Regional Climate Change Adaptation Plan for the Eyre Peninsula

February 2014

EPICCA
Eyre Peninsula Integrated Climate Change Agreement

Prepared for EPICCA by
Mark Siebentritt, Nicole Halsey and Mark Stafford Smith

Acknowledgements

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Preface

The Eyre Peninsula Climate Change Agreement Committee (EPICCA) is a partnership between the Eyre Peninsula Natural Resource Management Board, Regional Development Australia Whyalla and Eyre Peninsula Board, Eyre Peninsula Local Government Association and the South Australian Government.

We are pleased to present the first Eyre Peninsula Regional Adaptation Plan. This was not intended to provide us with a small-focus, 'nuts and bolts' plan. Rather, it delivers a practical benchmark-planning process for decision-makers, peak bodies and leaders in our communities to begin the process of addressing the climate challenges that science tells us we are facing.

While it will always be the role of each sector, industry and, indeed, individuals, to take ultimate responsibility for their detailed adaptation and risk management planning, EPICCA's role is to facilitate a coordinated and cross-sectoral approach, with the goal of ensuring that best practice leads to optimal and timely outcomes at a whole-of-region level.

This Plan is innovative: it was developed by trialling new engagement methods and a new approach to adaptation planning that is user-focused and resource-efficient. We have successfully explored the process of ***targeted stakeholder engagement***, introduced the concept of ***decision timelines*** and trialled a unique ***applied adaptation pathways model*** for the Eyre Peninsula.

We know our communities have diverse resources and many natural advantages, but we need to understand and be ready for change. The release of the Working Group I report of the 5th Assessment of the Intergovernmental Panel on Climate Change (IPCC) in September 2013[1] was a timely reminder that the science of climate change is agreed by over 170 nations and more than 97% of scientists working in this field globally.

The Working Group One report confirms that current levels of emissions will result in a 2°C warming in less than three decades. It is also very likely, with continuing unabated emissions, that we will see increased global average temperatures in the range of 4°C by the end of the century. This is the science that informs and underpins the Plan.

Eyre Peninsula communities can expect to experience longer periods of much higher temperatures, increasing variability in rainfall patterns and rising sea levels. Changes to ocean currents, falling pH and higher storm surges are also likely.

We must be aware of change. Of opportunities that change may present and be prepared to respond to those drivers of change in a timely and practical way. At the same time we must realise that the changes we are talking about - driven by greenhouse gas accumulation in the Earth's atmosphere - are ongoing, and very long-term in nature.

Climate change adaptation and transformation are complex issues that affect every field of human and natural endeavour. However, if we focus on those long lifetime decisions and the requirements of the stakeholders who currently have responsibility for making them (in our case at a regional scale), and if we adopt an ***adaptation pathways*** approach, (that is apply the latest science and best knowledge available to achieve progressive, staged decision-making) we can keep the broadest range of options open and build a responsive pathway that will follow changing circumstances over time. In our view, this will be the region's best response, and deliver its best long-term outcomes.

We are fortunate that we were able to incorporate ground-breaking international and Australian-based scientific work into this Plan. We acknowledge the invaluable contribution of the CSIRO Climate Change Adaptation Flagship to this project over a lengthy period and highlight four seminal papers: *Rethinking Adaptation for a 4°C World* [2], *Reconceptualising Adaptation to Climate Change as Part of Pathways of Change and Response*[3], *Dynamic Adaptive Policy Pathways: A Method for Crafting Robust Decisions for a Deeply Uncertain World*[4], *and Exploring Pathways for Sustainable Water Management in River Deltas in A Changing Environment*[5].

I would also like to acknowledge the work of Dr Mark Siebentritt, Nicole Halsey and Dr Mark Stafford-Smith, in leading us through this project, Cecilia Woolford for her facilitation of the project and wise counsel throughout, and the many community members who actively participated over an eight month period.

The work presented in this Plan has just begun. Refinement and experience will guide its adoption as we face adaptation and transformative change and challenges, but this is only part of the picture, because, through necessity and out of concern for future generations, including our own grandchildren, we will need to embark on a programme that leads us to a strong, diverse, low carbon regional economy in the foreseeable future.

Mr Brian Foster

Independent Chair
EPICCA

Executive summary

The Eyre Peninsula is a vibrant region, supported by a diverse economy underpinned by traditional industries like farming and fishing and emerging sectors like tourism and mining. It has an abundance of natural assets on the land and in the sea and a community that is engaged and motivated to plan for a sustainable future.

The region has been proactively planning for climate change for nearly a decade through supporting research projects and industry and community work into climate change impacts and potential adaptation options.

This Regional Climate Change Adaptation Plan is the next step in preparing for climate change on the Eyre Peninsula. It has been developed by the Eyre Peninsula Integrated Climate Change Agreement Committee (EPICCA) who adopted an innovative approach through the use of adaptation pathways analysis. The Plan is the product of a regional community engaged in practical thinking about how it can respond to the future impacts of climate change, considering how individual sector actions interact to deliver regional priorities.

Climate change will impact the Eyre Peninsula by leading to warmer and most likely drier conditions on the land. Rising sea levels will impact the coast and rising temperatures and acidity will occur in the Great Southern Ocean and Spencer Gulf. In responding to these changes, there will be 'adaptation tipping points', that is, some actions that will be viable to begin with will later become inadequate.

Agriculture will most likely experience a fall in cropping yields as temperatures rise and rainfall declines, while fisheries will experience a change in the location of commercial species, with some becoming more abundant and other less. Changing levels of production of the region's primary industries may not necessarily translate to economic decline, which will also be influenced by the costs of doing business, that is, changing input costs and output prices.

The challenges for Local Government will be numerous, requiring attention to development in coastal areas, expansion of peri-urban areas into bush fire prone zones and maintenance of essential transport services, especially roads.

For natural resource managers, the focus will be on water resources management and biodiversity conservation, both of which will be impacted by declining rainfall and projected increased temperatures.

The adaptation pathways analysis focussed on eight issues and areas of decision making (described in italics below). These were then considered in a regional context to explore interactions and issues that are not captured at the sector level. The outcomes of the analysis were as follows:

Agriculture - *How and when can the farming sector transition to more viable agricultural practices in the face of warmer and drier conditions in areas that are currently marginal for cropping?*

Various agricultural practices that are considered leading edge will provide some measure of adaptation in the coming 10-20 years, however, long term adaptation may require more transformational responses such as adoption of advanced breeding techniques by that time, and earlier planning is needed for these options.

Conservation management - *How can ecological communities that are currently threatened be protected as species distributions change in response to a warmer and drier climate?*

In the short term greater emphasis needs to be placed on better forecasting of changing species distributions. Within the next one to two decades arrangements will need to be made for large scale refuges within the region and assisting plants and animals to move to more suitable habitat outside the region.

Fisheries – *How will the fisheries sector respond to changing distribution and abundance of wild catch commercial species and changed conditions for aquaculture as a result of increasing temperatures and acidity in Spencer Gulf and the Great Southern Ocean and changing ocean currents?*

Climate change will likely result in a mixture of both positive and negative impacts for the fisheries sector meaning that in the short term better stock assessment models will be required as well as an integrated approach to managing Spencer Gulf's marine resources. In the long term the location of the fishing fleet and infrastructure may need to be reassessed.

Maintenance of road infrastructure - *How will bitumen and unsealed roads respond to an increasing frequency of extreme events?*

In the short term a strategic transport plan is required to better manage the multiple demands on regional transport infrastructure such as roads. In the longer term greater design allowance needs to be made for increasing frequency of extreme events.

Management of coastal development - *How can communities manage existing and new developments in low-lying areas close to the coast?*

In the short term, planning, mapping and educational responses can be taken that will provide some measure of adaptation for coastal development to sea level rise, particularly in relation to preventing new development occurring in areas of known vulnerability. Within two to three decades, retreat and protection initiatives will be required for existing development. Although action may not be required in the short term, thinking and planning is required now given the complexity and cost of these types of adaptation options.

Peri-urban expansion - *How will Councils manage peri-urban expansion in close proximity to remnant vegetation that may come under increasing threat from bush fire?*

In the short term, enforcement of Section 104 (clean up) notices and education can reduce fire risk. In the longer term, there will be increasing demand to allow larger scale native vegetation clearance.

Port and wharf facilities - *How can port and wharf facilities be managed to provide the greatest resilience to future changes in sea levels and related impacts such as storm surge?*

A decision about the location of a new port and wharf facility for the Eyre Peninsula is expected within the next 10 years. It is vital that this consider potential impacts of future climate change, especially sea level rise and coastal inundation.

Water resources management - *How does the Eyre Peninsula maintain or increase the supply of potable water in major towns given future possible reduction in supply, either as a consequence of climate change induced rainfall decline or reduced availability from the Murray?*

Household demand management and increased stormwater harvesting are popular short term adaptation options. Within 10 years a major supply side option will be required such as extending a pipeline carrying Murray water into the region or investing in desalination.

Regional pathways

In the short term, regional scale adaptation will likely focus on continued adoption of current best practice within sectors, integrated strategic planning initiatives and revising development plan policy. In the medium and longer term, adaptation will require protect and retreat strategies and transformation of some sectors. At a regional scale, sectors need to consider interactions between major adaptation actions especially when they are occurring at the same time.

A learning from the engagement of regional leaders in the development of this plan is that future adaptation planning within individual sectors should be guided by an approach based on principles that seeks to build economic resilience; takes action that prepares the region rather than repairs infrastructure after impacts are experienced; takes joint responsibility across sectors; identifies long life time decisions and avoids cross sectoral maladaptation**.**

A key focus of this regional adaptation planning process has been to identify priority actions that affect multiple sectors or are of regional importance as well as those relevant to the sectors individually. It is anticipated that cross sectoral or regional priority actions will require significant coordination and collaboration to progress and being cross sectoral warrant elevation to enable action to occur.

In addition, this regional adaptation planning process has identified a range of priority actions that are relevant to individual sectors and it is anticipated that the sectors will undertake more detailed investigations, analysis and engagement to progress their implementation.

Priority actions for the region under this plan are as follows:

- **Adaptation responses are required that support multiple sectors** - Priority cross sectoral actions are the development of an Integrated Management Strategy for Spencer Gulf and a Regional Transport Infrastructure Plan. The Spencer Gulf Strategy aligns closely with regional economic development priorities for the State.
- **Commence preliminary work now for long timeframe actions** - Some adaptation options within sectors will need preliminary work to commence soon if the adaptation options are to be in place by the time they are required to adapt to future climate change impacts. For example, informing the location of ports is required now given that this infrastructure will be in place for at least 70-80 years. Also, while the need for genetically modified crops might not be for another two to three decades, work is required now to ensure sufficient community engagement and debate and development of a suitable regulatory framework.
- **Enabling conditions must be addressed** – The region must invest in maturing the enabling conditions for adaptation by further evolving the regional governance approach and training the next generation of industry and community leaders.

1 Introduction

The Eyre Peninsula in the western part of South Australia is home to unique ecosystems and diverse industries and communities underpinned by abundant natural and mineral resources. The region's economy is sustained primarily by farming and fishing with mining and tourism becoming increasingly important. Unique environmental assets exist on land and in the marine environment surrounding the Peninsula, from the Great Southern Ocean through to Spencer Gulf.

As with many other parts of southern Australia, climate change on the Eyre Peninsula will lead to warmer and drier conditions on land, rising sea levels and changing ocean conditions. These changed conditions will influence the productivity of primary industries and, combined with rising sea levels, will change how people live and work in the region and experience the environment.

Regional organisations on the Eyre Peninsula from the farming, business, local government and natural resource management sectors have been preparing for the challenge of climate change for at least the past decade. This has involved the commissioning of studies and partnering with research organisations to better understand the impacts of climate change and explore adaptation options.

Since 2009, adaptation planning on the Eyre Peninsula has been led by the Eyre Peninsula Integrated Climate Change Agreement Committee (EPICCA). EPICCA's role has been to develop and implement practical, regionally appropriate and sensitive measures to address the likely impacts of climate change by building resilience within the region. The signatories to EPICCA are:

- The Minister for Sustainability and Climate Change;
- Eyre Peninsula Natural Resources Management Board;
- Regional Development Australia – Whyalla and Eyre Peninsula; and
- Eyre Peninsula Local Government Association.

EPICCA has facilitated the development of this Regional Adaptation Plan, which provided an opportunity to consolidate past climate change planning work and identify a clear path forward for adaptation, where possible identifying actions or areas of interest relevant to multiple sectors where joint action will make best use of available resources. The Plan also meets the requirements of the Climate Change Adaptation Framework for South Australia which requires that regions in South Australia develop regional adaptation plans.

The plan identifies:

- potential impacts of climate change on key sectors and adaptation options;
- areas of decision making that need to consider climate change the most;
- adaptation pathways; and
- priorities for adaptation action.

This Plan is focussed on adaptation to a different future climate rather than mitigation (emissions reduction) to reduce climate change; in practice, both should be pursued. However, the region by itself cannot dramatically change the course of global climate change, and must prepare for a range of possible futures. While adaptation will present challenges to the region's people, economy and environment, by drawing on past experience in the region and elsewhere and existing relationships within and between sectors, the region can build resilience to a different future climate and identify the opportunities presented by it.

Many actions under this plan will need to be implemented or further prioritised by individual sectors. This plan provides those sectors with a benchmark planning process to guide their own adaptation assessments. However, there are a number of actions that will continue to require a coordinated regional and cross sectoral approach to development and implementation.

2 How was this Plan developed?

Development of this Plan combined new methods for adaptation planning, best available science on the impacts of climate change on key sectors in the region and a tailored engagement process. It was also informed by a climate change impact and adaptation options knowledge audit recently prepared for the region[5] and the results of an Integrated Vulnerability Assessment (Attachment A).

The planning approach adopted was adaptation pathways analysis which was informed by a vulnerability analysis as described in the State Adaptation Framework. Adaptation pathways analysis is an emerging approach for identifying how to adapt to future climate change and differs from a number of current approaches to climate change planning[3, 4, 6]. Rather than being limited to identifying the best single set of adaptation options for a limited set of climate change scenarios, it enables decision makers to consider a range of possible adaptation options, how they will be impacted by various climate change scenarios through time, and whether any options have a "sell by date" (i.e. a point in time at which they are no longer viable). It also enables decision makers to explore what combination of options (described as pathways) are most suitable for adapting to future climate change. This analysis also helps break down the disempowering sense that everything will be affected by climate change.

The method developed for this project was built on a conceptual understanding of how adaptation pathways can be constructed. However, key regional stakeholders need to be directly involved in the development of a plan if it is to be implemented in a community. Information to identify adaptation options and pathways specific to the Eyre Peninsula was collected through an active process of engagement. This was delivered through interviews, continual structured conversations and workshops with key regional leaders and influencers.

Interviews and structured conversations were designed to collect information that addressed the objective of the forthcoming workshop and the information collected was then used to develop discussion papers distributed prior to each workshop. This ensured that workshops were used to review and where possible agree to information amongst regional leaders and influencers rather than generate new information. Involvement and knowledge from industry participants helped to improve the design of the workshop process. A list of interview and workshop participants is provided in Attachment B.

