us about the need for communities of practice, and have suggested that a key aspect of the Tool would be to provide access to expert advice, perhaps through a system of regional expert panels.

NCCARF will work to understand how the Tool can contribute towards building successful and long-lived engagement between the research and end-user communities, to the mutual advantage of both. Areas of stakeholder engagement that NCCARF has already identified as important include through:

- the reference groups and the Project Review Committee;
- consultation and review of the beta version of the Tool in late 2016;
- the dissemination program once the final version of the Tool is released.

NCCARF plans to develop a program to engage coastal stakeholders more directly in the early stages of Tool development. We will advertise for coastal stakeholders who wish to be involved; these may be coastal councils or other coastal stakeholders in the coastal zone, for example, private companies or utility companies (one per jurisdiction). Successful applicants will work as partners with NCCARF during Tool development to ensure we stay on track with addressing stakeholder needs. Ideally, these will be stakeholders who are already working to understand their vulnerability to climate change and sea-level rise through risk assessment, and to develop adaptation plans. We envisage that the identified stakeholders will engage with us through to the completion of the beta testing of the Tool.

4. Knowledge needs for the Coastal Tool

As explained in Section 2, NCCARF undertook extensive stakeholder engagement in order to understand what was wanted from the Coastal Tool. This engagement identified the need for a Tool or Framework that:

- is consistent with adaptive planning and risk management frameworks, and enables constant improvement
- supports access to comprehensible guidance about each component of the adaptation framework
- provides links to national data sets that may be used to support community consultation, risk analysis and planning at a local level
- provides analysis of current adaptation work being conducted across Australia, and possibly abroad, including identification of criteria about why the project is working or not and what makes it leading practice
- supports integrated decision making
- demystifies various approaches that are unique to climate change adaptation such as Adaptation Pathways or Planning for multiple possible futures
- can be accessed with various levels of detail (low level for time poor people, and high level for technical experts)
- is backed up at all levels by cases studies and worked examples of any complex aspects
- is simple and straightforward to use.

In order to fulfil these goals for the Tool, NCCARF compiled a detailed ‘wish list’ for Tool content from stakeholder feedback. This represents a comprehensive statement of what is needed from the Tool if it is to deliver to stakeholder needs in the coastal zone. It was originally presented in the Executive Summary of the *Analysis of End User Needs Report*, and is reproduced here as Box 4.1. It forms the basis for our consideration of what research is required in order to address any knowledge gaps that might limit the utility of the Tool.

In Table 4.1, we inspect each item from Box 4.1 in turn to understand how and where it will feature in the Coastal Tool, and how NCCARF will incorporate the necessary information into the Tool. This process, taken together with understanding of the current state of adaptation knowledge as set out in the *State-of-Play Report*, reveals where the knowledge gaps lie. Table 4.1 therefore also identifies where research is required in order to fully populate the Tool with the required knowledge for decision makers. Note that most if not all of the research projects identified are meta studies— they are expected to consist largely of systematic reviews of existing information together with targeted interviews with key players, leading to a synthesis providing advice and guidance on best practice.

Box 4.1: Desired Tool content compiled from stakeholder consultation

a. The Tool should be a data portal providing:

- access to nationally-consistent, freely-available data on present-day and future climate and climate change, coastal hazards, sea-level rise, regional impacts and their costs, damage estimates and biodiversity loss
- integration of datasets
- visualization of datasets.

b. The Tool should provide advice, support and guidance on the process of risk assessment and decision-making under climate change including on:

- data quality and use
- appropriately scaled (down to regional and local levels) scenarios of future climate change, hazards and sea-level rise
- sea-level rise management options through defending against, retreating from and accommodating risks
- methodologies for vulnerability, impact and risk assessment, including methods to identify at-risk hotspots
- decision-making under uncertainty
- understanding the legal implications of adaptation decisions, actions and inaction
- laws, planning and building regulations as these affect risk management
- consistent methods of valuation – cost-benefit analysis, multi-criteria analysis; these methods should be applicable to valuation across the range from ecosystems to hard infrastructure, and should have the capacity to inform decision pathways analysis
- assessment of costs of adaptation options and avoided damages through, for example, cost-benefit analysis
- the role of insurance
- financing for disaster resilience, preparedness and recovery
- building a business case for adaptation
- innovative financing mechanisms for adaptation, such as public/private partnerships.

c. The Tool should advise on the use of decision pathways to map out adaptation strategies, choice points, trigger points and thresholds for action, to support understanding of when and where to adapt.

d. The Tool should incorporate ecosystem analysis, including:

- information on ecosystem goods and services
- methods to value ecosystem goods and services.
- The Tool must balance environmental, economic and social considerations.

e. The Tool should provide frameworks for peer-to-peer learning and advice through:

- on-line forums to support communities of practice
- case studies of good practice (and what didn't work), accompanied by short videos
- a panel of independent experts.

f. The Tool should provide guidance on community engagement and consultation.

g. The Tool should review national and international adaptation activity and provide information on lessons learned from experience in coastal adaptation.

Table 4.1: Desired Tool content compiled from stakeholder consultation. [A shaded row indicates that a research need has been identified.]

Tool content:	How will the Tool support this?	Are there research needs?
A data portal providing:		
Access to nationally-consistent, freely-available data on present-day and future climate and climate change, coastal hazards, sea-level rise, regional impacts and their costs, damage estimates and biodiversity loss	See Section 3.2.1 and through an Information Manual	No, NCCARF needs to make a comprehensive stocktake of available datasets but this is not a research issue.
How to make data useful: integration and visualisation of datasets	See Section 3.2.1	Yes. An exploration of the ‘best’ ways to integrate and display datasets is required, to be carried out by a group with expertise in data and portal management. This will contribute to NCCARF’s development of the Tool, as well as providing information useful to decision makers.
Advice, support and guidance on the process of risk assessment and decision-making under climate change including on:		
Data quality and use	Through an Information Manual: see Section 3.2.3	No. The Manual will contain guidance on how to interpret and use data, including advice on dealing with uncertainty.
Appropriately scaled (down to regional and local levels) scenarios of future climate change, hazards (including inundation risk) and sea-level rise	Through an Information Manual: see Section 3.2.3	No. NCCARF will make a comprehensive stocktake of available datasets, including local scenarios. Note that the Information Manual will contain guidance on how to interpret and use scenarios, including advice on dealing with uncertainty.
Sea-level rise management options through defending against, retreating from and accommodating risks	Through an Information Manual: see Section 3.2.3	No.
Methodologies for vulnerability, impact and risk assessment, including methods to identify at-risk hotspots	Integral part of the decision support system, see Section 3.2.4	Yes. NCCARF will consider whether two projects are required: <ul style="list-style-type: none"> • A review of the assessment literature, together with an assessment of adaptation plans from a range of councils and other organisations • Understanding how to define and identify Australian coastal hotspots, including consideration of social resilience.
Decision-making under uncertainty	Through an Information Manual: see Section 3.2.3	No
Understanding the legal implications of adaptation decisions, actions and inaction	Through an Information Manual: see Section 3.2.3	No. For many legal issues, a firm determination relies on legal precedents but there are a number of excellent

		opinions and reviews of existing case law that provide a sound basis for action (e.g., Bell, 2014). It is unlikely that further research will yield more certainty, but this area could benefit from treatment under KA3.
Laws, planning and building regulations as these affect risk management	Through an Information Manual: see Section 3.2.3	No. This topic is comprehensively reviewed by the <i>State-of-Play Report</i> . The Information Manual will take this review and use it to discuss how risk management is affected by the legal and regulatory environment. It is expected that the Project Review Committee will make useful input to this Manual.
Building a business case for adaptation	Integral part of the decision support system, see Section 3.2.4	Yes. Although there is a large literature on building a business case, very little of it relates to adaptation, with its unique intergenerational properties.
Financial aspects of adaptation including financial instruments: a) Consistent methods of valuation – cost-benefit analysis, multi-criteria analysis; these methods should be applicable to valuation across the range from ecosystems to hard infrastructure, and should have the capacity to inform decision pathways analysis b) Assessment of costs of adaptation options and avoided damages through, for example, cost-benefit analysis c) The role of insurance d) Financing for disaster resilience, preparedness and recovery e) Innovative financing mechanisms for adaptation, such as public/private partnerships	Integral part of the decision support system, see Section 3.2.4	Yes. It is likely that two projects are required: <ul style="list-style-type: none"> • A systematic review of valuation methods with advice on their application to adaptation, covering (a) and (b) in column 1. • A review of financing mechanisms for adaptation, including consideration of insurance, disaster preparedness and recovery, betterment and innovative financial instruments, and covering (c) to (e) in column 1.
Advice on the use of decision pathways to map out adaptation strategies, choice points, trigger points and thresholds for action, to support understanding of when and where to adapt.	Integral part of the decision support system, see Section 3.2.4	Yes. There is an emerging literature on decision pathways, an approach which has great appeal to resource-constrained decision-makers. A considered review of the literature combined with advice on how to apply the method and define decision points and triggers is required to inform development of the decision support system
Ecosystem analysis, including: <ul style="list-style-type: none"> • Information on ecosystem goods and services • Methods to value ecosystem goods and services 	Integral part of the decision support system, see Section 3.2.4	Yes. Prior research exists about how to place a non-monetary value on ecosystems, and how to make an economic valuation of ecosystem services. There is a need to review these for the Tool and apply them to the