The interview and workshop process is summarised in Figure 1.

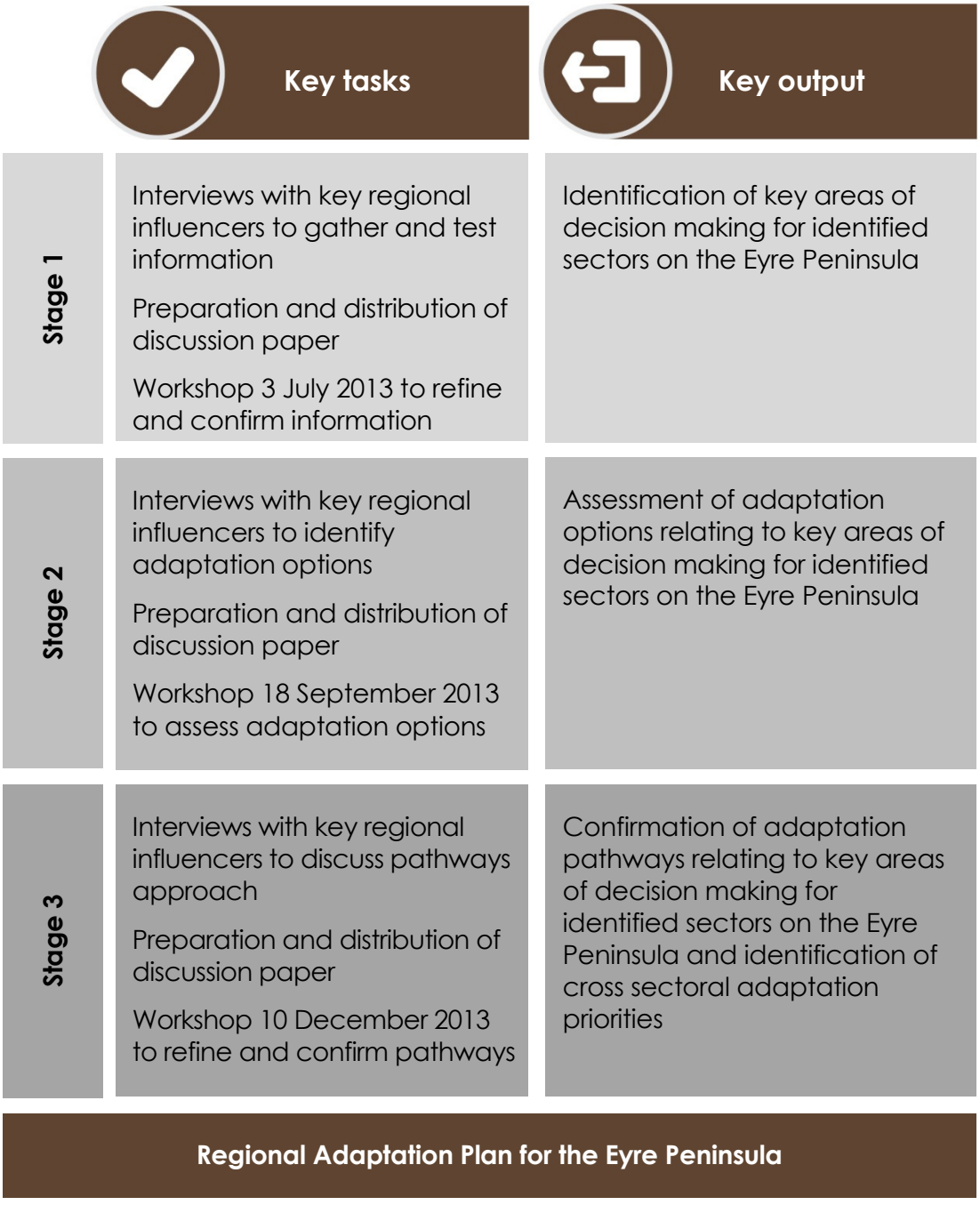


Figure 1. Summary of the process used for this project.

3 The Region

The Eyre Peninsula covers 80,000 km^2 in the western part of South Australia. It is bounded in the west by the Great Southern Ocean, the east by Spencer Gulf and the north by the Gawler Ranges (Figure 2). The region is characterised by warm, dry summers and cold, wet winters. The southern areas have a milder, moister climate compared with the warmer and drier north and northwest parts of the region. Mean annual rainfall ranges from 250 mm in the north and northwest to more than 500 mm in the south[7].

Approximately 56,000 people live in urban and rural communities across the region, with over half of the population in the cities of Whyalla and Port Lincoln (RDA 2013). The region includes the 11 local government areas of Whyalla, Ceduna, Cleve, Elliston, Franklin Harbour, Kimba, Wudinna, Lower Eyre Peninsula, Port Lincoln, Streaky Bay and Tumby Bay. There has been a decline in population in some regional areas in recent decades following reduced employment in the agriculture sector. This has led to a population increase in some coastal towns associated with the development of aquaculture and tourism, and the arrival of people making a lifestyle change[8, 9].

Aboriginal people have lived in the Eyre Peninsula for thousands of years meaning there is a strong Aboriginal cultural heritage in the region and there are many sites of importance to Aboriginal people. The regional population has a higher proportion of Aboriginal people when compared to South Australia and Australia and significant indigenous populations are located in Ceduna, Port Lincoln and Whyalla[10].

The economy of the region is based on a diverse range of activities, including agriculture, aquaculture and fishing, mining, mineral processing and tourism. Combined these activities generate an estimated $2.4 billion in revenue each year of which $1.76 billion comes from exports to overseas markets[11].

The climate and soils of the region support a substantial agricultural industry, producing approximately 42% of South Australia's total agricultural output, with a total value exceeding $500 million per annum. The region is known for its broadacre cropping and production of high quality premium grains such as high protein wheat, malting barley varieties, milling oats and canola. Livestock grazing is also important to the region, especially in relation to sheep for meat and wool[10].

The surrounding coastal and marine environments sustains a commercial fishing and aquaculture industry that produces about 80% of South Australia's seafood product and employs over 1,000 people. The region is renowned internationally for the production of high quality Southern bluefin tuna and also supports other important aquaculture industry sectors that produce oysters, abalone, mussels and marine finfish. The combined value of the regions seafood industry exceeds $200 million[10].

Manufacturing and resource processing is the region's third largest industry employing over 11% of the regional workforce, primarily in Whyalla which has a focus on manufacturing, steel production and resource processing in the Upper Spencer Gulf region. Emerging industries include mining and tourism. Mining is the fastest growing industry following exploration activity on the Eyre Peninsula, with large resources of iron ore, coal and graphite along with uranium, gold and kaolin prospects. Tourism has significant growth potential due to the region's rapidly growing reputation for unique and diverse nature-based visitor experiences and premium seafood products[10].

Common to most industries is the importance of regional transport infrastructure including being able to access and utilise port and wharf facilities on the coast. Growth in the mining sector combined with the need to meet existing export requirements for the agriculture sector and manage impacts on the fishing

sector has led to numerous studies being undertaken about how best to manage competing demands on port facilities. A decision on how best to address this challenge (e.g. where to locate a new port facility) has not yet been reached.

Unlike many other areas in the southern part of South Australia, 45% of the original vegetation on Eyre Peninsula remains intact. These remnant areas, most of which are protected, contain important Mallee habitat, several woodland communities, a high number of endemic fauna and flora species, and a number of rare, threatened or endangered flora and fauna.

A major natural resource management issue facing the region is water resources management. The region has no major surface water supplies and most of the potable water comes from the two major groundwater basins of the region in the Southern Basins Prescribed Wells Area and Musgrave Prescribed Wells Area. Demand for potable water in the region is expected to exceed supply within 10 years if no mitigating action is taken.

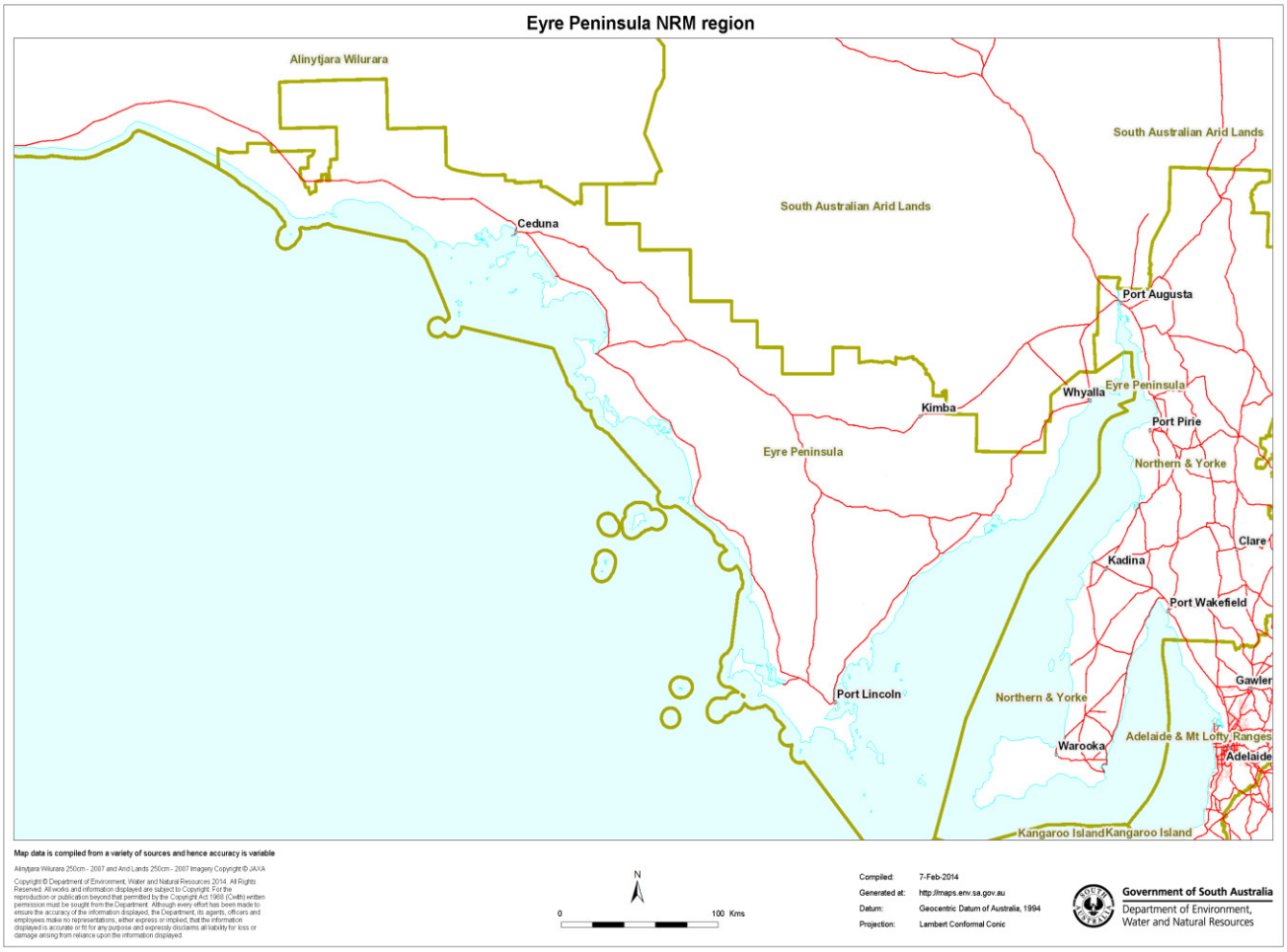


Figure 2. Map of the Eyre Peninsula natural resource management region.

4 How will climate change impact the region? [a]

Climate change is occurring as a consequence of the release of greenhouse gases like carbon dioxide, methane and nitrous oxide into the Earth's atmosphere. These gases come from a range of sources including the stationary energy, transport, industrial processing, waste management, agriculture and land management sectors. Increasing concentrations of greenhouse gases act to trap more of the sun's energy in the Earth's atmosphere leading to changes in the global climate.

Significant changes have already occurred in Australia's climate over the past 100 years. The nation's annual average surface air temperature has increased since 1910 by about 0.9°C[12]. This has been most noticeable since 1950 with a warming trend of nearly 0.2°C per decade. Rainfall on the other hand has been declining in southern Australia since 1950, with much of the Eyre Peninsula experiencing an average decadal reduction in rainfall of between 5-10 mm[12].

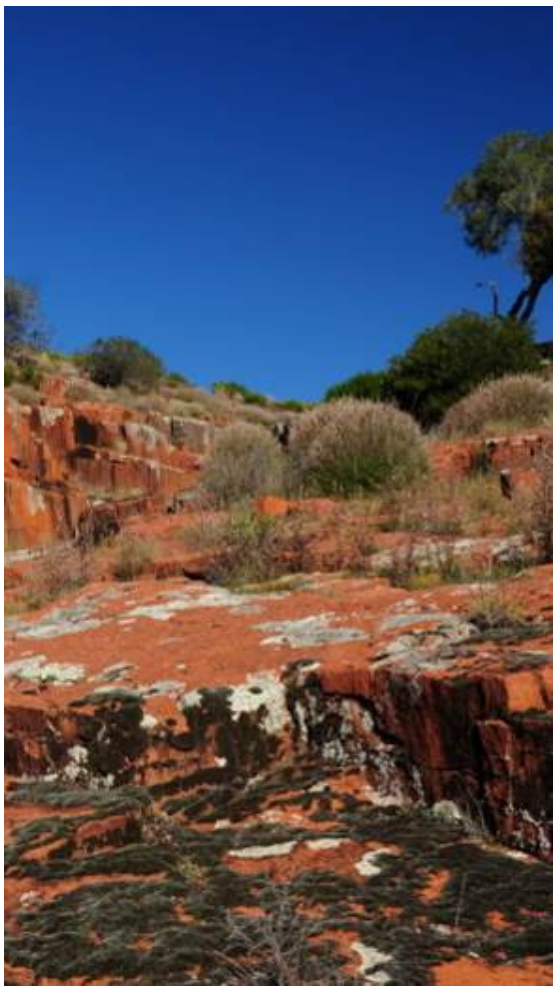
[a] This Plan presents an overview of the potential impacts of climate change for the Eyre Peninsula. More detailed information is available in DENR (2010)[12] including an explanation of the sources of variability in climate projections.

The climate projections referred to in this Plan are based on modelling undertaken by the Intergovernmental Panel on Climate Change, the world's leading authority on assessing climate change. This Plan refers to the results from the IPCC Fourth Assessment Report (AR4)[13] for temperature and rainfall and the IPCC Fifth Assessment Report (AR5) for changing ocean conditions[b]. An overview of the main conclusions of AR5 are outlined in Box 1.

The Eyre Peninsula will be impacted by climate change through warmer and drier conditions on the land, rising sea levels on the coast and changing temperatures and pH in the Great Southern Ocean and in Spencer Gulf.

Climate change will result in warmer conditions on the Eyre Peninsula in the future. By 2030, the best estimate[c] under a medium emissions scenario is for annual average temperatures to rise by 0.8'C and by 1.75'C by 2070[14]. This best estimate increase in temperature applies equally to all seasons for both 2030 and 2070.

While projections on the occurrence of heat waves for the Eyre Peninsula are not available (e.g. consecutive days with temperatures exceeding 40°C), based on work completed in other regions of South Australia it can be expected that the frequency and intensity of heatwaves will increase in the future. In contrast, the number of days experiencing frost should decline in general.



[b] Regional projections for temperature and rainfall are not yet available for the IPCC Fifth Assessment Report, but these are not expected to differ substantially.

[c] Climate change projections are made by a number of different "global climate models". The best estimate referred to in this Plan is the 50th percentile model output.

Box 1. What is the evidence that the Earth's climate is changing?

The Intergovernmental Panel on Climate Change (IPCC) is the world's leading international body for the assessment of climate change. The IPCC releases an assessment of the state of scientific knowledge relevant to climate change about every 6 years. Working Group I of the IPCC released its part of the Fifth Assessment Report in September 2013 and included the following conclusions which are relevant to adaptation planning:

- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased;
- Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850;
- Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010;
- The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia. Over the period 1901 to 2010, global mean sea level rose by 0.19 m;
- The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. Carbon dioxide concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions. The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification;
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system; and
- Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

The Eyre Peninsula is likely to experience a drying trend under future climate change, although there is more confidence in modelled projections of temperature than rainfall. By 2030, the best estimate under a medium emissions scenario is that rainfall will decline by 3.5% and by 2070 decline by 15%[12].

Rainfall projections vary much more than for temperature across seasons. The best estimate of changes in summer and autumn rainfall is for a 3.5% decline by 2030 compared with a 7.5% decline during winter and spring. By 2070, summer and autumn rainfall could decline by 7.5% compared with a 15% decline in winter and spring. While these represent the best estimates for a medium emissions outlook the drier end of the modelling outputs suggest up to a 30% decline could occur in rainfall across all seasons, whereas the wetter end of model outputs suggest that rainfall could increase by up to 15% during summer and autumn by 2070 but remain unchanged for winter and spring[13].

Climate change projections indicate that the marine waters surrounding the Eyre Peninsula will increase in height, become warmer and pH will fall. Rising sea levels will occur as a result of thermal expansion of the oceans as they warm and additional water entering the world's oceans from melting ice. The recent IPCC 5th Assessment Report[1] suggests that global mean sea level rise for 2046–2065 relative to 1986–2005 could be 0.26 m for more moderate emissions outlooks and up to 0.48 m by 2081–2100. Under a high emissions outlook sea level could rise by as much as 0.98 m by 2100.

The world's oceans will continue to warm in the coming century as they absorb heat from the atmosphere. By 2046–2065 this could result in about a 1.4°C rise in global sea surface temperatures under a medium emissions outlook relative to 1986–2005 and a 1.8–2.2°C rise by 2081–2100[1]. While these projections may apply to the Great Southern Ocean to the west and south of the Eyre Peninsula, the extent of change in water temperatures in Spencer Gulf is less clear given that this area is already substantially warmer than the nearby ocean during the summer.

IPCC Assessment Report 5 suggests that the earth's oceans will become more acidic under all scenarios assessed. Projections for increasing pH range from 0.06 to 0.32 by 2100, with a best estimate more likely to be in the order of a 0.2 rise[1]. This compares with a 0.1 rise that has already been experienced since the beginning of the industrial era.

5 Potential impacts of climate change and adaptation options

Climate change is likely to impact most sectors within a community, from economic development and provision of infrastructure and community services to natural assets and values. The potential impacts of climate change for the Eyre Peninsula described below focus on a selection of the sectors most relevant to the region's prosperity.

The sectors were those that emerged with the most information and concern from the stage one interview and workshop results; the project steering committee envisage this as a process which will be repeated in future, thus allowing other sectors to be considered over time.

Adaptation options identified in this section are based on findings from studies relevant to the region or from the experience and opinion of key regional stakeholders collected via the interview and workshop processes.

5.1 Agriculture

The potential impacts of climate change on Australian agriculture are well documented and include increased invasion of weeds, pests and diseases and changes in crop yields, pasture growth, animal health, carrying capacity and soil condition[14, 15].

Of primary concern for farmers on the Eyre Peninsula is how a warming and drying climate could influence broadacre cropping yields and production of pasture for grazing. An understanding of how dry years impact yield and farm production has been developed through use of models like APSIM (Agricultural Production Systems sIMulator).

The results from this model suggest that under a mild level of climate change (1°C warmer and 5% drier) yields will not change significantly but that a more severe level of climate change (4°C warmer and 25% drier) could result in yield declines of 10-20% depending on location and soil type. In the northern parts of the Eyre Peninsula this may result in greater areas of farming land becoming marginal for cropping[16].

Much of the research on the Eyre Peninsula is now about identifying suitable adaptation options. Based on the results of key stakeholder interviews and recent studies, climate change adaptation strategies for the region could include:

- new crop varieties from traditional breeding programs that develop traits better suited to changing local conditions and improved water use efficiency, salt tolerance, disease resilience and nutrient usage;
- genetically modified crops that possess new traits that enable farmers to maintain productivity as local environmental conditions change[d].
- soil protection through land management techniques that reduce erosive forces, such as wind breaks, cover crops and retaining stubble[15];
- soil modification through addition of clay on sandy soils to increase moisture and nutrient retention or deep spading to introduce organic matter at depth[17];
- agricultural business management to maintain high equity and hence greater capacity to weather the negative financial impacts of a more inclement climate[18]; and
- increased diversification of wheat enterprises enabling income from susceptible land uses to be augmented in high risk years with more stable sources.

Without successful adaptation actions, the general trend will be a decline in agricultural production levels at a regional scale, with some farms possibly unable to continue as cropping enterprises in the north while properties in the south could continue broadacre cropping with yield reductions. How this translates to the regional value of agriculture depends on other factors given that reductions in yield could be offset by declining input prices or increasing output prices[19].

[d] Genetically modified crops can be attractive because of the potential to develop new traits at a rate quicker than may be otherwise possible through traditional breeding programs. Despite interest, genetically modified crops are not currently permitted in South Australia under a State Government ban which is understood to last until September 2019.

5.2 Biodiversity conservation

Natural resources on the Eyre Peninsula underpin the viability of many sectors. Significant research and modelling has been undertaken regarding the impact of climate change on terrestrial biodiversity.

Warmer and drier conditions on the Eyre Peninsula and changing fire regimes will likely result in changes in the distribution of native land-based vegetation communities, which in turn will affect the type of habitat available for native fauna. Modelling suggests that at least half of the native plants on the Eyre Peninsula will have a reduced distribution under mild, moderate and severe climate scenarios[16]. Many plants believed to be sensitive to warmer and drier conditions will tend to move southward following regionally cooler and higher rainfall areas. A consequence is that important refuge and conservation areas will likely become more concentrated in southern latitudes and higher altitudes and some species may become regionally extinct.

For coastal and marine ecosystems, the general impacts of climate change in Australia include sea level rise causing shoreline erosion, inland migration of coastal ecosystems such as mangroves and salt marshes and changing ocean chemistry affecting the ability of corals, molluscs and other marine calcifiers to produce their skeletons.

While various national and international reports have been undertaken to explore the potential impacts of climate change on the marine environment, little research has been done of direct relevance for

marine biodiversity conservation in the marine environments surrounding Eyre Peninsula. The most useful source of information on impacts is the Risk Assessment of Impacts of Climate Change for Key Marine Species in South Eastern Australia[20,21]. It can be inferred from this work that some species may move out of the region in response to changing ocean currents and ocean warming while others will expand their distribution in areas like the Gulf. It is possible that new species including marine pests may enter the region creating new conservation management challenges.

Adaptation options for biodiversity conservation include:

- developing methods for large-scale habitat restoration;
- incorporating into planning the relative importance of habitat area, environmental diversity, connectivity, isolation and different types of refuges;
- developing concepts and guidelines to accommodate rapidly spreading native species and help managers decide when these are desirable or undesirable due to their impact on other resident species; and
- managing parts of the environment that provide refuge for species (habitat and resources) during climatic extremes and ecological disturbance (fire, drought, flood, storms).

5.3 Fisheries

Fisheries will be impacted by climate change through changing ocean temperatures and pH and rising sea levels. These impacts will in turn influence other aspects of the marine environment such as upwellings and currents. The National Climate Change Action Plan for Fisheries and Aquaculture[22] found that the potential effects of climate change on fishery resources in Australia could include:

- changes to oceanic and inshore productivity and food webs (e.g. due to altered upwellings);
- possible changes to the availability of suitable aquaculture sites because of sea-level rise and increased wave activity impacts; and
- warming oceans causing changes to growth and reproductive rates and a southward shift in the distribution of many species, particularly off south-eastern mainland Australia.

The impact of climate change on fisheries can be expected to differ between the Ocean and Gulf side of Eyre Peninsula. Wild catch fisheries and aquaculture on the Great Southern Ocean side of the Eyre Peninsula will experience changing ocean temperatures and increasing acidity along with changes to ocean currents and upwellings. While Spencer Gulf fisheries may be less exposed to changes in ocean currents and upwellings they will

experience increasing acidity and potentially greater impacts from warming ocean temperatures given that the Gulf is typically much warmer, during summer in particular, than the Great Southern Ocean.

The best guide to the species specific impacts of climate change for the Eyre Peninsula region comes from a recent assessment of key marine fisheries for south eastern Australia[20,21]. The findings of this assessment include that:

- Blue swimmer crabs (*Portunus pelagicus*) and Western king prawns (*Penaeus latisulcatus*) could become more productive because of warmer temperatures in Spencer Gulf, but that Western king prawns (*Melicertus latisulcatus*) may experience increased recruitment failure if upwellings increase in frequency and strength;
- rising pH could significantly affect blacklip and greenlip abalone (*Haliotis rubra & H. laevigata*) growth rates;
- Sardines could experience increased egg hatching rates because of warming oceans and productivity could rise if there is an increase in upwellings;
- changing ocean temperatures could result in changes in the distribution of Southern bluefin tuna (*Thunnus maccoyii*) but parasites may become a greater issue in Southern bluefin tuna aquaculture in Gulf waters;
- climate change is likely to affect Pacific oyster (*Crossostrea gigas*) performance, farming infrastructure and farm management practices; and
- small increases in water temperatures may have negative effects on Blue mussel (*Mytilus galloprovincialis*) health and productivity.

The impacts of climate change on total fisheries earnings therefore remains uncertain, given that some species may expand their distribution and abundance while disease could impact aquaculture operations and wild catch fish stocks could shift and be serviced better by towns other than those on the Eyre Peninsula. The economic impact will therefore be influenced by which species are favoured by changing conditions and the value of these species in domestic and export markets.

There are some adaptation options that are already available for fisheries in the region. For example, innovative management techniques that reduce exposure to extreme conditions, such as the BST long lines in the oyster industry will enable producers to respond to periodic extreme hot weather events. Into the future selective breeding of aquaculture species could reduce vulnerability to changed ocean conditions. Ultimately the fisheries sector will need more research into adaptation options including identifying where productivity of certain species may be enhanced in the future which could allow increased harvest of some species and shift in fishing effort away from fisheries/species that are likely to be negatively impacted[20,21].

5.4 Local Government

Local Government provides and maintains infrastructure and services that underpin community well being. This includes infrastructure (roads and stormwater) and property services, recreation facilities, health services, planning and development approvals and water and sewage services23. In many parts of Australia, Local Government has led climate change adaptation initiatives and the development of an understanding of the potential impacts of climate change for communities. Impacts on Local Government could include[23]:

- changes in rates of deterioration of roads and pavements;
- reduction in stormwater drainage capacity due to sea level rise and storm surge damage;
- higher rates of building deterioration and associated maintenance costs because of bushfires;
- increased frequency of inundation of coastal infrastructure and utilities, e.g. water, sewerage, gas, telecommunications, electricity;
- reduced water quality and quantity resulting in less irrigation of open space; and
- increased uncertainty in long-term land-use planning and infrastructure design.

5.4.1 Coastal development

One of the climate change impacts of most concern to Councils on the Eyre

Peninsula is coastal inundation as a result of the combined effects of sea level rise, storm surge, run-off from storm events and land subsidence. A number of Council Development Plans explicitly address the extent of sea level rise that must be taken into account for development planning purposes.

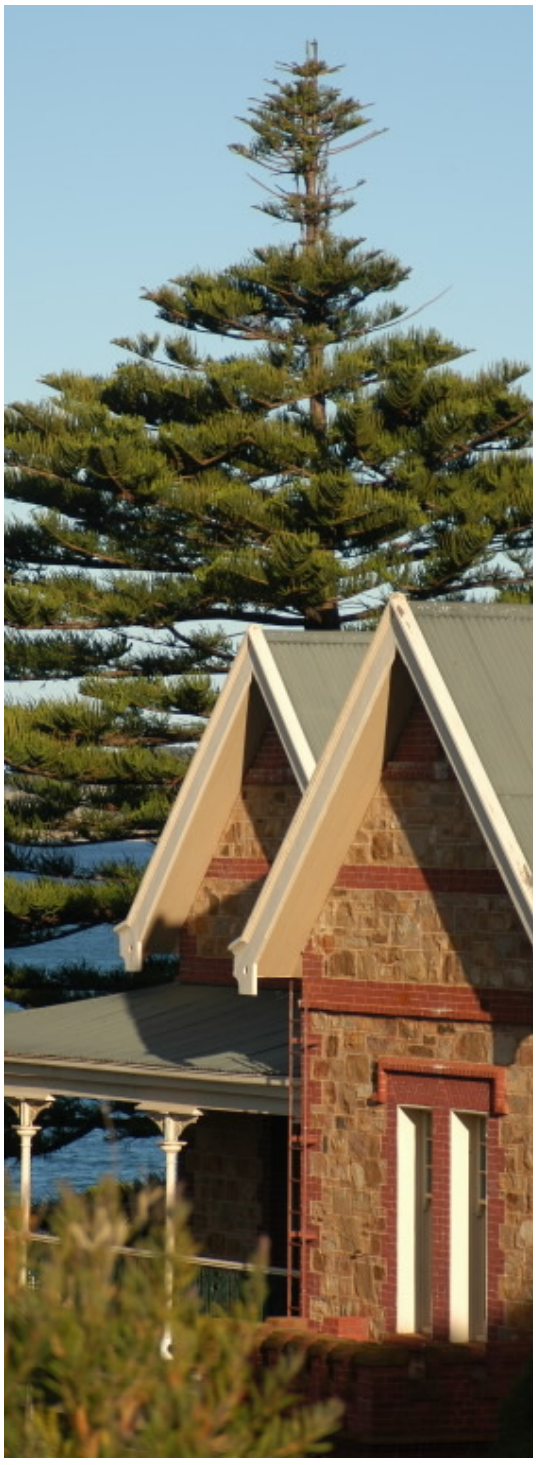
There are a number of contemporary typologies identified for adaptation to coastal climate change impacts, In a given location, coastal adaptation can involve one or more options from one or more typologies, and can be either reactive (after impacts are experienced) or anticipatory, and either autonomous or planned.