		<p>determination of:</p> <ul style="list-style-type: none"> • the valuation of losses due to sea-level rise and climate change; • the costs of adaptation actions; • how to arrive at equitable outcomes.
Frameworks for peer-to-peer learning and advice through:		
Case studies of good practice (and what didn't work) and lessons learned, accompanied by short videos	Integral part of the decision support system, see Section 3.2.4	Yes. Case studies of practice exist, both here and overseas, but there has been no comprehensive synthesis to understand what does and doesn't work, and what are the determinants and predictors of success
On-line forums to support communities of practice	NCCARF will explore the potential to develop an online community of practice, with advice forums.	No
Panel of independent experts	NCCARF will explore with the Project Review Committee the potential to set up expert advisory panels at state level; undertaking this activity with the Committee will assist in operationalizing beyond the timespan of NCCARF Phase 2	No
Guidance on community engagement and consultation	Through an Information Manual: see Section 3.2.3	Yes. There is a large body of research on effective communication and an emerging literature on communicating and engaging with stakeholders on issues associated with climate change. Some of this is highly targeted or very general, and hence there is a need for a meta study to address the requirements of the Tool
Review of national and international adaptation activity and information on lessons learned from experience in coastal adaptation	Through restructuring the <i>State-of-Play Report</i> as an Information Manual: see Section 3.2.3	No. The <i>State-of-Play Report</i> reviews national and international adaptation activity, and will become part of the Coastal Tool by being restructured as an Information Manual. Lessons learned from adaptation experience will be handled through the case studies of good practice

5. Research projects to support the Coastal Tool

Section 4 has identified, through intensive and widespread stakeholder consultation, a number of topics important for the Coastal Tool, for which further research is required in order to ensure that the best possible information is incorporated into the Tool. These are set out in Table 5.1.

Feedback shows that decision makers require integrated information, rather than the outputs of single research questions or topics. This form of research builds a body of knowledge around key topics which is often more robust than the information being generated from more thematic based research. It is clear that decision makers require simple, plain English guidance for action and simple, plain English summaries of technical information, based around available information and current good practice. Some of these knowledge needs will be met through the development of the coastal tool and support materials (e.g. information manuals, synthesis products, supporting information), but some require more sophisticated analysis and research to build bodies of knowledge from case studies and existing research outputs. It is this latter category that we plan to address through targeted research projects.

5.1 A set of targeted research projects

Through stakeholder analysis, we have identified ten research projects. There is clear line-of-sight between the stakeholder discussions outlined in Section 2 of this Report, and the projects identified here. These projects can all be undertaken in an 8-12 month period, which fits with the timeline for Tool development. At least one of the projects, Project 1 in the list below, will contribute to NCCARF's capacity to build the Tool, since it should inform our understanding of how to integrate and display data within the Tool, as well as providing advice to stakeholders on the use of these datasets.

Project 1: Integration and visualisation of datasets. This project will address the needs of:

- NCCARF in developing the Tool, to understand how best to make use of the datasets already available: how to display these and the potential to bring them together to add value
- end users of the Tool in understanding how they can make effective use of the many datasets already out there and so avoid incurring costs by, for example, employing consultants generate new site-specific datasets.

NCCARF will employ a specialist group in integration and visualisation of datasets to undertake this project and to provide appropriate advice on the use of datasets in Tool development.

Project 2: Methodologies for vulnerability, impact and risk assessment, including methods to identify at-risk hotspots. This project should:

- review the assessment literature, both the theoretical literature and assessment of adaptation plans from councils and other organisations
- build understanding of how to define and identify Australian coastal hotspots, including consideration of social resilience.

Project 3: Building a business case for adaptation. Potential users of the Tool have been clear that they need support in developing a business case that will persuade their senior management and, in the case of local councils, elected representatives, of the need to adapt. The literature on developing business cases is large, but is seldom applied to the case of climate change adaptation. A small project will be undertaken to understand how to develop a business case around the need for adaptation action, taking into account the need to convince stakeholders of the reality of climate change, the timescales involved, the need to adapt, the types of adaptation required and, most importantly, the financial and possibly legal penalties incurred by not taking action.

Project 4: A systematic review of valuation methods with advice on their application to adaptation. Valuation methods are required to compare and prioritize different adaptation measures, and compare these with the costs of inaction. Valuation is not straightforward because costs and benefits are distributed over long time frames, are subject to high levels of uncertainty, and may involve non-monetary values attached to ecosystem services. The project will compare the different techniques available, and make recommendations as to the appropriate techniques to use and how to parameterise these. The project will produce accessible guidelines and clear instructions on how to apply these techniques.

Project 5: Review of financing mechanisms for adaptation, including consideration of insurance, disaster preparedness and recovery, betterment and innovative financial instruments. Through a literature review and semi-structured interviews with finance industry representatives and stakeholders (including, for example, the disaster response community), the project will explore the actual and potential roles played by the sector in coastal adaptation. The project will include consideration of reports by the Productivity Commission and Treasury, as well as other Australian and international examples of current practice. An outcome will be a clear user-friendly guide to understanding the roles of these organisations, and how best to engage with them in adaptation planning and response.

Project 6: Use of decision pathways to map out adaptation strategies, choice points, trigger points and thresholds for action, to support understanding of when and where to adapt. This is an attractive technique to resource-constrained decision-makers, since it provides a rationale for deferring action. This may be a legitimate approach given the levels of uncertainty involved in climate change science, but there is the risk that it will be misused. It is important, therefore, that end users have a full understanding of the approach, its application, and the opportunities it provides to engage with stakeholders around the need for action at a future date, so allowing for orderly transition to action. This project feeds into Project 9.

Project 7: Ecosystem analysis, including information on ecosystem goods and services and methods to value ecosystem goods and services. This project will draw on existing, new and emerging information on the services provided by coastal ecosystems and habitats. It will explore the mechanisms underpinning the services provided and consider benefits and opportunities which can be derived by integrating the environment into long term planning and management of coastal developments. It will explore methods to value ecosystem goods and services, and so will feed into Project 4.

Project 8: Case studies of practice, in Australia and overseas, with a comprehensive synthesis to understand what does and doesn't work, and what are the determinants and predictors of success. As noted in Table 5.1, case studies of practice exist, both here and overseas, but there has been no comprehensive synthesis to understand what does and doesn't work, and what are the determinants and predictors of success. This project will compile a catalogue of projects demonstrating both success and failure. It will evaluate these against objective criteria in order to understand what are the determinants and predictors of success.

Project 9: Guidance on community engagement and consultation. This project will review the literature on communication, especially the growing literature on climate change communication, to identify best practice and indicators of success. Then, it will compare and contrast the way in which councils engage with their communities around climate change. Semi-structured interviews will be conducted with the teams responsible for communication and, where possible, their audience. The research will explore mechanisms of successful communication, examine whether desired outcomes from the communication were achieved, and whether these were evaluated as part of the project. Outcomes from this research are directly relevant to the Coastal Tool and to the expressed needs of stakeholders.

Project 10: Moving from assessment to implementation. This project is aimed at learning lessons from the preparation of risk assessments. The project will entail working with a number of councils with limited resources to undertake a risk assessment process, and to communicate the outcomes of the project to key stakeholders and the community. A critical analysis of the approaches used, the outcomes and any pitfalls will be undertaken. Key aspects include success in using the risk assessment to inform other planning components, integration of adaptation into core business within Councils and the use of risk assessments to develop communication products that are used to inform key audiences.

In addition, NCCARF plans to add two projects that will contribute to its capacity to build an accessible, informative and useful Coastal Tool. These are:

Project 11: Monitoring and evaluation (M&E) in adaptation. This project will analyse current literature and practice to identify best practice in M&E associated with climate change adaptation. It will provide guidelines on how to monitor success or failure of actions, programs and investment (as measured, for example, by the extent risk to communities has been reduced). A sub-component of this project will focus on the communication of M&E results to stakeholders. This project will contribute to the development of the area of the Coastal Tool decision support system on monitoring (Step 8 in Section 3.2.4).