These typologies (or adaptation options) include[24,25]:

- planned retreat, which involves refocusing development and settlement on land and structures in areas less vulnerable to the impact of sea level rise. This could be achieved through development plan policy and relocating existing infrastructure and houses;
- accommodate, focussing on the implementation of building codes and design standards that require development to be able to withstand periodic inundation, for example through minimum flood heights, foundation design requirements, enhanced drainage and evaporation provisions, building on pilings, demountable homes, adapting drainage schemes to allow flood waters to drain more quickly without impacting receiving environments; building emergency flood shelters in high risk areas as well as early warning and evacuation systems; requiring hazard insurance for all properties at risk; requiring home
- buyers to be informed of risk at property purchase, changing agricultural crops or pasture to more salt tolerant species in areas prone to coastal inundation, prohibiting clearance of coastal vegetation, damage or disturbance to coastal wetlands;
- protect and defend, using hard (e.g. sea walls) and soft (e.g. dune restoration) structural options protective works to defend vulnerable areas, population centres, economic activities, infrastructure and natural resources;
- do nothing, where buildings are seen to have reached their 'expiry date' once sea level rise has encroached, properties are abandoned and losses and damages are the owners' responsibility; and
- capacity building, through developing and sharing information, resources and decision making tools regarding adaption options, clearly communicating potential risks when the information becomes available and sharing understanding within the community on the need to adapt.

5.4.2 Peri-urban expansion

One of the greatest risks of climate change in many peri-urban areas is the projected increase in the frequency and intensity of bushfires. On the Eyre Peninsula, the movement of the region's population away from smaller farming communities toward larger towns on the coast is placing greater development pressure and leading to peri-urban expansion. Many of these homes are located in close proximity to native vegetation because of the attraction of rural living or a nature based living experience. While the choice to live in these areas is a personal one, their transition from farm land to residential zoned land is a decision of Local Government.



Adaptation options for peri-urban areas exposed to increasing bushfire risk include:

- Preventing peri-urban expansion on prime agricultural land on fringes of townships and considering bushfire mapping in zoning decisions;
- Not allowing cul de sacs in the design of new peri-urban areas;
- Requiring clean up of land and fuel loads under Section 104 of the of the Environment Protection Act 1993;
- Educating landowners about land management; and
- Change native vegetation clearance regulations.

5.4.3 Maintenance of road infrastructure

Adequate road based transport logistics are essential for the long term viability of the farming sector on the Eyre Peninsula because of the need to move grain and other produce to port facilities. Roads also play an important role for fisheries (e.g. transporting shellfish across the Eyre Peninsula and onto Adelaide), tourism and emergency services and may play a role in moving ore for future mining projects. Most roads on the Eyre Peninsula are the responsibility of Local Government.

Heatwaves, bushfire, storms and inundation of roads will lead to increasing rates of deterioration of the road surface. Adaptation options could include:

- more frequent bitumen resealing due to temperature induced oxidation;
- thicker asphalt to cope with heat induced flexing and deformation;
- resurfacing of bitumen roads with new, more heat tolerant materials;
- development of a roads' database to prioritise asset management by factors such as regional economic importance; and
- diversify transport options to reduce reliance on roads through improved rail infrastructure.

5.5 Water resources management

The Eyre Peninsula is almost entirely reliant on groundwater for potable, irrigation and stock and domestic supplies. The majority of Eyre Peninsula's reticulated water comes from the Uley South Lens in the Southern Basins Prescribed Wells Area (PWA)[26]. Observations during the drought in the early 2000s suggest that groundwater levels fell in response to reduced rainfall in the region.

The South Australian Department of Environment, Water and Natural Resources has conducted a comprehensive analysis of the climate change impacts on water resources on Eyre Peninsula[26]. The study focussed on the impacts of climate change on groundwater recharge in the Southern Basins and Musgrave PWAs and surface water runoff in the Tod Reservoir catchment.

The report found that for 2070 rainfall decline projections (median rainfall change and medium range emissions scenario), reductions in annual groundwater recharge could be expected of up to 12% to 49% and 11% to 47% compared to historic in the Musgrave and Southern Basins PWAs, respectively. In the Tod Reservoir catchment reductions in discharge could be from 23% to 69%.

If the changes to recharge eventuate in response to reduced average annual rainfall, they will have major implications for continued economic development on Eyre Peninsula and

for the viability of some current agricultural practices. Addressing this reduced supply requires consideration of alternative water sources and/or water demand reduction strategies.

Adaptation options for water resources management in the region include:

- household demand management options such as installation of water efficient household appliances and rainwater tanks;
- stormwater harvesting from industrial structures and wastewater re-use;
- a desalination plant on the southern coast and/or north west coast of Eyre Peninsula;
- rehabilitation of the Tod Reservoir;
- increasing the ability to distribute water from the Murray across the region;
- additional ground water resources;
- sheeted catchments that use plastic covered catchments to accumulate moisture from overnight dews or rainfall; and
- reducing evaporation through covering dams with plastic sheets.

6 Priority areas for decision making

Regional scale climate change adaptation planning needs to focus on those issues that are fundamental to its long term viability and resilience. These issues can include factors that affect a region's economic base, how a community functions, the natural environment or the way in which these collectively interact.

Narrowing down the suite of possible issues for adaptation planning can be done using the concept of decision lifetimes[2], where a lifetime is the time taken to make a decision (lead time) plus the duration of that decision's implications (consequence time). This approach recognises that some decisions made by individuals or organisations have lifetimes that are short (e.g. < 5-10 years) and much less than the timeframes over which the major impacts of climate change will occur. In contrast, there are decisions made today that have long lifetimes (e.g. > 70-80 years) equivalent to the timing of some of the major projected impacts of climate change. For example, annual crops like wheat and canola are planned, planted and harvested within the space of 12 months and therefore the future climate in 2030 or 2070 will have little bearing on the outcome of that decision this year. In contrast, a new suburb is likely to still be in place in 100 years time or more and should therefore consider the corresponding future climate projections for its region.

Using information collected during the stakeholder engagement process, regional leaders identified key decisions relevant to their sector and the region as a whole and assessed their decision lifespans. The results are presented in Figure 3.

This assessment revealed that there are many important, climate-sensitive decisions made by different sectors on the Eyre Peninsula which have lifetimes of 1-5 years, such as planting a crop (which is a decision made each year), setting fishing quotas (which are reviewed biennially) and developing fire management plans (reviewed annually and audited every 5 years). These decisions do not need to consider long term climate change impacts. In contrast, there are other decisions relevant to the Eyre Peninsula region that have much longer lifetimes such as:

- electricity distribution networks, which based on recent experience in the region, may take at least 10 years for the feasibility phase to be completed, up to 10 years (estimated) to construct and then 40 years operating lifetime (estimated);
- peri-urban and coastal developments which may take years to decades to plan and will be in place for at least 100 years in most instances; and

- ports and wharves, which will take years to a decade to plan and construct and can be expected to have an operational lifespan of at least 70-80 years.

In addition to making potential priority climate change impacts clearer, the process also helps to demonstrate how sectors may be impacted on by climate change through some regional scale, cross sectoral issues. For example, while most farmers may focus on decisions about planting annual crops and individual fishing licencees may focus on fishing quotas, the viability of both sectors in the long term will be influenced by being able to continue to maintain access to port and wharf facilities. Similarly, an efficient transport system for the region is essential to most industries (e.g. farming, fishing, mining, tourism) as well as emergency management and general community services.

The stakeholder engagement process provided a clear direction on priority areas of decision making that need to be considered in identifying adaptation options for the region. Key issues and areas of decision making are as follows:

Agriculture - How and when can the farming sector transition to more viable agricultural practices in the face of warmer and drier conditions in areas that are currently marginal for cropping?

Conservation management - How can ecological communities that are currently threatened be protected as species distributions change in response to a warmer and drier climate?

Fisheries - How will the fisheries sector respond to changing distribution and abundance of wild catch commercial species and changed conditions for aquaculture as a result of increasing temperatures and acidity in Spencer Gulf and the Great South Ocean and changing ocean currents?

Maintenance of road infrastructure - How will bitumen and unsealed roads respond to an increasing frequency of extreme events (e.g. hot weather and higher intensity storm events)?

Management of coastal development - How can communities manage existing and new developments in low-lying areas close to the coast?

Peri-urban expansion - How will Councils manage peri-urban expansion in close proximity to remnant vegetation that may come under increasing threat from bush fire?

Port and wharf facilities - How can port and wharf facilities be managed to provide the greatest resilience to future changes in sea levels and related impacts such as storm surge?

Water resources management - How does the region maintain or increase the supply of potable water in major towns given future possible reduction in supply, either as a consequence of climate change induced rainfall decline or reduced availability from the River Murray?

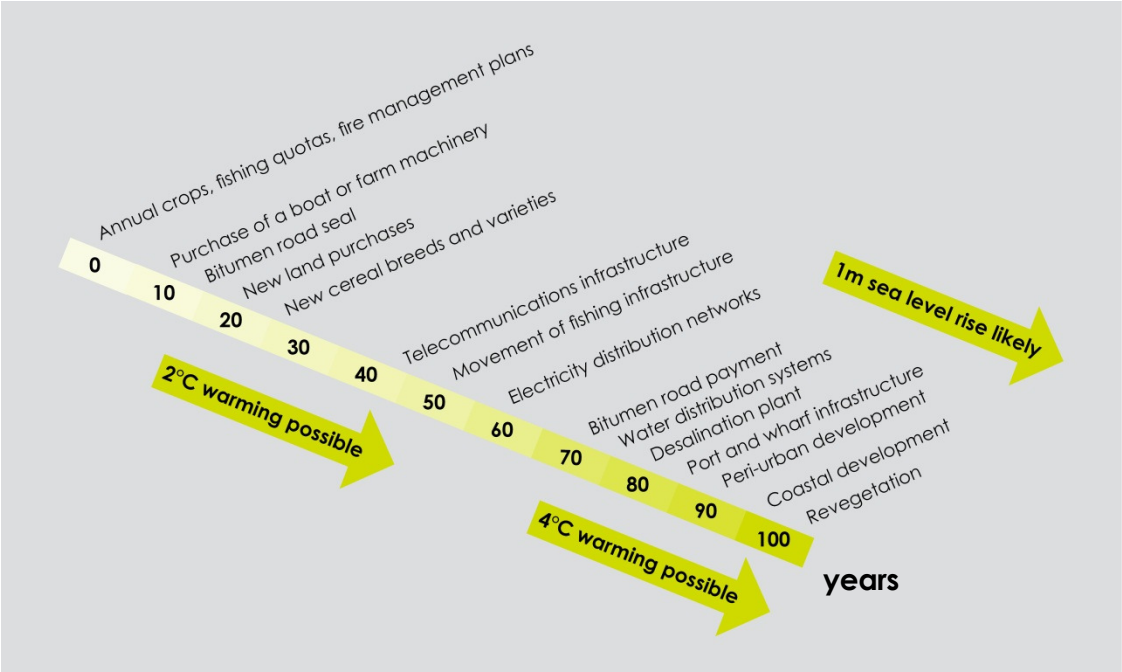


Figure 3. Decisions and their lifetimes identified for key sectors on the Eyre Peninsula. This diagram has been modelled on the decision lifetime figure presented in Stafford-Smith *et al*. (2011)[2].

7 Adaptation pathways

The following sections present pathways for each of the eight areas of decision making. These are then collated into a simplified regional pathway to help draw out the interactions among sectors in terms of regional needs and the timing of key adaptation actions.

A description of how to interpret the pathways maps is provided in Box 2. It should be noted that the diagrams in this section present emerging pathways which in most cases need to be further assessed by individual sectors.

7.1 Agriculture

Climate change could impact agriculture in the region by reducing long term yield and resulting in a change toward more pastoral/forage based grazing systems in country that is currently marginal for cropping.

An adaptation pathway has been prepared for the key decision of "How and when can the farming sector transition to more viable agricultural practices in the face of warmer and drier conditions in areas that are currently marginal for cropping?" (Figure 4).

Significant information is already available on potential adaptation options for farmers, many of which have been specifically developed in

the context of farming conditions on the Eyre Peninsula. In the short term, adoption of leading practices (e.g. stubble management and precision agriculture) and soil modification can provide immediate adaptation measures. However, while traditional breeding programs are still considered important, there is an emerging view that they will not be able to deliver new traits at a rate quickly enough to keep up with the speed of a changing climate. If this is the case, alternate options may be required such as a switch to genetically modified crops; these will have significant lead times in terms of public policy, community opinion and actual variety development which need consideration now.

In general, industry would prefer not to transform away from cropping in these marginal regions if possible, so the last two options are shown shaded; however, if carbon farming is to become a significant part of the enterprise mix, then there is again a significant lead time in understanding what options are feasible and addressing cross-sectoral concerns about monocultures and conservation. It was also noted, inasmuch as marginal lands may transform away from cropping, fertile lands which are often being taken over by peri-urban expansion will become ever more important to maintain agricultural output, raising a further cross-sectoral concern on land use planning.

Various agricultural practices that are considered leading edge will provide some measure of adaptation in the coming 10-20 years, however, long term adaptation may require more transformational responses, such as adoption of advanced breeding techniques by that time, and earlier planning is needed for these options.

Box 2. How to interpret the pathways maps

Each map identifies adaptation options on the y-axis relevant to a key decision. A pathway shows how a single adaptation option plays out through time. The pathway maps are not meant to imply that all options should be pursued, instead, there are various options some of which may be pursued and others not.

To assist with interpreting the maps, it should be noted that:

- a **solid, dark green line** indicates the time period over which an option could usefully address the relevant key decision. A **lighter green line** indicates time before an action occurs where preparatory work is required;
- a **dashed, thick dark green** line indicates that the option contributes to the adaptation solution but only in part;
- a **solid dark grey line** indicates an option that was not favoured in these discussions. A **lighter grey line** indicates time where preparatory work would be required if such an option was to be pursued;
- **circles** indicate a decision point, such as when decision makers may need to choose between different options;
- a **solid line that ends in a vertical black line** indicates an adaptation tipping point, or a point beyond which an option is no longer viable;
- **yellow lines** with arrows indicate emerging pathways that need to be further assessed in most instances with each sector;
- there is no priority in the order in which options are presented;
- the **x-axis** represents a general trend in changing climate through time and should be read as indicative (e.g. decades) rather than precise in terms of the timing of adaptation options; and
- given that the x-axis represents time, it should also be noted that other factors will change through time that will impact on the choice of adaption option such as population changes and market forces.

Issue

Agriculture

Key decision

How and when can the farming sector transition to more viable agricultural practices in the face of warmer and drier conditions in areas that are currently marginal for cropping?

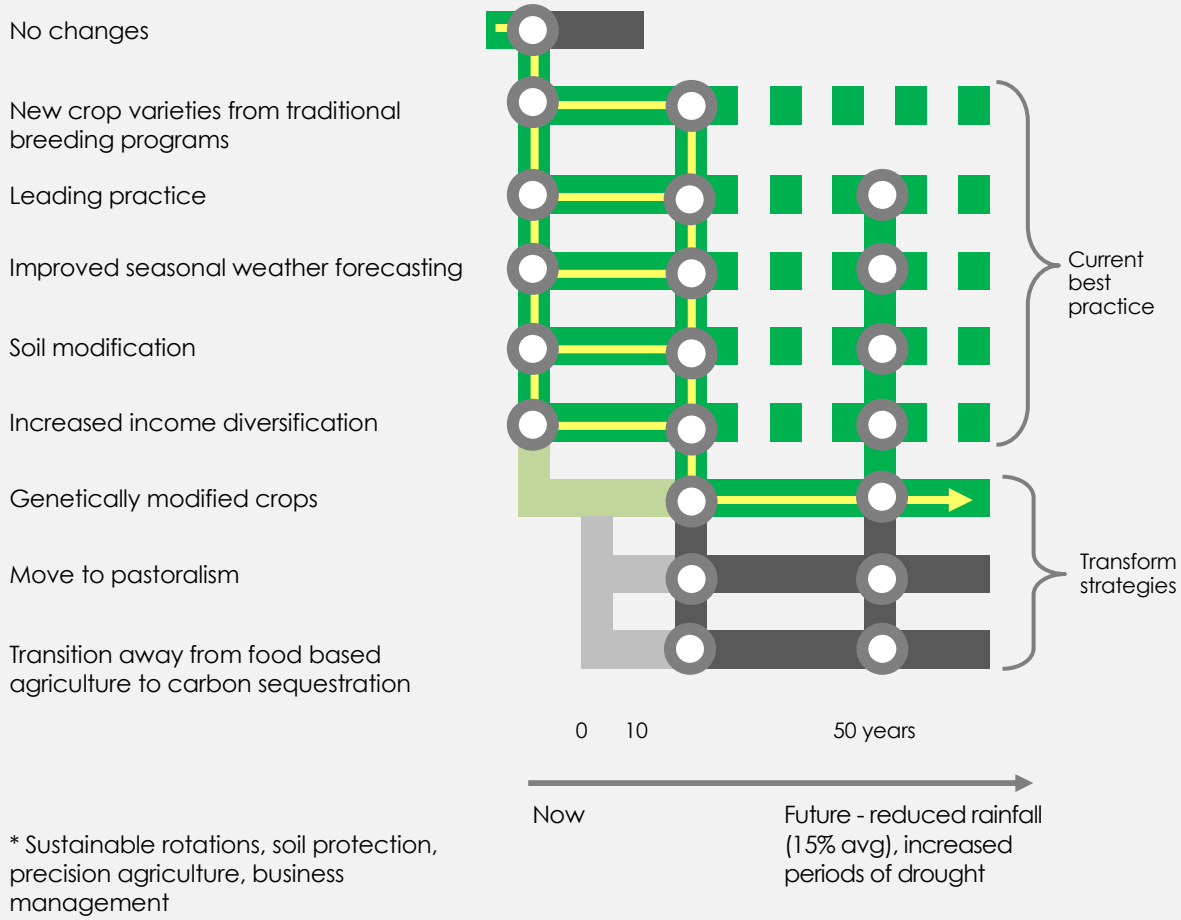


Figure 4. An adaptation pathways map for understanding how and when the agriculture sector will transition to more viable practices in the face of warmer and drier conditions in areas that are currently marginal for cropping. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.2 Conservation management

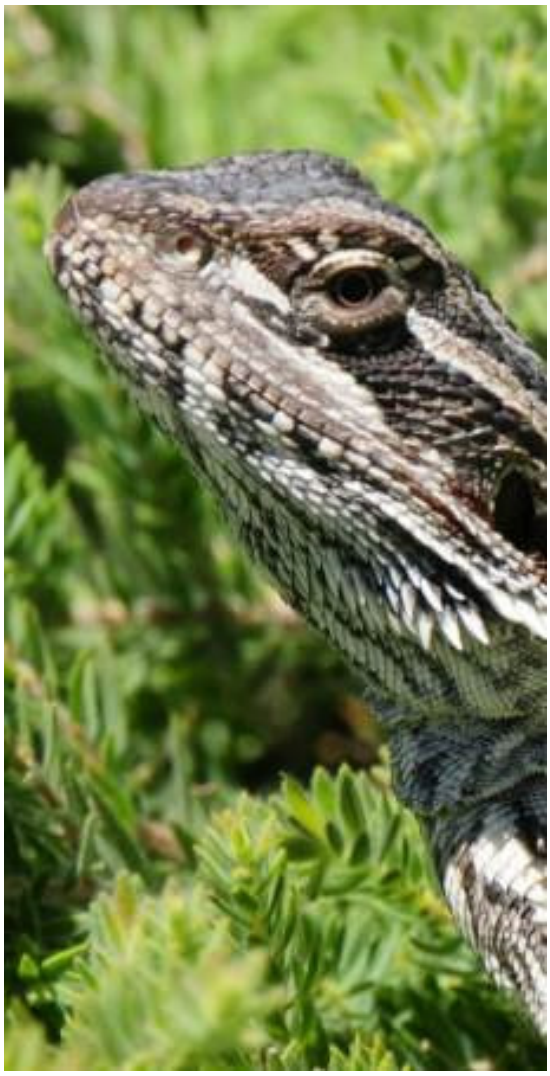
A warmer and drier climate and increasing risk of bushfires will result in changed distributions of native plants and animals, with some potentially becoming regionally extinct.

An adaptation pathway has been prepared for the key decision of "How can ecological communities that are currently threatened be protected as species distributions change in response to a warmer and drier climate?" (Figure 5).

In the immediate short term a range of management measures are required such as improved monitoring and forecasting of changing species distributions. More importantly though is the need to identify future refuge and protected areas and develop management arrangements for large scale adaptation and refuge protection, which was identified as a priority by key stakeholders in the region. This may require changing the selection criteria for identifying protected areas.

In the longer term, higher cost actions may be required such as assisted migration or translocation of key species or gene banking. While these actions may not be required for some time, preparatory work is required now to ensure these options remain open in the future such as determining what species would be important for a gene banking program.

In the short term greater emphasis needs to be placed on better forecasting of changing species distributions. Within the next one to two decades arrangements will need to be made for large scale refuges within the region and assisting plants and animals to move to more suitable habitat outside the region.



Issue

Conservation management

Key decision

How can ecological communities that are currently threatened be protected as species distributions change in response to a warmer and drier climate?

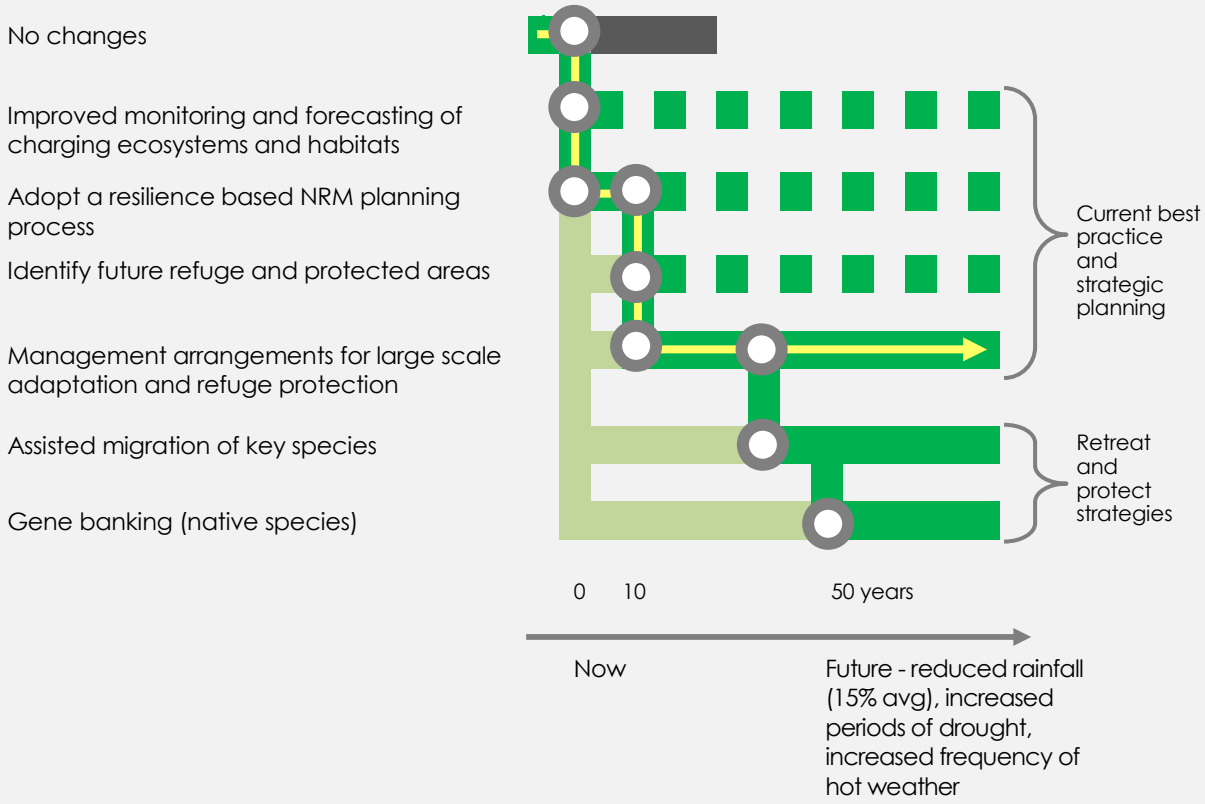


Figure 5. Adaptation pathways exploring options for how ecological communities that are currently threatened could be protected as species distributions change in response to warmer and drier climate. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.3 Fisheries

Climate change will impact the region's fisheries and aquaculture primarily through the warming of oceans, ocean acidification and changing currents. The outcomes of this could be negative for some commercial species without adaptation and positive for others that experience an increase in distribution.

Adaptation pathways have been developed for the key decision of "How will the fisheries sector respond to changing distribution and abundance of wild catch commercial species and changed conditions for aquaculture as a result of increasing temperatures and acidity in Spencer Gulf and the Great Southern Ocean and changing ocean currents?". Pathways maps were developed for Western king prawns, Sardines and Southern bluefin tuna (Figures 6-8). While only a single map has been provided for other sectors, multiple maps are presented here because differences in fish biology can lead to different impacts of climate change and hence adaptation options.

Pathways maps for all three species have a common starting point, indicating that in the immediate short term, adaptation response should consider improving stock assessment models to consider climate factors, developing and implementing a biosecurity management strategy and system, reviewing fisheries-related policies and legislation (particularly to address the currently geographically static view of regulations) and develop a shipping management strategy for Spencer Gulf. Pursuing these options independently though can lead to a piecemeal, incremental approach to fisheries management, lending support therefore to the concept of an Integrated Ocean Management Strategy (IOMS) which could be pursued for Spencer Gulf as a more systemic response. The IOMS was identified as the highest priority cross sectoral adaptation option.

In the longer term a range of other options need to be considered, potentially shifting target species and eventually involving movement in the base location of the fishing fleet and infrastructure.

Climate change will likely result in a mixture of both positive and negative impacts for the fisheries sector meaning that in the short term better stock assessment models will be required as well as an integrated approach to managing Spencer Gulf's marine resources. In the long term the location of the fishing fleet and infrastructure may need to be reassessed.

Issue

Fisheries management – Western king prawn fishery

Key decision

How will the prawn fishery respond to changing distribution and abundance of prawns as a result of increases in Spencer Gulf temperatures and acidity?