Project 12: Working with stakeholders in Tool development. Small projects will be conducted together with local government and industry partners. These partners will work with NCCARF during the development of the Tool, and will pilot its use within their organisations once the beta version is released. The research team will identify the interest and objectives of the partners in using the Tool (e.g. supporting the production of an adaptation plan; engaging with Counsellors and stakeholders etc.). The team will establish why the Tool is being used, how and by whom. They will determine whether it has led to successful outcomes and whether its objectives have been achieved. Feedback from the projects will be used in adjustments to the beta version to produce the final Tool (see also Section 3.3 of this Report).

Table 5.1: Research topics to address knowledge gaps for the Coastal Tool

Research topic:	Comments:
How to make data useful: integration and visualisation of datasets	An exploration of the ‘best’ ways to integrate and display datasets is required, to be carried out by a group with expertise in data and portal management. This will contribute to NCCARF’s development of the Tool, as well as providing information useful to decision makers.
Methodologies for vulnerability, impact and risk assessment, including methods to identify at-risk hotspots	This project should: <ul style="list-style-type: none"> • Review the assessment literature, including assessment of adaptation plans from councils and other organisations; • Build understanding of how to define and identify Australian coastal hotspots, including consideration of social resilience.
Building a business case for adaptation	Although there is a large literature on building a business case, very little of it relates to adaptation, with its unique intergenerational properties.
Financial aspects of adaptation including financial instruments: <ol style="list-style-type: none"> Consistent methods of valuation – cost-benefit analysis, multi-criteria analysis; applicable to valuation across the range from ecosystems to hard infrastructure, with the capacity to inform decision pathways analysis Assessment of costs of adaptation options and avoided damages through, for example, cost-benefit analysis The role of insurance Financing for disaster resilience, preparedness and recovery Innovative financing mechanisms for adaptation, such as public/private partnerships 	Two projects are required: <ul style="list-style-type: none"> • A systematic review of valuation methods with advice on their application to adaptation, covering (a) and (b) in column 1. • A review of financing mechanisms for adaptation, including consideration of insurance, disaster preparedness and recovery, betterment and innovative financial instruments, and covering (c) to (e) in column 1.
Advice on the use of decision pathways to map out adaptation strategies, choice points, trigger points and thresholds for action, to support understanding of when and where to adapt.	There is an emerging literature on decision pathways, an approach which has great appeal to resource-constrained decision-makers. A considered review of the literature combined with advice on how to apply the method and define decision points and triggers is required to inform development of the decision support system
Ecosystem analysis, including <ul style="list-style-type: none"> • Information on ecosystem goods and services • Methods to value ecosystem goods and services 	Prior research exists about how to place a non-monetary value on ecosystems, and how to make an economic valuation of ecosystem services. There is a need to review these for the Tool and apply them to the determination of: <ul style="list-style-type: none"> • Valuation of losses due to sea-level rise and climate change; • The costs of adaptation actions; • How to arrive at equitable outcomes.
Case studies of good practice (and what didn’t work) and lessons learned	Case studies of practice exist, here and overseas, but there is no comprehensive synthesis to understand what does and doesn’t work, and what are the determinants and predictors of success
Guidance on community engagement and consultation	There is a large body of research on effective communication and an emerging literature on communicating and engaging with stakeholders on issues associated with climate change. Some of this is highly targeted or very general, and hence there is a need for a meta study to address the requirements of the Tool

6. Next steps

Over the coming weeks, NCCARF will further scope the research projects to support the Coastal Tool, using the knowledge gaps identified here as a starting point. NCCARF staff, in conjunction with our Networks and the Technical Reference Group, will expand on the scope of each of the research gaps identified, including an understanding of the breadth the issues, specific research questions, a research timeline and potential research experts to conduct the work.

Research projects will be prioritised based on their value to the development and uptake of the Coastal Tool, the availability of appropriate experts and the resources (both time and financial) required to carry out the projects. The considerable expertise and knowledge of research currently being undertaken that is embodied in the Technical Reference Group will be drawn upon to help assess and prioritise research projects. It is likely that some of the identified projects can be handled through the production of an Information Manual, rather than requiring a research project (for example, Projects 6 and 8 in Section 5.1). Given the budget available, optimally we consider that between six and eight projects could realistically be undertaken.

The process of scoping projects and identifying researchers must be complete by end July 2015 with delivery of final products and incorporation into the Coastal Tool due by the end of December 2016 (see Table 6.1).

Table 6.1: Timeline for development of research projects under Key Activity 2

Task:	Timeline:
Research projects scoped and calls to researchers made	April-July 2015
Research projects commence	November 2015
Research projects underway	December 2015-June 2016
Research products are delivered and peer reviewed	July 2016
Research products are provided to decision makers as stand alone products and incorporated into the Coastal Climate Tool	September-December 2016

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Appendix 1: Research gaps and research scoping from the Adaptation Networks

Networks were asked to address three questions:

Question 1: What are the key issues (impacts, barriers, options) for adapting in the coastal zone for your sector?

Question 2: Thinking about these issues, what are the key research questions that need to be addressed that would help support adaptation in the coastal zone?

Question 3: What 'tools' or aspects of a 'tool' might help support adaptation in the coastal zone for your sector?

A.1.1 Vulnerable communities (including human health)

Question 1: What are the key issues (impacts, barriers, options) for adapting in the coastal zone for your sector?

Risk to coastal communities: Climate change poses a serious and perennial risk to many coastal communities, yet some social cohorts will be more vulnerable than others. For communities facing serious risk from coastal flooding and storm surges, social, psychological, economic, health, and linguistic barriers may curtail the range of adaptation options available to them in short and long-term timeframes.

Consider, for example, long-term caravan park residents living adjacent to beaches and coastal rivers. This subpopulation can be characterised as vulnerable to climate change on all vulnerability characteristics (exposure, sensitivity, and adaptive capacity). They are spatially exposed, with many coastal caravan parks being positioned adjacent to beaches and sand dunes, directly exposed to storm surges, dune and cliff erosion, and flooding. Further, some individuals in this population also experience socio-economic and psychological stressors that increase their sensitivity to climate impacts. The scope of potential adaptation actions is constrained as a function of limited access to financial, social, and material resources.

Risk to Indigenous communities: Aboriginal and Torres Strait Islander Peoples living in coastal communities are also significantly exposed to sea-level rise and storm surges impacts from climate change. These communities have strong cultural ties to their land, and adaptation responses such as relocation will have serious impacts on their future well-being. Climate change in coastal regions will have implications for Indigenous communities' dependant on natural resources, and poses serious health risk, especially to individuals with pre-existing health issues. Moreover, the threat of vector-borne disease, such as dengue, are predicted to increase as a result of flooding, confronting some vulnerable communities with another dimension of health risk.

It is clear that the risks associated with climate change will be asymmetrically distributed throughout society, exacerbating existing social, health, psychological and economic problems. As a result, adaptation options for vulnerable groups in coastal areas will be largely delimited by economic and social factors. Vulnerability will be further magnified when institutions fail to plan for risk and changes within the social system, compounding vulnerability of the system.

Question 2 Thinking about these issues, what are the key research questions that need to be addressed that would help support adaptation in the coastal zone?

Many potentially vulnerable groups are under-researched or overlooked in traditional research on climate change vulnerability, and the socio-economic factors contributing to a groups' vulnerability are often not accounted for in vulnerability assessments and adaptation plans. In particular, a paucity of research has addressed the vulnerability of less visible groups, such as those experiencing housing instability and people suffering from health and psychological co-morbidities.

Research will need to address questions of how vulnerability in coastal zones is differentially experienced along socio—economic and spatial dimensions. Some research could fruitfully focus on better understanding and identifying how climate change impacts are mediated by people’s social conditions and their perceptions of their own adaptive capacity, leading to a more nuanced appreciation of how these vulnerability factors can be remediated.

Moreover, there is a distinct lack of knowledge and research on how to effectively increase community resilience in coastal zones before, during and after flooding events and storm surges, through the use of warnings and public alerts that prompt adaptive behaviour change. A better understanding of how warnings are received and interpreted - and why they are often ignored - is critical to reducing risks associated with weather-related emergencies. Research needs to develop innovative methods of message dissemination, ensuring community-wide equity in access to warnings and advice, particularly for the most vulnerable groups in society, as well as people who are non-English speaking, the socially isolated, and those in remote coastal locations.

Question 3: What 'tools' or aspects of a 'tool' might help support adaptation in the coastal zone for your sector?

Research could inform an adaptation tool sensitive to how climate change interacts with key vulnerability factors, including age, poverty, health, social isolation and financial instability; where these vulnerability factors are more concentrated geographically; and whether particular factors change over time or under certain conditions.