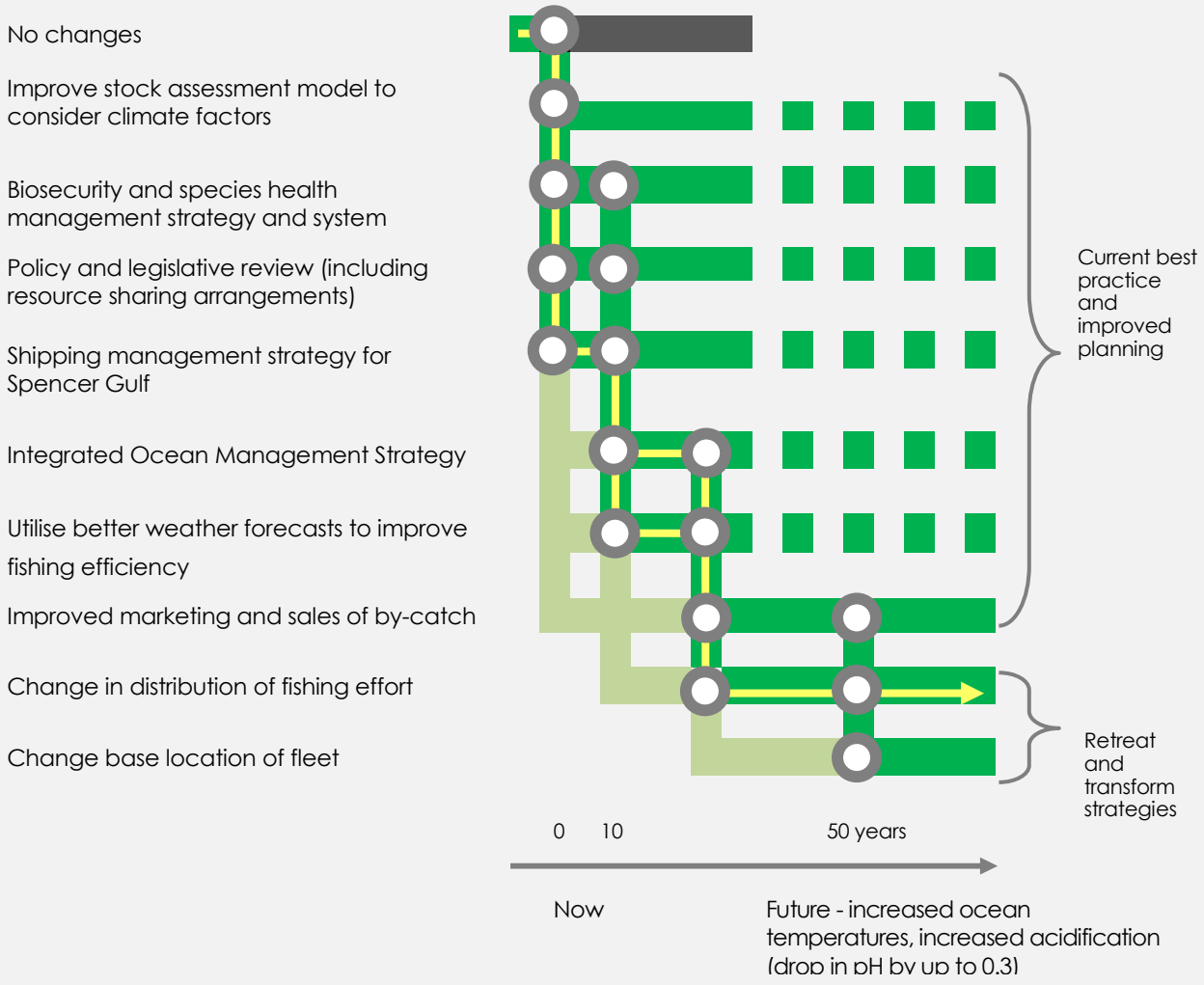


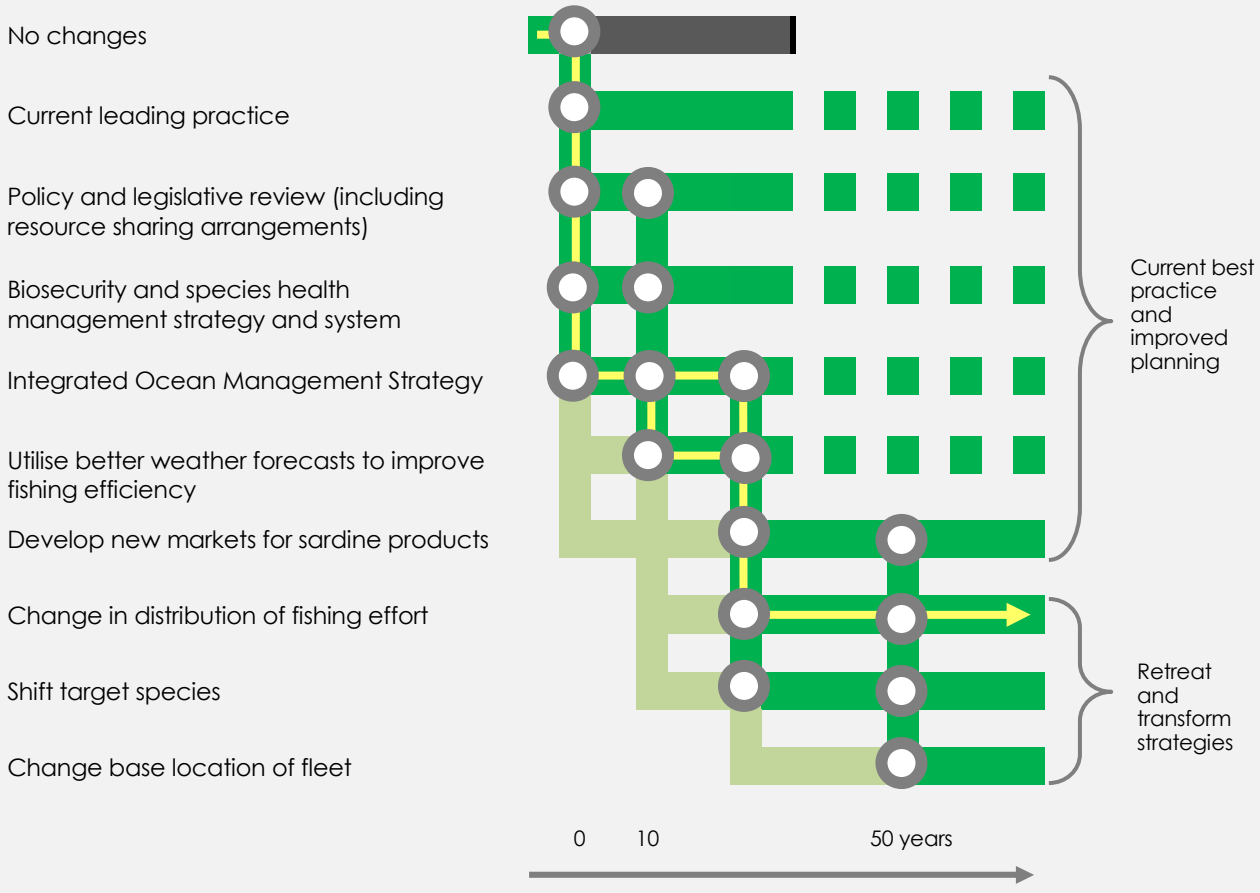
Figure 6. Adaptation pathway exploring how the Western king prawn fishery industry will respond to changing distribution and abundance of prawns as a result of increases in Spencer Gulf temperatures and acidity. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

Issue

Fisheries management - Sardine fishery

Key decision

How will the Sardine industry respond to changes in sea surface temperatures, currents and upwellings?



* Current leading practice includes integrated monitoring and tracking system, further improve stock assessment model to consider climate factors

Figure 7. Adaptation pathway describing options for how the Sardine industry could respond to changes in sea surface temperatures, currents and upwellings. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

Issue

Fisheries management - Southern bluefin tuna

Key decision

How will the Southern bluefin tuna industry respond to changes in sea surface temperatures, currents and upwellings?

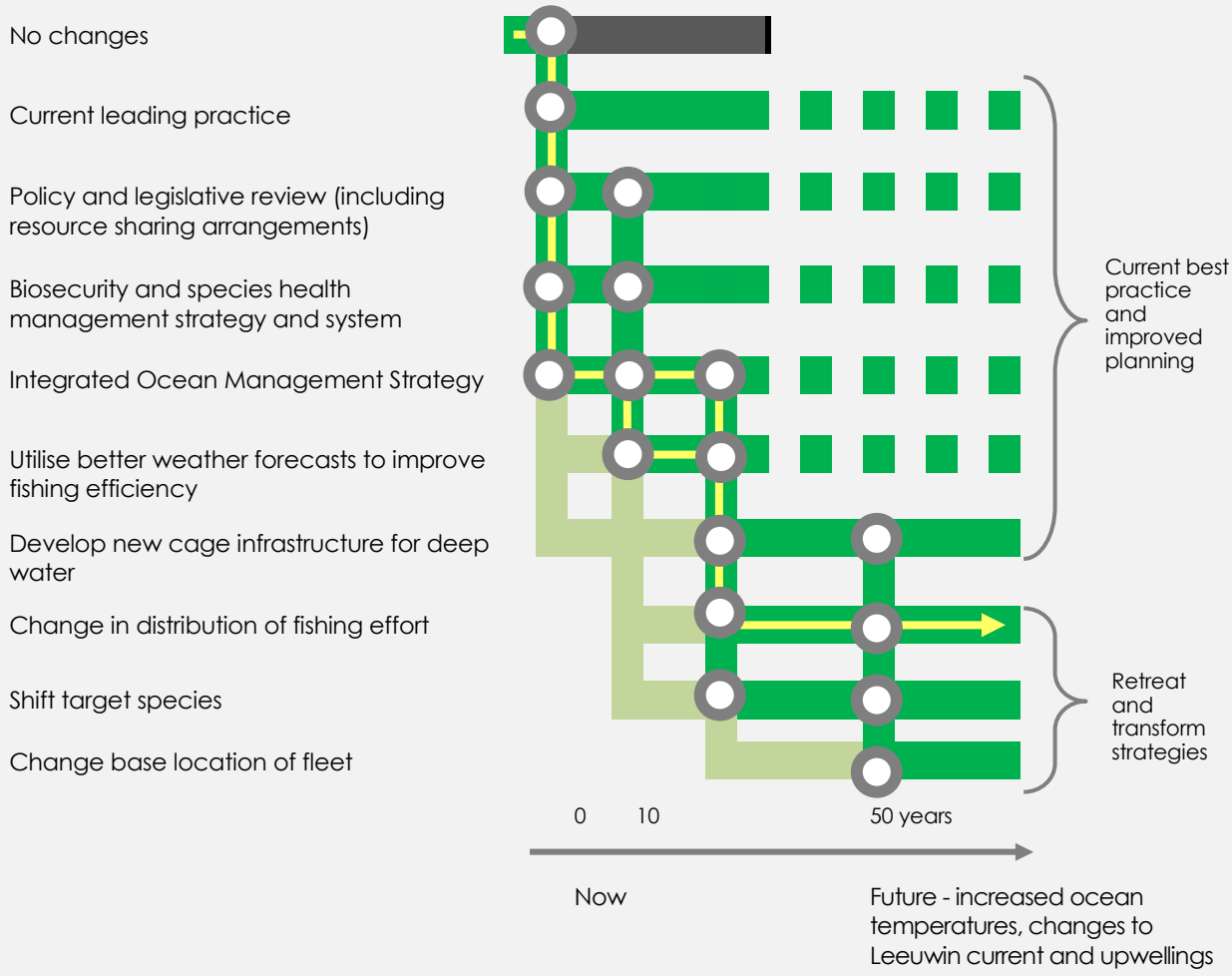


Figure 8. Adaptation pathways exploring options for how the Southern bluefin tuna industry can respond to changes in sea surface temperatures, currents and upwellings. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.4 Maintenance of road infrastructure

Future road maintenance will require consideration of the impact of extreme weather events on bitumen roads in particular, whether these are storm events and flooding or extreme hot weather which can result in deformation of the sealed surface.

An adaptation pathway has been prepared for the key decisions of "How will bitumen and unsealed roads respond to an increasing frequency of extreme events (e.g. hot weather and higher intensity storm events)"(Figure 9).

In the immediate short term adaptation needs to focus on developing a strategic transport plan that considers future transport modes and demands and encourages design allowance for an increasing number of extreme events. This adaptation option has been identified as a high priority by key stakeholders in the region.

In the longer term and where roads are not built to withstand more frequent extreme events, more regular bitumen resealing (in the case of extreme hot weather) may be required.

In the short term a strategic transport plan is required to better manage the multiple demands on regional transport infrastructure such as roads. In the longer term greater design allowance needs to be made for increasing frequency of extreme events.

Issue

Roads

Key decision

How will bitumen and unsealed roads respond to an increasing frequency of extreme events (e.g. hot weather and higher intensity storm events)

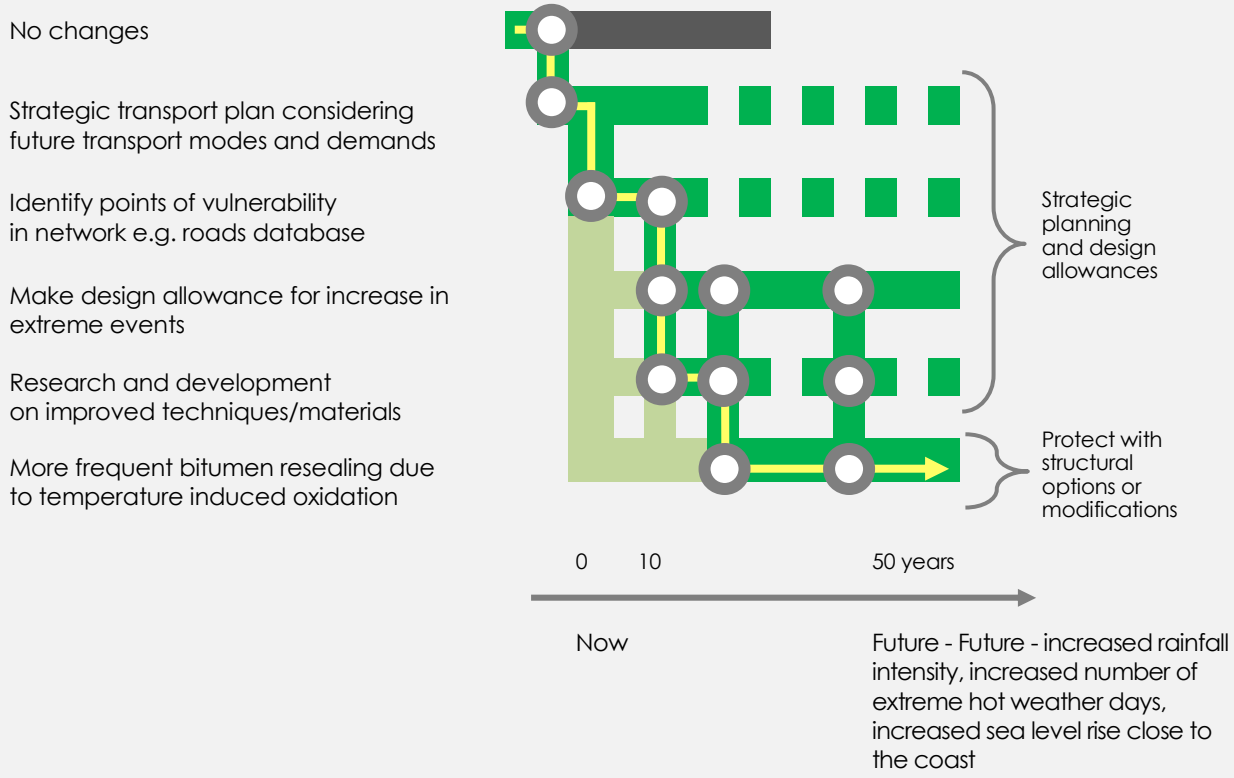


Figure 9. Adaptation pathways exploring options for how management of bitumen roads and unsealed roads can respond to an increasing frequency of extreme events such as hot weather and flooding. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.5 Management of coastal development

The climate change focus of most Councils on the Eyre Peninsula is the threat of coastal inundation which could occur as a result of sea level rise, storm surge, run-off from storm events and land subsidence, either individually or in combination.

An adaptation pathway map has been prepared for the key decision of "How can communities manage existing and new developments in low lying areas close to the coast?" (Figure 10). A number of adaptation options were identified during stakeholder interviews and have been added to with recent work undertaken for Engineers Australia[25] and Queensland Coastal Councils[26].

The pathways map suggests that there are planning, mapping and educational responses that could be taken now that provide some measure of adaptation or provide the information needed to adapt. For example, changes to development planning policy could prevent new developments from occurring in areas that could be impacted by future sea level rise.

Preventing new development is a proactive strategy that refocuses development and settlement on land and structures in less vulnerable areas. Despite this some existing infrastructure will remain in areas that could be impacted by future sea level rise and decisions will need to be made as to whether these areas will be protected through strategies such as sea walls and storm barriers.

In the short term, planning, mapping and educational responses can be taken that will provide some measure of adaptation for coastal development to sea level rise, particularly in relation to preventing new development occurring in areas of known vulnerability. Within two to three decades, retreat and protection initiatives will be required for existing development. Although action may not be required in the short term, thinking and planning is required now given the complexity and cost of these types of adaptation options.

Issue

Management of coastal development

Key decision

How can communities manage existing and new developments in low lying areas close to the coast?