New methods can develop from combining physical approaches (spatial and biophysical) to vulnerability with social analysis, leading to a more socio-ecological framework for conceptualising and addressing vulnerability. Vulnerability in coastal zones is a dynamic phenomenon, and it will be in continuous flux as physical and social conditions change through time. Assessment tools that aim to understand and measure vulnerability of communities in these regions will need to be sensitive to the social processes and structures influencing adaptation capacity, whilst concomitantly, identifying critical geographic areas prone to risk from sea-level rise and storm surges.

A.1.2 Natural Ecosystems Network

The Natural Ecosystems Network is an integration of three main sectors: Marine, Freshwater and Terrestrial Biodiversity. In the following summary to identify briefly the research gaps in research we will refer to each sector.

Question1: What are the key issues (impacts, barriers, options) for adapting in the coastal zone for your sector?

For the marine sector the key issues are:

- **Sea level rise:** Rising seas are likely to cause accelerated erosion for many beaches around the Australian coastline. The switch from generally accreting beaches to a receding coastline is a key threshold for coastal management and is not well understood. Revegetation and better coastal management have reversed erosion where vegetation removal had made dunes unstable. Hard engineering and development on fore dunes coupled with rising sea level have resulted in erosion hotspots.
- **Responses to climate-induced erosion:** These include beach replenishment, dune protection and hardening, and progressive retreat. However, beach replenishment is costly and ongoing if the cause of erosion is not addressed, and longer-term solutions will be required.
- **Carbon storage:** Coastal ecosystems, including tidal marshes, mangroves and seagrasses, have the capacity to sequester and store large quantities of carbon in organic forms (e.g., plants, sediments), a process termed 'Blue Carbon'. Carbon enhancement initiatives for these

ecosystems can help stabilise them and so contribute to the resilience of coastal areas and to fisheries production.

- Impacts on fisheries: The impacts for the coastal fisheries, aquaculture and the coastal infrastructure are the changes in species distribution and abundance as a result of ocean warming; as well as extreme events such as floods.
- Providing a barrier: Coastal squeeze for littoral habitats – migration landward prevented by infrastructure.
- Having options: These need to mean having a coast-wide approach to balance between protection, planned retreat that is sensitive to habitat needs for landward movement.
- Making connections: The need for synergistic/connected impacts of land-use/freshwater/coastal ecosystems on the marine biodiversity such as:
 - links between fauna migration and ocean currents, and the effects that changes in currents due to climate change will have on fish distributions
 - impacts on the Great Barrier Reef from fertilizers and soil washed from the land may be exacerbated or reduced under climate change due to changes in the rainfall regime.
- Cumulative: These include Synergistic impacts of extreme events (e.g. co-incidence in time and space of increased sea level, high tides and freshwater flooding events).

For the freshwater sector the key issues are:

- Altered estuarine hydrodynamics.
- Salt water intrusion into coastal acquirers and freshwater wetlands.
- Sandwiching of coastal wetlands between rising sea level, and development.
- Urban/anthropogenic infrastructure.

All resulting in ecosystem change and potential loss together with services they provide and a reduction in the quality of life for coastal residents.

For terrestrial ecosystems the key issues are:

- Develop planning strategies and policy that recognise novel ecosystems, shifting climates and conservation paradigms in coastal habitats.
- Identify refugia and connectivity in coastal areas.
- Understand and predict, responses and vulnerability of coastal ecosystems such as mangroves.
- Understanding the influence of extreme events on coastal areas and measures to reduce them.
- Interactions between climate change and other stressors on coastal areas between terrestrial and marine biodiversity.
- Protect and increase more habitat and greater environmental diversity in coastal areas.
- Manage habitat to reduce threats and maintain resilience.
- Manage landscape-scale issues such as connectivity in coastal areas.

Overall issues are:

- Identify and prioritize measures and actions to increase resilience and reduce vulnerability in coastal ecosystems.
- Climate change impacts on coastal ecosystems and how will affect different sectors (infrastructure, agriculture, urban areas, water supply, etc.).
- Mitigation and adaptation measures in other sectors how will affect coastal ecosystems (emphasis in biodiversity)
- Measures and actions of climate change adaptation and mitigation on coastal areas to reduce impacts.

Question 2 Thinking about these issues, what are the key research questions that need to be addressed that would help support adaptation in the coastal zone?

For the marine sector, we may consider the knowledge gaps set out in the National Adaptation Research Plan for Marine Resources and Biodiversity, in particular:

- Priority Research Question 5.5: How can mitigation initiatives in marine environments, such as carbon sequestration in coastal or marine areas, contribute to adaptation outcomes? (medium priority)
- Priority Research Question 3.1: Which ecosystems and species of conservation priority most require adaptation management and supporting research, based on their status, value, vulnerability to climate change and the feasibility of adaptive responses? What adaptation management frameworks and tools will identify vulnerable species and habitats within ecosystems, and how can these approaches build adaptive capacity and/or resilience? [Since high latitudes and the tropics, coral reefs and coastal habitats including wetlands, are projected to be most affected by climate change impacts.]
- Priority Research Question 4.7: What are the most appropriate techniques for preserving beaches in the face of rising sea levels? (Medium priority)
- Where are the areas where the coastal squeeze will be most prevalent?
- Where are the restoration areas that might be used to manage ecosystems and biodiversity under climate change to promote adaptation?

For the freshwater sector:

- Predictive models of hydrological change.
- What are the limits of tolerance of vulnerable species or communities, or likely ecological response to changing hydrological, salinity and other parameters?
- What are the effects of these ecological responses on the ecosystem services provided by wetlands? How will the mechanisms to maintain functionality of aquatic ecosystems be affected? What will be the cost to society of allowing ecosystem services to be lost? The latter question is crucial – workshops held by the Marine Biodiversity Network in Phase 1 indicate many governments/councils are unaware or underestimate the “free” services natural systems provide.

For the terrestrial biodiversity sector:

- How can large-scale carbon mitigation initiatives, such as revegetation and forest related mitigation (e.g. mangroves), be designed to maximise biodiversity conservation benefits and to avoid adverse impacts on biodiversity?
- How will climate change interact with other key stressors such as fire, invasive species, salinity, disease, changes to water availability, grazing and clearing, and what are the integrated implications for coastal ecosystem structure and functioning?
- What conceptual models and long-term observation systems are needed to support the design, analysis and assessment of active adaptive management and policy experiments at regional and national scales in coastal areas under climate change?
- How will climate change interact with other key stressors such as increase sea level, fire, invasive species, salinity, disease, changes to water availability, grazing and clearing, and what are the integrated implications for coastal ecosystem structure and functioning?
- How can we better integrate conservation plans and actions across landscapes, incorporating marine and coastal protected area management, off-reserve conservation measures and other land and marine uses, to maximise biodiversity conservation benefits/outcomes under a changing climate? For example, when planning coastal infrastructure or habitat restoration

designed to protect coastal systems, to include consideration of how to simultaneously achieve positive biodiversity benefits for both the terrestrial and estuarine biodiversity.

Question 3: What 'tools' or aspects of a 'tool' might help support adaptation in the coastal zone for your sector?

Across the three sectors, the aspects of the Coastal Tool that will support adaptation in the coastal zone for the Natural Ecosystems sector include the capacity to do the following.

- Demonstrate the value of natural habitats as ecosystem engineers to protect coastal regions – providing a large scale view, and then a cost demonstration of loss of function.
- Show areas where recovery of degraded habitats might be enhanced, as trade-off for other lost areas.
- Focus on adaptation policy concerns how coastal and urban planning decisions could affect the capacity of aquaculture operations to relocate to more suitable locations.
- Support Spatial conservation planning to identify and implement adaptation measures on coastal areas.
- Linking and show the impacts of climate change on other sectors with natural ecosystems, to make better cost efficient informed decisions.
- Identify what are the costs and benefits of different climate change adaptation measures in vulnerable ecological communities and ecosystems.

A.1.3 Social Economic and Institutional Dimensions of Adaptation

Question1: What are the key issues (impacts, barriers, options) for adapting in the coastal zone for your sector?

Most climate change adaptation responses are mediated through social, economic and institutional processes. Hence, the key issues associated with the social, economic and institutional dimension of climate change adaptation are applicable across various domains, including vulnerable communities, managing natural ecosystems, and human settlements. However, these issues are often context specific. For example, a key economic issue affecting a common pool resource such as the Great Barrier Reef may be quite different to an economic issue that involves private property rights.

While the key issues may vary the dominant themes largely relate to:

- the capacity to adapt
- the incentives and disincentives to do so (including motivations and preferences)
- the institutional structures that impede or enhance adaptation.

Question 2 Thinking about these issues, what are the key research questions that need to be addressed that would help support adaptation in the coastal zone?