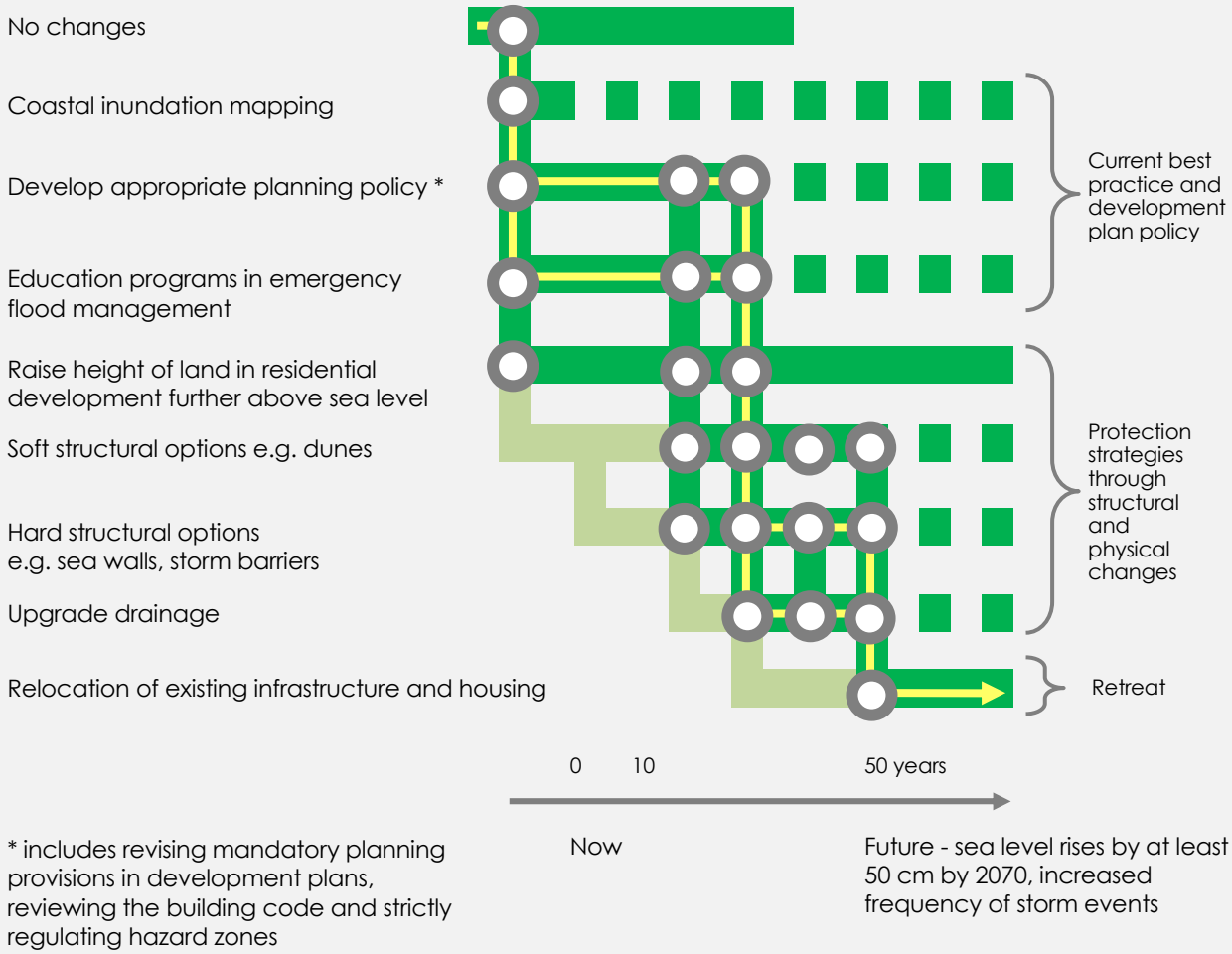


Figure 10. An adaptation pathways map for assessing options regarding how communities can manage existing and new developments in low-lying areas close to the coast in the face of rising sea levels and related impacts. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.6 Peri-urban expansion

Population movement is placing development pressure on coastal towns as people move away from smaller farming communities. Housing developments in peri-urban areas can place an increasing number of homes in areas more likely to become prone to bushfire under future climate change.

An adaptation pathway has been prepared for the key decision of "How will Councils manage peri-urban expansion in close proximity to remnant vegetation that may come under increasing threat from bush fire?" (Figure 11).

In the short term a range of options exist such as enforcing Section 104 notices (under the *Environment Protection Act 1993*) regarding clean-up of land and fuel load and educating landowners about land management. While prescribed burns are also an important tool now, it is expected that there will be a shortened burning season in the future due to changing rainfall and temperature conditions in spring and autumn, the time for conducting prescribed burns.

While promoting higher density development is an option to offset expansion into peri-urban areas, this is unlikely to be successful because it does not provide the bushland setting that home owners are seeking in the region. As such it is anticipated that as the risk of bush fire increases in the future, there will be mounting pressure to change development plan policy and native vegetation clearance regulations. As such, options to enable vegetation clearance to occur may be required, such as enabling vegetation clearance subject to suitable vegetation offsets being obtained consistent with the requirements of the *Native Vegetation Management Act 1991*.

In the short term, enforcement of Section 104 notices and education can reduce fire risk. In the longer term though, there will be increasing demand to allow larger scale native vegetation clearance.

Issue

Peri-urban expansion into bush fire prone zones

Key decision

How will Councils manage peri-urban expansion in close proximity to remnant vegetation that may come under increasing threat from bush fire?

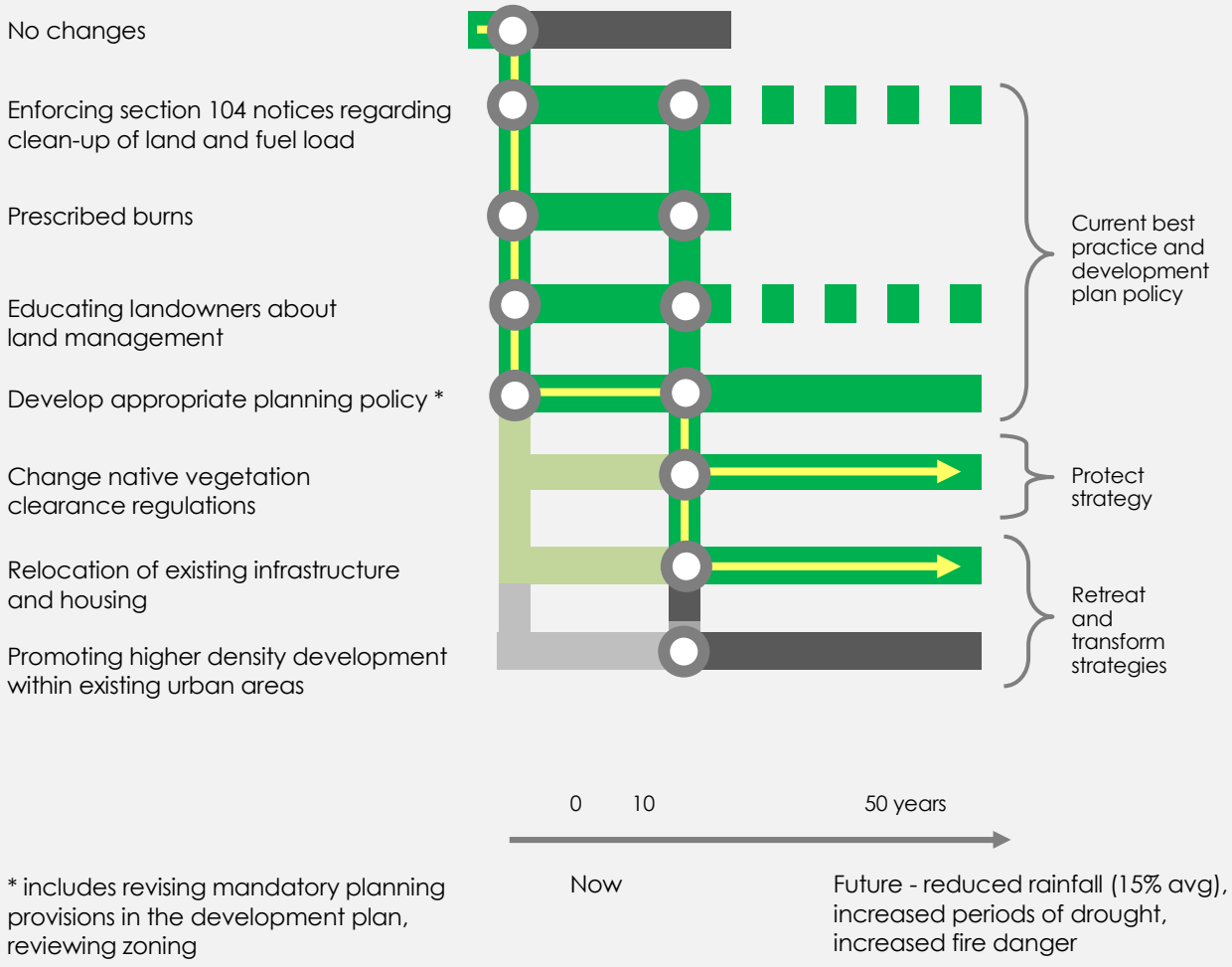


Figure 11. An adaptation pathways map for exploring how Councils can manage peri-urban expansion in close proximity to remnant vegetation that may come under increasing threat from bush fire. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.7 Port and wharf facilities

Port and wharf facilities will be impacted by rising sea levels which combined with periodic storm surge events could result in physical damage to infrastructure.

An adaptation pathway has been prepared for the key decision of "How can port and wharf facilities be managed to provide the greatest resilience to future changes in sea levels and related impacts such as storm surge?" (Figure 12).

Feedback from interviews and the second workshop suggest that a major decision point will occur within 10 years about upgrading or constructing a new port and wharf facility on the Eyre Peninsula. Even if a decision was made to retain existing infrastructure it is expected that within 30-40 years, sea level rise would require retrofitting of existing infrastructure (e.g. raising wharves) as a minimum or providing additional protection from sea level rise and the related storm surge impacts (including for example ancillary infrastructure such as silos, noting that some silos may be nearing the end of their asset lifetime).

Construction of new port and wharf facilities was identified as one of the priority adaptation options across sectors. If a new structure is built within the next 10 years, it would be important to consider future climate change impacts given that the functional lifetime of such infrastructure is expected to be at least 70-80 years.

A decision about the location of a new port and wharf facility for the Eyre Peninsula is expected with the next 10 years. It is vital that this consider potential impacts of future climate change, especially sea level rise and coastal inundation.

Issue

Maintenance of port and wharf facilities

Key decision

How can port and wharf facilities be managed to provide the greatest resilience to future changes in sea levels and related impacts such as storm surge?

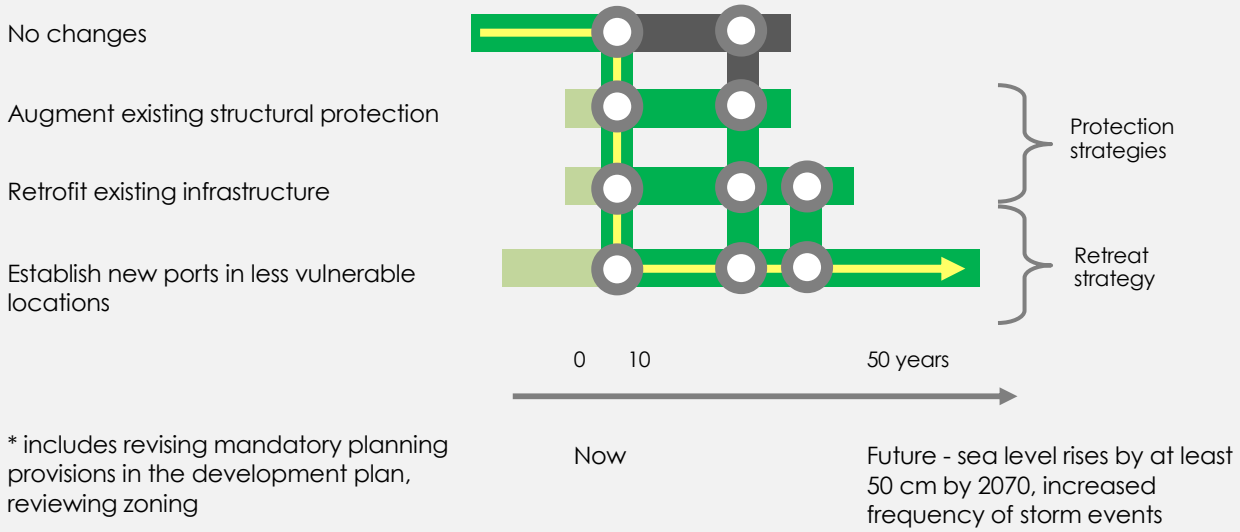


Figure 12. Adaptation pathways exploring options for how port and wharf facilities could be managed to provide the greatest resilience to future changes in sea levels and related impacts such as storm surge. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.8 Water resources management

Modelling and monitoring of groundwater resources on the Eyre Peninsula indicate that groundwater levels are likely to be negatively impacted by reduced rainfall as a consequence of climate change. Water availability is a major environmental, social and economic issue for the region.

An adaptation pathway map has been prepared for the key decision of "How does the region maintain or increase the supply of potable water in major towns given possible reductions in supply, either as a consequence of climate change induced rainfall decline or reduced availability from the River Murray?" (Figure 13). The adaptation options identified on the pathway map are informed by SA Water's Long Term Plan for the Eyre Peninsula[27], which has a 20-25 year planning horizon.

The pathway map suggests that in the immediate short term, options such as demand management (e.g. increased cost, water restrictions, encourage rainwater tanks) and stormwater harvesting from industrial structures[e] should continue. Demand

[e] This may require treatment of water to ensure it is suitable for potable consumption.

management for water resources was identified as one of the highest priority adaptation options for the entire Eyre Peninsula for all sectors. However, along with stormwater harvesting from industrial structures, it only provides limited adaptation to the longer term impacts of warmer and drier conditions on water resources availability.

Given that the Eyre Peninsula Demand and Supply Statement indicates that demand will exceed supply for potable water on the Eyre Peninsula within 10 years, there is a pressing need to make a decision about a major supply side, infrastructure option. Depending on what infrastructure option is chosen in the coming 10 years, another adaptation option may be required in the longer term as the impacts of further warming and drying are experienced.

While increasing supplies from the River Murray could provide a solution, there is concern amongst the local community about the vulnerability of this option given other demands on this resource. In contrast, desalination remains a popular option given that it can provide water independent of climate conditions, although concerns remain about the environmental impacts of waste brine.

Household demand management and increased stormwater harvesting are popular short term adaptation options. Within 10 years a major supply side option will be required such as extending a pipeline carrying Murray water into the region or investing in desalination.

Issue

Water

Key decision

How does the region maintain or increase the supply of potable water in major towns given possible reduction in supply, either as a consequence of climate change induced rainfall decline or reduced availability from the River Murray?