Notwithstanding various context specific research needs, there are three research questions that have broad applicability to many domains. These include:

- What institutional arrangements influence effective adaptation responses?
- What social processes are required to transition between various adaptation pathways over time?
- What capacities exist (and which are required) to enable effective adaptation planning and implementation?

Question 3: What 'tools' or aspects of a 'tool' might help support adaptation in the coastal zone for your sector?

Aspects of the Coastal Tools that will assist decision makers, communities of place, and communities of interest will include supporting the ability to:

- recognise and understand vulnerabilities
- chart preferred and plausible adaptation pathways (including specific techniques such as economic and institutional instruments)
- recognise tipping points and implement transition mechanisms towards appropriate adaption solutions
- develop the capacities required for effective adaptation (including social, human, financial, built and environmental capital)
- assess the efficacy of various adaptation actions (i.e. monitoring and evaluation)
- undertake effective community engagement and ongoing learning.

A.1.4 Australian Climate Change Adaptation Research Network for Settlements and Infrastructure

Question 1: What are the key issues (impacts, barriers, options) for adapting in the coastal zone for your sector?

For the settlements and infrastructure sector there are several key issues that, although common to other sectors, pose specific challenges for the built environment through direct impacts of sea level rise and associated implications for planning for this sector. Despite much knowledge there remains lack of fundamental understanding of key coastal processes which is a barrier to effective adaptation decision making. We list these key issues below

- **Uncertainty:** We are uncertain of the timing and scale of impacts—such as changes in beach width and sand volume—that will impact the coast/shorelines with long term changing climate. What will be the relative importance of Sea level rise (SLR) and wave climate changes?
- **State of knowledge:** Sea level rise is well documented with much discussion over the interpretation BUT knowledge is high. In contrast the state of knowledge on possible wave climate changes is poor: there is low reliability in projections for magnitude and rates of change.
- **Knowledge about time and scale of impacts and associated response:** How and when will the changes become significant and adversely impact coast/shorelines? How will coast/shorelines respond? When will the changes/impacts take us out of our comfort zone – when will the changes require new adaptation approaches?
- **Lack of data:** Baseline and event data is necessary to benchmark and test ability of numerical models for short term beach erosion, medium term beach recovery and longer term climate change response (sea level rise and wave climate). There is a lack of baseline and monitoring data on bathymetry, extreme wave climate, extreme water levels, geomorphology etc. as an indication of medium and long term likely changes is limited for dealing with climate change adaptation. Still needed is baseline and extended monitoring data /information.
- **Confidence in models:** Confidence in models is needed for acceptance in coastal management and adaptive planning, for instance, forecasting of beach erosion (changes in beach width and sand buffer volume over days) with approaching storm event; predictions of beach recovery (width and volumes over weeks to months to years in extreme events), assessment of sand

nourishment placements as to effectiveness in providing beach width and volumes over short to medium term. All the above required as a base for any expectation of model ability to provide robust projections of beach /shoreline response to climate changes in SLR and wave climate.

- Capacity of existing infrastructure: A barrier to effective adaptation is the capacity of existing infrastructure (public and private) to withstand future extremes. There is a significant amount of existing key infrastructure that is already beyond capacity for present extreme events. High value coastal infrastructure and lands are and/or will rely on sand nourishment and seawalls. More effective use of such practices needs higher understanding of the physical aspects as well as the environmental/ecological impacts.
- Clear hazard or vulnerability lines: A key aspect of CZMPs is the delineation of hazard and/or vulnerability lines – projected shoreline positions in time for defined extreme events. In assessing these lines key components include short term storm erosion, longer term allowances for sediment imbalance (usually erosion deficiency but can in some locations be accretionary), longer term erosion due to climate change (frequently the simple semi-empirical “Bruun rule” is used to allow for loss of shoreline with sea level rise), a zone of reduced foundation stability and estimations of extreme water levels including tide, storm surge, wave setup and wave runup. All components presently have simplistic approaches – all components can benefit individually from advanced research BUT importantly an understanding of the interactions of the components and best practice for a probabilistic/risk based approach to the combinations of the components is needed.

For the settlements and infrastructure sector there are also a number of key issues which overlap strongly with the social, economic and institutional dimensions. These include the following list.

- Determining tradeoffs – impacts on current and future generations: A key issue is the unavoidable reality that improving our future resilience requires society to incur costs today in return for benefits which occur largely in the future. While it is clear that as a society our past decisions shape our present, there is very little established public policy enabling management practices (adaptation) which is oriented to 50 or 100 years into the future. The notion required by adaptation that current generations should bear costs to improve the well-being of future generations is not yet accepted, in fact if you are to look at the current state of most Australian Government budgets there are structural deficits which indicate that the opposite is in fact true that society holds a position that future generations should be willing to bear the costs of benefits enjoyed by present generations. Guidance on minimum planning periods and acceptable/tolerable risk for different levels of development around Australia would be a valuable step forward. An accepted and robust methodology for inclusion of probability of shoreline change over time in economic, social and environmental decision making analysis would be of equal value.
- More balanced tools for economic evaluation: Considerations of social, cultural, environmental and ecosystem values in decision making which is dominated by economic evaluation (most frequently Cost Benefit Analysis CBA) remains a barrier to effective longer term adaptation.
- Clear direction for state level policy: State governments changing policies on coastal management, land use planning and climate change create confusion in the community and loss of consistency in decision making. We need to understand how best to balance over time the implementation of short term solutions (‘protect our house now’) leading to longer term options (such as ‘retreat in a generation or two’). How do we engage more effectively with the community to influence political decision making?

- Lack of guidance and support to local government: For effective implementation of Coastal Zone Management Plans (CZMPs), local governments need CZMPs to have statutory authority for inclusion in land use planning. Clear guidance to local government of the process (hazard identification, risk and vulnerability assessment, coastal management and adaptation options, funding and finance assessment and community consultation) is needed with local government provided with legal indemnity.

Question 2: Thinking about these issues, what are the key research questions that need to be addressed that would help support adaptation in the coastal zone?

We outline the key research questions to support adaptation in the coastal zone and also make some suggestions about research projects to address these questions.

- Improved approaches for determination of hazard vulnerability lines: currently all components in the determination of hazard and/or vulnerability lines have simplistic approaches. All components can benefit individually from advanced research such as the magnitudes and rates of erosion and recovery and extreme water levels over varying time scales.
- Review of the Bruun rule: It is important to review of the application of the simple Bruun rule for coastline retreat with rising sea levels to ensure it better accounts for the complexity of the coast. The present application of the Bruun rule ignores possible onshore migration of sand from offshore with SLR. This requires basic and demanding research – we suggest a detailed sub bottom analysis from beachface to closure depth off two east coast beaches be carried out utilising vibro coring and sediment sampling (similar to that undertaken at Tuncurry NSW). This includes dating of material in transit being compared to that which has been in place since the 100m plus Post Glacial rise which ended 6000-7000 years ago. Sites off the Gold Coast or Casuarina and mid coast NSW (Old Bar) are suggested as providing contrast. Such a study will set the scene for high quality understanding and provide basis for ongoing necessary research of sediment compartment dynamics. Early findings from laboratory modeling under a new ARC project should be incorporated.
- Review of approaches for shoreline hazards: The extent of Reduced Foundation Zone, developed as a component of shoreline hazard assessment in NSW is now applied in almost all states. It is generally accepted as being conservative and consistent with observation for back beach primary dune heights of 5 to 6 m whilst for higher dune systems the allowance is overly conservative. A research review project by an experienced Coastal engineer/researcher in collaboration with an experienced Geotechnical engineer/researcher should evaluate the existing method and advise if an alternative approach can be developed.
- Identify best practice for a probabilistic approach: Importantly an understanding of the interactions of the components, and best practice for, a probabilistic/risk based approach to the combinations of the components is needed – review and further development of the probabilistic approach reported by Water Research Laboratory (WRL UNSW) for Avoca and Casuarina in NSW. Additional case studies for other representative locations can follow for inclusion in the “tool”. This should incorporate knowledge from areas with significant data (Collaroy/Narrabeen and Gold Coast) to support process understanding in other locations?
- Testing of models for sand nourishment: Sand nourishment is likely to be implemented more frequently in providing protection (sand buffer against erosion arising from sea level rise and

climate change and preserving beach amenity (perhaps in conjunction with seawalls). For sand nourishment the optimum placement of the sand volumes across the beach profile (from the upper visible beach to nearshore underwater depths up to 10m) needs application of robust models that require field data verification. Testing of available models for application to sand nourishment performance is needed. Such research will rely on the collation and availability of beach change data (preferably for sand nourishment projects but usefully also defined erosion and recovery related to extreme storm events). Guidance on the assessment of environmental/ecological impacts at sand source and placement locations is needed.

- Research on replacement and local impacts of sea walls: Research is needed to provide advice as to if existing seawalls be retrofitted for climate change and if so what is best practice and optimum cost effective timing for upgrade? Guidance on the assessment of environmental and ecological impacts of seawalls on site and the wider beach is needed. The local impact of seawalls on the immediate beach amenity and adjacent shorelines needs quantification.
- Identify methodologies to estimate extreme water levels for design and planning with inclusion of climate change: Extreme water levels within estuaries affect many more properties and infrastructure than erosion of open coasts. Extreme water levels arise from complex interactions of tide, storm surge (barometric and wind), waves (setup and runup) and catchment rainfall/runoff – all components operating at different time scales and with varying degrees of inter-dependence.
- Assess the relative importance of economic, social, cultural, environmental and ecological values in adaptive decision making is needed to enunciate the roles of Cost Benefit Analysis (CBA) and Multi-Criteria Decision analysis (MCDA). Guidance in application of values assessment and innovative approaches to finance and funding of coastal adaptation options is required.
- Community engagement: How do we engage more effectively with the community to influence political decision making? Mechanisms for public debate requires attention to media policy, many coastal communities are poorly served by traditional mass media however new media is increasingly providing new opportunities, the challenge with harnessing the potential for new media is the propensity for hostile interactions and the resultant isolation of ideas and interests rather than productive and constructive public deliberation. We also need to better understand the responses of individuals to loss of asset and inter-generational transition to a climate challenged future.
- What are the most effective tools for local government? A compilation research study is needed to update earlier work funded under NCCARF phase 1.

Question 3: What 'tools' or aspects of a 'tool' might help support adaptation in the coastal zone for your sector?

The Tool will act as a national coastal knowledge hub with links to publications and data sources and provide specific guidance for the settlements and infrastructure sector on the following issues.

- Minimum planning periods and acceptable/tolerable risk for different levels of coastal development and infrastructure around Australia
- Selection, capabilities and application of the various coastal process models.

- Updated probabilistic/risk based approach to determination of hazard/vulnerability for coastal adaptive management and planning.
- Guidance/knowledge on coastal adaptation options – update/enhancement of Engineers Australia National Committee of Coastal and Ocean Engineering (EA NCCOE) Guidelines.
- Guidance in application of values assessment and innovative approaches to finance and funding of coastal adaptation options
- An accepted and robust methodology for inclusion of probability of shoreline change over time in economic, social and environmental decision making analysis.
- An accepted and robust method for estimation of extreme water levels inclusive of the components of tide, surge, wave and catchment rainfall/runoff for application to open coasts and importantly estuaries.
- A number of good and bad practice case studies – including third pass hazard/vulnerability and adaptation options assessment.
- Community engagement guidelines

Appendix 2: Summary of relevant information in the *State-of-Play Report*

The *State-of-Play Report*, currently under preparation as part of the NCCARF Phase 2 deliverables, and due for submission on 1 April 2015, is designed to provide a detailed assessment of the existing science and regulatory framework in which the Coastal Tool will need to operate. The structure of the *State-of-Play Report* follows a basic adaptation framework as follows:

- **Establishing the context.** In this section we considered available physical data, climate projections, resources and stakeholders.
- **Analysing the problem and making decisions.** In this section we considered the available tools for decision-making and risk assessment.
- **Implementation, monitoring and evaluation.** In this section we looked at resources and examples of putting these tools into practice and at available resources and examples of monitoring and evaluation. We also looked at case studies of existing adaptation strategies and plans.

Establishing the context

A national investment means decision-makers have access to the latest climate change scenarios developed specifically for Australia (see the Climate Change in Australia website, <http://www.climatechangeinaustralia.gov.au/en/>). In addition, decision makers are able to access downscaled projections for their area through state-based programs.

Sea-level rise mapping is available for the densely populated areas of the country through OzCoasts (www.ozcoasts.gov.au/climate/sd_visual.jsp):

- Sydney, NSW
- Hunter and Central Coast, NSW
- Adelaide, SA
- Melbourne, VIC
- South East Queensland (including Brisbane and the Gold Coast)
- Perth to south of Mandurah, WA.

Some states and regional or local bodies have invested in modelling the risks of sea level rise, storm tide surge and inundation in their locality— although the coverage and inclusion of storm tide modelling is patchy.

Other physical data includes:

- National digital elevation information – NEDF (Geoscience Australia)
- Digital elevation (LIDAR) data for some regions
- National classification maps of coastal landforms – Smartline Coastal Geomorphic Map of Australia; as well as coastal landforms and sediment movement – Coastal Sediment Compartment Model;
- National intertidal/benthic habitat maps;
- Studies of the impact of climate change on individual species and habitats, and their vulnerability to these risks.

Information on the human environment is more difficult to gather and relies on methods of assessing vulnerability and adaptive capacity for which there is some guidance. Reliable indicators of adaptive capacity or examples of assessment of adaptive capacity are not well documented.

The role that the insurance industry might play in the future remains unclear, although there is some evidence of insurance markets influencing policy and adaptation action in Australia. Whether there is a market to insure against some risks (e.g. gradual sea level rise) remains unclear. The role of the insurance sector is likely to evolve over time rather than reveal itself through research.

There are a number of recent, comprehensive treatments of the legal liability and issues associated with climate change. This produces, however, an inherent level of uncertainty around legal risk as any individual decision is open to be tested in the courts and will build the precedence for decisions. Despite this, there is now available some good information that can guide local government actions. There is some commentary on the role that legislation might play in providing indemnity for decision-making and this is an area the states are likely to consider in policy and planning system review.

A review of state jurisdictional planning and policy frameworks (excluding the non-coastal ACT) reveals that each state has taken its own, diverse path and there is considerable distinction between the approaches of each state. In common, in all states except the Northern Territory, local councils have responsibility for development planning decisions, with differing levels of state legislative, policy and knowledge based guidance. Individual states have introduced legislation specifically dealing with coastal management, and some with climate change directly. At the local scale, individual councils have undertaken risk assessments, vulnerability assessments and even developed adaptation strategies, while other have not yet considered climate change in long term planning. In NSW, SA and Tasmania there have been state initiated processes to build these processes at the local and regional level. The Australian Government has no direct legislative power over coastal management and planning, but is an important source of funding, information, data and resources, as well as a significant landowner.

Analysing the problem and making decisions

While no single resource focuses solely on the context setting or ‘stocktake’ stage of adaptation planning, several guidelines and frameworks include some guidance for undertaking this initial planning step. In most cases, there is considerable emphasis on the need for early and ongoing engagement with stakeholders and to identify the ‘objective’ or vision of the plan. These objectives will largely depend on the perspective of stakeholders and may range from economic to ecosystem outcomes. A number of tools and guidelines exist to support the engagement of stakeholders including communication tools and visualisation tools.

There are a number of guidelines available for assessing risk and/or vulnerability to climate change. A reasonable number of councils have undertaken the Australian/NZ Standard ISO 31000:2009 risk assessment process. Guidelines exist specifically for assessing coastal hazards and specific climate related risks or specific sectors. There are also a number of published risk assessments that provide useful case studies of the process undertaken by other decision makers.

Specific guidelines of potential adaptation actions have also been developed to guide local government in considering their options. Engineers Australia has provided guidance particularly on engineering solutions. There are also a number of worked examples of adaptation options that have been analysed for specific case studies.

While decision-support tools and decision-making frameworks are designed to help manage the uncertainty inherent in climate change adaptation decision-making, the variety of approaches and large number of tools available make this a difficult space to explore. Several commentators have undertaken reviews and provided guidance on choosing a decision-making framework. There is also an emerging suite of tools and frameworks developed specifically for considering coastal hazards under climate change.

Implementation, monitoring and evaluation

The implementation stage of the planning process seems to be the most poorly documented and studied. The guidelines developed by Engineers Australia acknowledge the integrative nature of implementing adaptation plans and the need to balance intervention and planning. Implementation of

actions will be determined by a number of factors including council resourcing. Fletcher et al. (2013) undertook a cost benefit analysis for different types of coastal communities which is likely to be useful for identifying the appropriateness of individual adaptation options.

There are few examples of monitoring and evaluation frameworks that will be appropriate for local government adaptation processes. The Sydney Coastal Council Group have developed a guide for monitoring and evaluating climate change adaptation strategies and practices of local government in coastal areas. Beyond this, most monitoring and evaluation frameworks are largely targeted at national or larger scale programs.

Case studies

There are quite a number of coastal local councils in Australia that have undertaken an Adaptation planning process, and a number of these are identified and summarised by the Western Australia Local Government Association (WALGA) and NCCARF. There is a range of approaches and diversity of stages of the process for individual councils. NCCARF, in its *Good Practice Project* found that most case studies were still at the planning or decision-making process, with limited implementation and no clear examples of monitoring and evaluation. International case studies demonstrate national and state approaches, including through a legislative process (the UK) that includes a monitoring and evaluation process and policy approaches (California). There is considerable case study material available although few comparative analyses of the approaches, processes and success or otherwise of these case studies.

Existing climate adaptation planning and decision making frameworks

In the *State-of-Play Report*, we profile fourteen adaptation planning and decision making frameworks from Australia and overseas. Of these six specifically look at coastal issues. Most share a common underlying adaptation planning process: establishing the context and objectives, analysing the problem and identifying options, making decisions, implementing, monitoring and evaluating. Most are iterative and circular in recognition of the need for flexibility and adaptive management. Most are delivered in a document format. The UKCIP does provide an online wizard which helps collate the planner's thoughts and resource during the process (www.ukcip.org.uk/wizard/). To assist with monitoring and evaluation, the online tool *AdaptME* is also provided. The Western Australian Local Government Association has developed a climate change management toolkit that provides support information targeted at individual decision maker level (e.g. elected member, executive officer, community member) and for individual geographical regions.

Appendix 3: High priority research questions identified in the National Adaptation Research Plans from NCCARF Phase 1

A.3.1 Settlements and Infrastructure

Urban planning and management

- How can existing urban planning principles and practices accommodate climate change and the uncertainty of climate change impacts? How should these principles and practices differ, based on the location and spatial scale of the settlement? What can we learn about the adaptive capacity of settlements from responses to stresses in the past?
- How can planning approaches address the multiple objectives of urban adaptation to climate change impacts, mitigation of greenhouse gas emissions and biodiversity conservation?
- How can the governance of urban planning in Australia, including formal and informal rules, nationally consistent approaches and guidelines, and locally driven standards and outcomes, and the institutions responsible for decision-making, be improved to facilitate planning processes and outcomes which incorporate adaptation to climate change?
- What are the particular planning needs of remote and Indigenous settlements under a changing climate?
- What information about urban and regional planning and climate change impacts, in what form and at what resolution, should be publicly available? How should climate change impacts and adaptation information be presented and made available to urban and regional planning decision-makers?

Built environment

- What are the design options and principles for adapting new buildings to climate change in different locations and how can these be implemented?
- What are the design options and principles for adapting existing buildings to climate change in different locations and how can these be implemented?
- What are the full life-cycle costs and benefits of adapting the built environment and how can they be reliably estimated? Who will bear these costs and who will benefit? What financial and other policy instruments can be used to address equity impacts of these costs?

Vulnerable coastal communities

- How will demographic pressures and changes in different Australian coastal settlement types affect (1) potential impacts of extreme and gradual climate change, and (2) current policy and regulatory settings which govern the decision-making by government agencies, businesses and individuals? How will planning for coastal climate change impacts respond to local circumstances?
- How do coastal communities perceive coastal vulnerability in different settlements and to what extent is that influencing adaptive capacity now and likely to influence it in the future under scenarios of climate change?
- How well do we understand the relationship between climate and coastal processes? How can methods currently used to determine the physical risk on a regional basis of extreme inundation and coastal erosion from climatic and oceanic processes, either singularly or in combination, be improved and new methods developed and applied?

Infrastructure

- What is the vulnerability of infrastructure (individual and interlinked critical sectors) to existing and predicted climate change conditions at various spatial scales, considering average and extreme weather conditions? How can climate-induced service or structural failure thresholds for infrastructure and services be identified in light of the inherent uncertainty in climate projections?
- What impacts on key infrastructure may have downstream or cascading impacts during extreme climate events, and how might these impacts be avoided?

- What design standards (ARI and/or AEP) and planning periods for the various infrastructure components should be adopted for particular locations and over what time-frames?

Cross-cutting issues

- What sectors of society are most vulnerable and least able to adapt to climate change in urban, regional and remote settlements? What is the nature of those vulnerabilities and the barriers to adaptation? How can physical, social, economic and institutional factors reduce their vulnerability and increase their adaptive capacity? At what spatial and temporal scales should adaptation responses for vulnerable communities be developed?
- To what extent can geological/geomorphic/historical/traditional/local knowledge be best applied to assessing vulnerability of existing settlements under different climate change scenarios?
- How can communication of climate change impacts and uncertainties be improved and communities be engaged in adaptive responses for settlements and infrastructure?

A.3.2 Terrestrial Ecosystems

National- / continental scale issues

- How will climate change affect existing conservation goals and how should changed conservation goals be promoted and achieved?
- How can the existing Australian legal, policy and institutional architecture for land management and biodiversity conservation respond to changes in conservation goals caused by climate change?
- What conceptual models and long-term observation systems are needed to support the design, analysis and assessment of active adaptive management and policy experiments at regional and national scales under climate change?

Regional issues

- What principles should guide ecosystem-based adaptation in Australia and the design of landscapes to support ecosystem resilience?
- How will climate change interact with other key stressors such as fire, invasive species, salinity, disease, changes to water availability, grazing and clearing, and what are the integrated implications for ecosystem structure and functioning?
- How can Australia's land-based carbon mitigation initiatives be designed to enhance ecosystem services, ensure appropriate ecological connectivity, deliver biodiversity conservation benefits and avoid adverse impacts on biodiversity?
- How can the major socio-economic trends occurring in many regions of Australia contribute to effective climate change biodiversity adaptation responses?

Local land management issues

- What are the costs and benefits of different climate change adaptation measures in vulnerable ecological communities and ecosystems?
- How should fire management adapt to climate change?
- How can management of local protected areas incorporate and adapt to climate change?
- How can we better integrate conservation plans and actions across landscapes, incorporating protected area management, off-reserve conservation measures and other land uses, in order to maximise biodiversity conservation benefits / outcomes under a changing climate?

Managing key species and communities

- How can investment in climate change adaptation measures to conserve species and communities be prioritised?
- How will climate change affect current management actions for protecting priority species and communities, and what management changes will be required?

- How will climate change affect current or potential problem species and what management responses will be required?

A.3.3 Marine Ecosystems

Aquaculture

- What are the likely policy changes driven by climate change that will affect aquaculture businesses either directly through changes in access to suitable locations, and natural resources such as freshwater or marine based feeds or indirectly because of changes in harvest marine policies, affecting feed supplies or non marine climate adaptation and mitigation policies?
- What options are there for businesses to adapt to climate change effects either by minimising adverse impacts or taking advantage of opportunities? What are the facilitators and barriers to implementing such changes and how might they be managed for effective adaptation outcomes?

Commercial and recreational fishing

- What options or opportunities are there for commercial fishers in identified vulnerable fisheries to adapt to climate change effects through changing target species, capture methods and management regime, or industry diversification, relocation or divestment? What are the enablers and barriers to fishers implementing adaptation options?
- What options or opportunities exist or might become available for recreational fishers in identified vulnerable fisheries to adapt to climate change effects through changing target species or preferred fishing method or travelling to pursue their preferred target species or method? What are the enablers and barriers to fishers implementing adaptation options?
- How have enablers to adaptation been used and barriers to adaptation been overcome? What significant changes in fisheries have occurred before because of extrinsic factors and what can be learned from those changes that will inform adaptation to climate change?

Conservation management

- Which ecosystems and species of conservation priority most require adaptation management and supporting research, based on their status, value, vulnerability to climate change and the feasibility of adaptive responses? What adaptation management frameworks and tools will identify vulnerable species and habitats within ecosystems, and how can these approaches build adaptive capacity and/ or resilience?
- How should conservation managers and planners adapt their practices to alleviate climate change risks and enhance adaptation options? What intervention strategies will increase system resilience and increase the time within which biological systems are given the opportunity to adjust to a future climate?

Tourism and recreational uses

- What is the adaptive capacity of the marine tourism industry and how can it be enhanced to cope with climate change impacts?

Cross-cutting issues

- What are the key interactions across sectors, cumulative impacts and cross-jurisdictional issues that will affect the development of adaptation strategies in each sector and how can these cross- and multi-sectoral issues best be addressed?
- What are the most appropriate techniques for preserving estuarine systems in the face of climate change?
- How can land-based climate change adaptation decisions be developed and implemented to also support adaptation for marine water quality and marine resources and biodiversity, including aquaculture, fisheries, conservation and tourism, taking account of multiple stressors, the cumulative pressures of co-occurring factors and flow-on effects for industries and ecosystem health?

A.3.4 Freshwater ecosystems

Incorporate climate change adaptation into management of freshwater species and ecosystems

- What management options will conserve freshwater species and ecosystems that are currently at or near their climate limits?
- What attributes will enable freshwater species to adapt and ecosystems to successfully change autonomously in response to climate change?
- How will climate change alter current freshwater biodiversity management effectiveness, and what management changes will be required, including for poorly understood species and ecosystems?

Identify climate change adaptation options for Australia’s freshwater biodiversity refugia

- How can the climate resilience of freshwater biodiversity refugia be increased?
- What changes to Australia’s conservation reserve system are required to improve protection of current and projected climate refugia and to support connectivity for freshwater biodiversity?
- What adaptation options will facilitate the type and level of connectivity and dispersal required under climate change impacts?

Understand climate change adaptation interactions between freshwater biodiversity and other sectors

- How will climate change impacts on other sectors affect existing stressors on freshwater biodiversity?
- How can current non-climate stressors on freshwater biodiversity be managed or reduced to minimise the synergistic effects of climate and non-climate stressors?
- What integrated climate change adaptation response plans at the local, landscape, catchment and regional scales will build the resilience of freshwater biodiversity, and also terrestrial biodiversity, primary industries, water resources, and associated communities and industries?

Understand the role of environmental policies in protecting freshwater biodiversity under changing climate conditions

- How will climate change affect existing conservation goals, policies and programs for freshwater biodiversity, including meeting Australia’s international obligations?

Cross-cutting theme – ensure that adaptation initiatives for freshwater biodiversity and other sectors are mutually supportive and integrated where appropriate

- What climate change adaptation and mitigation actions taken in other sectors will benefit freshwater biodiversity?

A.3.5 Social economic and institutional dimensions of adaptation

Understanding vulnerability and adaptive capacity

- The development and application of methods for assessing vulnerability and adaptive capacity that engage and harness the knowledge and skills of individuals, households, communities, businesses, industries and governments.
- Identification of the capacity of individuals, households, communities, businesses, industries and governments to adapt to climate change, and of options to enhance this capacity.
- Understanding the equity dimensions of current and future vulnerability and adaptation, including: a. the issues for specific population groups who have particular vulnerabilities and limited capacity to adapt by virtue of their socio-economic status, skills, livelihood, cultural or linguistic background, or other characteristics such as age; b. understanding the interaction between existing stressors and climate change, and the implications of this interaction for vulnerability and adaptive capacity.
- Understanding and overcoming the barriers and limits to adaptation
- Understanding the cognitive and affective dimensions of adaptation, including: a. the knowledge, perceptions and emotional responses of people and groups regarding climate risks; b. the time horizons

of people and groups who make decisions about adaptation; c. the degree to which people and groups feel empowered to adapt.

- Understanding enablers and barriers to collective action, including: a. how shared symbols, beliefs and practices enable or constrain adaptation; b. how economic factors, including distribution of capital and investment, enable or constrain adaptation; c. how social practices and opportunities enable or constrain adaptation; d. how the distribution of power in decision-making enables or constrains adaptation; e. what differing types of decision-makers consider to be the goals of adaptation (e.g., what defines ‘successful’ adaptation in their eyes); f. what and how differing types of decision-makers know about the vulnerability of others.

Measures to value adaptation.

- Understanding how to assess and value adaptations to climate change, including the value of opportunity costs, avoided damages, residual impacts, and benefits gained. This may involve: a. reviewing and determining the suite of assessment and valuation methodologies that are most appropriate for use by Australian adaptation policy-makers and decision-makers; b. identifying the limits to the use of these methodologies; c. testing the identified methodologies; c. testing the identified methodologies against relevant current policy in Australia.
- Understanding governance, institutions and decision-making
- Analysis of existing responses from public and private institutions to climate change risks, and assessment of proposals to improve the effectiveness, efficiency and equity of future responses, including: a. analysis of responses in the public, private and third (civil society) sectors; b. analysis of the distribution of roles, responsibilities and capacities of different levels of government and cross-jurisdictional bodies.
- Understanding how laws and legal institutions, including regulatory instruments, support or impede adaptation planning and practice, and identifying reforms needed to reduce obstacles.
- Assessing the potential for, and limits to, market-based adaptation measures, including insurance markets.

A.3.6 Human health

Human health

Heat

- Which categories of people are most vulnerable to short-term extremes of heat?
- Do levels of understanding of the nature of the risks, and personal / household-level ways of ameliorating them, vary between these population subgroups?
- Are changes needed to public health policy in order to manage heat wave impacts?
- Do early warning systems (EWSs) for heat waves and other extreme weather events reduce adverse health impacts?
- Which types of EWS are most effective and for what locations?
- Are current occupational health and safety standards in relation to climate change-induced health risks (e.g., extremes of workplace heat exposure) adequate? What are the potential impacts of short-term extreme weather events?
- Does public education about the risks of short-duration extreme events, and their avoidability, alter people’s knowledge and behaviour?

Vector-borne disease (VBD)

- What are the future increased risks of arbovirus diseases arising from climate change?
 - Does climate-driven predictive modelling of any particular vector-borne infectious disease outbreak reduce the occurrence of such outbreaks?
 - How would existing public health systems cope with increased levels of vector-borne disease infections?

- Can meteorological forecasts of impending seasonal weather conditions provide useful advance warning of altered risks of vector-borne infectious disease outbreaks? Does such usefulness differ between human-only and zoonotic VBDs?
- Are such forecasts enhanced by the inclusion of information about changes in environmental indicators (e.g., surface water, vegetation levels, etc)?
- Will the implementation of such early warning systems result in reductions in outbreaks or infection rates?

Food, air and water quality

- Where will the likely climate change impacts on food safety and quality be observed, and what measures / practices can be implemented to reduce the risk of food-borne disease outbreaks?
- How can the effects of climate change on air quality and aeroallergens be addressed?
- How can water security be ensured in the management of climate change impacts and what is the role of the existing water authorities?

Mental health

- What interventions are required to minimise the potential harmful mental health effects of natural disasters (such as drought, windstorms or floods)?

Community Health

- Which types of intervention most effectively increase the level of community resilience?
 - What key characteristics of Indigenous, rural and urban communities determine their level of resilience to the stress of long-term changes in climatic and environmental conditions?
- How might climate change and climatic extremes affect aspects of Indigenous culture and living conditions that affect health?

Health services and infrastructure

- Are health care and public health (health protection) systems adequately structured, staffed and resourced to handle increased demands from (i) extreme weather events and (ii) climate-related outbreaks of infectious diseases?
- What improvements are needed, feasible and effective?
- What policies/ service guidelines and models of integrating the entire health sector's adaptive responses best support the coordination of adaptive activities?
- What models of linkage and knowledge exchange between climate change researchers and policy-makers best provide relevant decision support in planning health sector responses
- What role should the primary health care sector play as part of a broader public health adaptive response to climate change?
- What forms of in-career training of health care and related professionals best prepare them to identify and respond to climate-related health impacts?
- What integrated responses are required between the health, transport, water, energy and other service provider sectors, including NGOs, to minimise impacts on vulnerable individuals during extreme heat events and other extreme events?

A.3.7 Emergency management

Understanding risk

- Where and how are changes in climate going to put us at greatest risk?
- What tools are needed to enable decision-making under future climate uncertainty?

Community and organisational resilience to disasters

- What does community resilience mean in a changing climate?

- What practices and processes promote community preparedness and preventive strategies in a changing climate?
- What are the most effective strategies to ensure that individuals, governments and the private sector adopt better practices in preparing for the increased risk of extremes to communities, business operations or critical infrastructure arising from climate change?

Adaptive strategies

- How will climate change affect the emergency management sector's capacity to support preparedness, response and recovery?
- What is the role of the private sector in adaptation through emergency management?

Regional implications

- How will climate change affect the capacity of emergency management systems in Australia and the Pacific region to interact for mutual benefit and support? How can these systems best support adaptation?

A.3.8 Indigenous communities

- Understanding how interactions between social, cultural, institutional, economic and biophysical processes make Indigenous individuals, households, communities, businesses and institutions sensitive to climate risks, and the identification and evaluation of strategies to reduce this sensitivity.
- Understanding how and why different Indigenous households, communities, businesses and institutions are vulnerable to the impacts of climate change, and the identification of strategies to reduce this vulnerability.
- Understanding the capacity of Indigenous individuals, households, businesses and institutions to adapt to climate change, and the identification of strategies to enhance this capacity.
- Understanding the capacity of Indigenous individuals, households, communities and institutions to prepare for, respond to, and recover from extreme weather events, and the identification of strategies to enhance adaptive capacity.
- Understanding the relationship between Indigenous population movement and severe climate variation.
- Understanding how the use of marine, terrestrial and freshwater biodiversity resources by Indigenous peoples and groups will be affected by climate change.