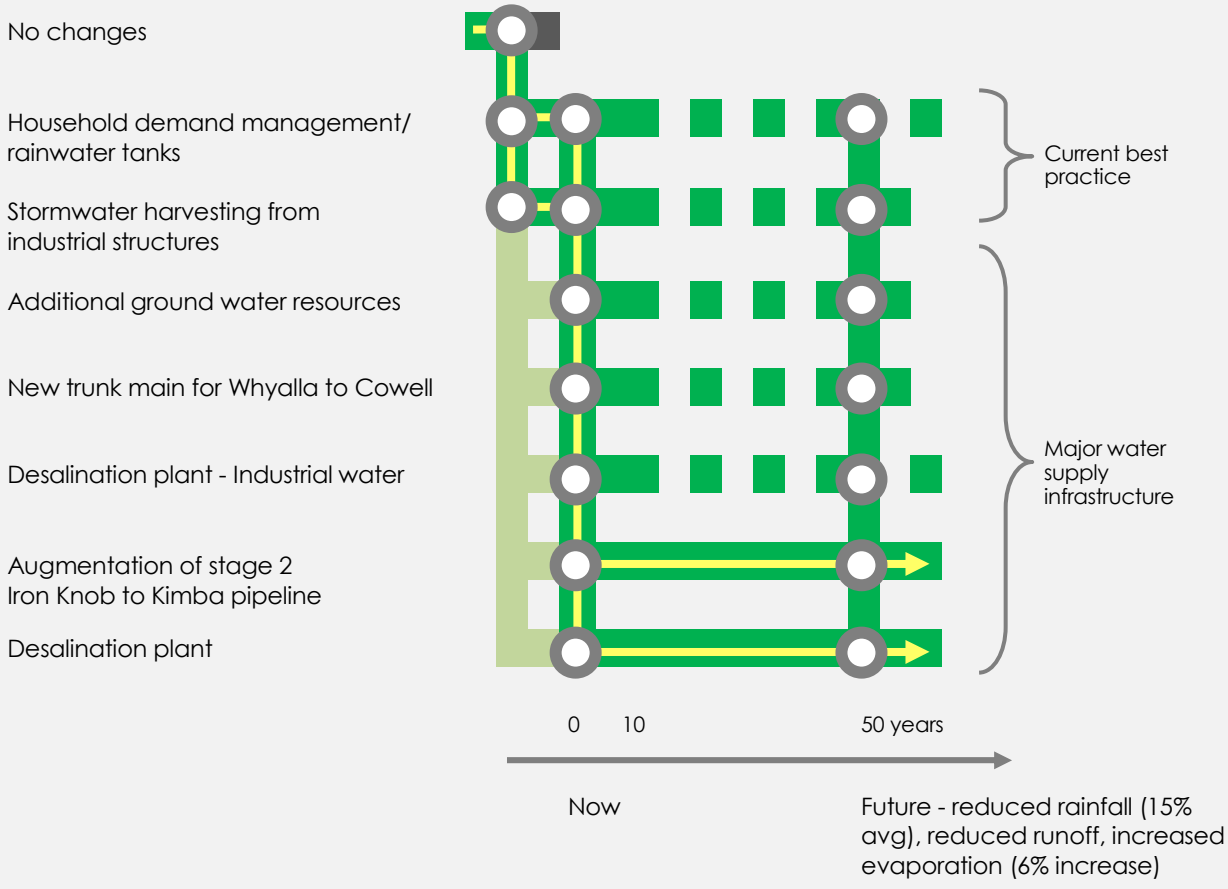


Figure 14. Adaptation pathways map for water resources management to maintain or increase the supply of potable water in major towns given future possible reduction in supply, either as a consequence of rainfall decline or reduced water availability from the Murray. See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

7.9 Emerging regional pathways

Much of the pathways analysis in this Plan is presented for individual sectors, however, regional climate change planning requires consideration of how decisions taken by one sector can impact on others and how the region as a whole prioritises action. Drawing on the pathways presented in Figures 4 –14, a cross regional emerging pathway map has been developed (Figure 15). This simplified regional pathway draws out some of the interactions among sectors in terms of timing and regional needs.

In the short term, many sectors are likely to continue with current best practices that will help to prepare for climate change through incremental change. Such actions could include fisheries stock assessment modelling, prescribed burns, coastal mapping, improved monitoring for conservation and fisheries species and selective breeding for agriculture and aquaculture.

Adaptation will also be assisted by continued strategic planning within and across sectors. The two highest priority planning actions that could assist with cross sectoral adaptation are an Integrated Management Strategy for Spencer Gulf and a Regional Transport Infrastructure Plan.

The regional pathway suggests that within a decade at least two major infrastructure initiatives may be required that will need to consider the impacts of climate change, both of which impact multiple sectors on the Eyre Peninsula. First is a major water supply infrastructure initiative, which is vital for the social, economic and environmental future of the region, and which if it occurs needs to account for projected declines in water resource availability because of declining rainfall. Second is the establishment of new port and wharf facilities, which if they were to occur, need to consider potential impacts of rising sea levels and associated storm surge impacts, given that the lifetime of this type of infrastructure is expected to be at least 70-80 years.

Within two to three decades, more of the region's adaptation actions will need to focus on protecting assets and starting to transform some sectors. Major emerging actions could be structural options such as sea walls for coastal defence, use of genetically modified crops and changing the distribution of fishing effort. In the long term, adaptation may require retreat and further transformation within sectors. Notably, planning work for many of these medium and long term actions needs to commence now.

Importantly, there is a need to consider interactions between major adaptation actions especially when they are occurring at the same time. Greater cross regional input will also be required when an adaptation action has the ability to impact multiple sectors e.g. responding to declining water resources availability.

In the short term, regional scale adaptation will likely focus on continued adoption of current best practice within sectors, integrated strategic planning initiatives and revising development plan policy. In the medium and longer term, adaptation will require protect and retreat strategies and transformation of some sectors. The region needs to consider interactions between major adaptation actions especially when they are occurring at the same time.

Issue

Regional scale, cross sectoral adaptation planning

Key decision

How do key sectors on the Eyre Peninsula respond to warmer and drier conditions on the land, higher sea levels near the coast and warmer and more acidic gulf and ocean waters?

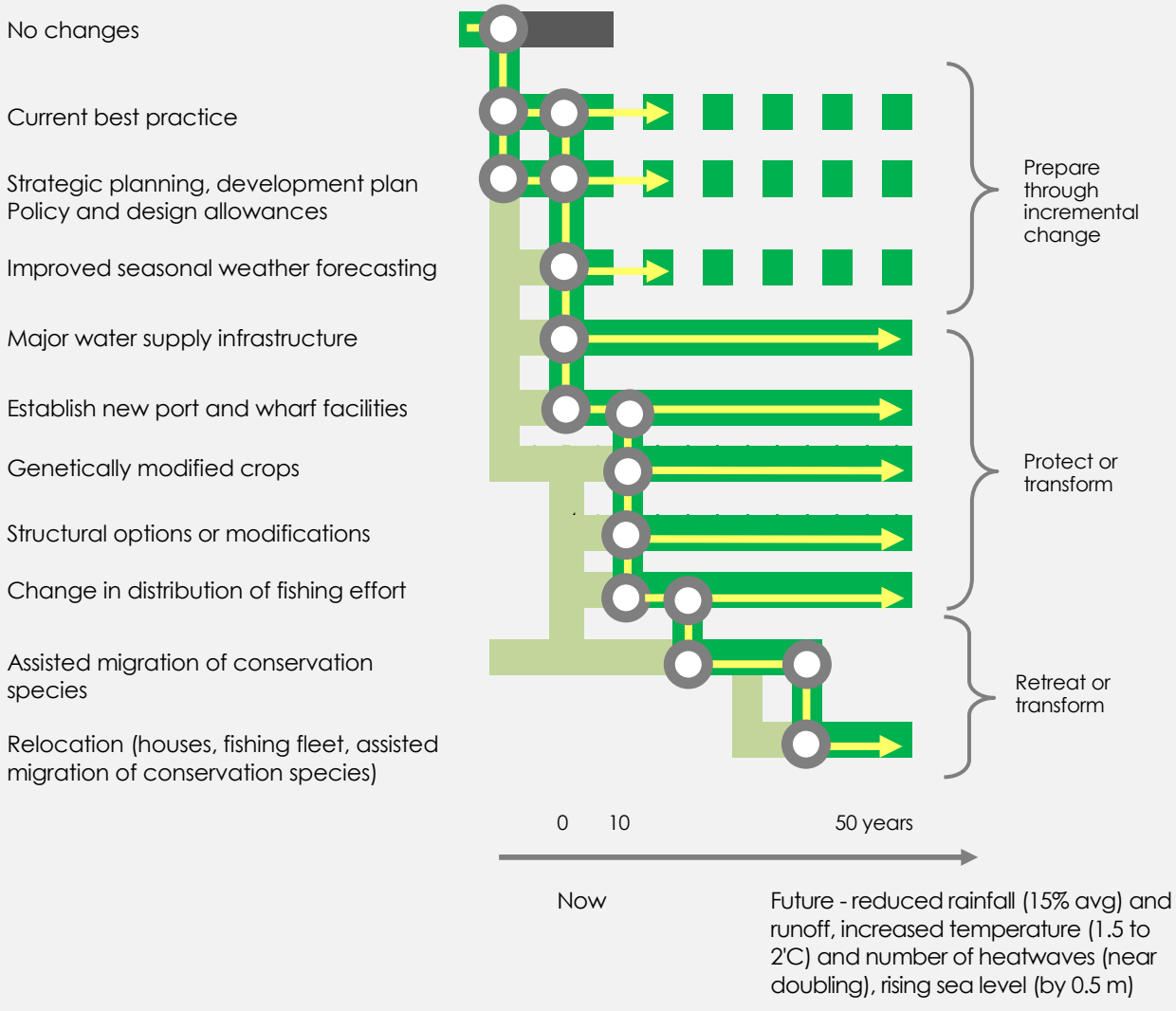


Figure 15. Emerging cross regional pathways for the Eyre Peninsula (see notes on following page). See Box 2 (pg. 31) for an explanation of how to interpret the diagram.

Notes

1. Current best practices include stock assessment modelling (fisheries), prescribed burns (emergency management/protection of property in peri-urban areas), coastal mapping (Local Government development planning), improved monitoring (conservation, fisheries), household demand management (water resources management) and selective breeding (agriculture, aquaculture).
2. Strategic planning priorities are likely to include an Integrated Management Strategy for Spencer Gulf and a Regional Transport Infrastructure Plan. Development plan policy could regulate development and construction in areas at risk from rising sea levels and increasing bushfire risk. Design allowances include allowing for climate change impacts in new road designs and establishment of ecological refuges.
3. Improved seasonal weather forecasting is relevant to farmers (e.g. rainfall outlook) and wild catch fisheries operators (e.g. sea surface temperature).
4. Structural options include sea walls and more frequent resealing of roads.
5. As the pathways map indicates, there are likely to be a range of activities that need to be implemented over time, and this analysis facilitates the consideration of the interactions among them and the need to schedule the mobilisation of investment in the future.

8 Implementing the Plan

8.1 An approach based on principles

This Plan outlines the adaptation priorities identified by key regional leaders on the Eyre Peninsula. In the future, further adaptation planning will be required by individual sectors and needs to be guided by the following principles:

- **Build economic resilience** - Adaptation planning should proceed on the basis that individuals and organisations are best able to adapt when they are profitable and sustainable. Economic resilience to climate change is therefore important to achieving social and environmental adaptation.
- **Prepare not repair** - Investment decisions across sectors in the region need to focus on investing in adaptation and mitigation actions rather than repairing damage once the impacts of climate change are experience.
- **Take joint responsibility** - While sectors are individually responsible for their own adaptation planning they are jointly responsible for regional scale, cross sectoral adaptation planning and implementation.
- **Identify long lifetime decisions** - Sectoral planning needs to ensure that decisions made today that have long lifetimes, such as major infrastructure initiatives and land use planning, consider long term climate change impacts in their design.
- **Seek out and avoid cross sectoral maladaptation** - Future adaptation needs to consider the interactions between different sectors and how this impacts the individual and collective response of the region. In some instances an adaptation action in one sector could have negative consequences for another, leading to maladaptation. For example, managing the bushfire risk to expanding peri-urban housing areas needs to balance protecting certain native vegetation communities which may be contracting due to climate change.

Action: Future adaptation planning within sectors should seek to build economic resilience; take action that prepares the region rather than repairs infrastructure after impacts are experienced; take joint responsibility across sectors; identify long life time decisions and avoid cross sectoral maladaptation.

8.2 Adaptation priorities

As emerges from Figure 15, this Plan has identified several adaptation actions that are relevant to multiple sectors. In doing so, these highlight regional scale priorities that, if implemented, can deliver cross sectoral adaptation and build regional resilience. The two highest priority cross sectoral adaptation actions are:

Integrated Management Strategy for Spencer Gulf

Ports and wharves service many sectors on the Eyre Peninsula. They provide export facilities for the farming, mining and fishing sectors, mooring sites for fishing and recreational boats and are an attraction for tourists and locals alike for fishing and walking. Similarly, the marine environment of Spencer Gulf provides passage for shipping and habitat for important commercial, recreational and conservation species.

An Integrated Management Strategy for the Spencer Gulf would provide a consistent approach to planning for the use of the coastal and marine resources of the Gulf. It would aim to optimise outcomes across multiple users of the resource and inform planning and infrastructure decisions (e.g. the location of port and wharf facilities) in a way that considers future climate change. It would help build economic resilience for the region and potentially streamline planning decisions that support regional economic diversification.

By contributing to decision making about the location of ports and wharves in the region, this action aligns with one of the most important regional development priorities for South Australia.

Regional Transport Infrastructure Plan

Regional leaders strongly supported the need to maintain transport infrastructure into the future to support development and access of various markets for goods from the Eyre Peninsula. This is critical for maintaining a diverse economic base to sustain the region.

Adequate road-based transport logistics are essential for the long term viability of the farming sector on the Eyre Peninsula because of the need to move grain and other produce to port facilities. Roads are also important for fisheries (e.g. transporting shellfish), tourism and emergency services and may play a role in moving ore for future mining projects. At the same time roads are potentially vulnerable to various climate change impacts such as increasing temperatures, increased risk of bushfires and closer to the coast flooding from sea level rise impacts.

Regionally coordinated transport infrastructure planning is required to prioritise future road maintenance giving consideration to the impact of extreme weather events. A regional transport infrastructure plan also needs to consider how to balance integrated management and use of ports, rail and roads to service the agriculture, mining, fishing, tourism and other sectors, considering climate change impacts in relation to major infrastructure decisions.

Action: Priority adaptation actions that support multiple sectors on the Eyre Peninsula are the development of an Integrated Management Strategy for Spencer Gulf and Regional Transport Infrastructure Plan.

This Plan has identified a number of adaptation options that need to be implemented or further assessed by individual sectors. While some of the adaptation options may not need to be implemented immediately, preliminary work will need to commence soon. For example:

- the agriculture sector needs to further assess how it will approach advanced breeding options and use of genetically modified crops, including how it engages the community on the issue and how it identifies regulatory changes that may be needed to enable their use;
- water resource managers need to determine what major supply side options will be implemented to address forecast water shortfalls given that some infrastructure projects may take several years to complete;
- Local Government needs to undertake a process to:
    - identify those areas that will be impacted by sea level rise and coastal inundation and preclude these areas from future development;
    - consider how existing development will be protected (if at all) from sea level rise and coastal inundation;
    - ensure that consideration of the impacts of sea level rise and coastal inundation is incorporated into Asset and Infrastructure Management Plans and Financial Plans; and
    - ensure plans and processes are in place to protect public safety when infrastructure/assets are inundated.

Action: Some large scale adaptation options within sectors will require preliminary work to commence within those sectors now if the adaptation option is to be available by the time it is required to adapt to future climate change impacts.

8.3 Enabling cross sectoral adaptation

Much of the focus of adaptation planning is on priority impacts and adaptation options. Yet various enabling conditions need to exist so that adaptation can occur. For example, proposed actions need to align with community values and need to be achievable within regional policies and governance arrangements. Cross sectoral adaptation in the region requires consideration of the following enabling conditions:

- a regional governance approach that provides for a continuation of a collaborative approach to adaptation planning across the region;
- further development of the business case for regional action on climate change;
- improved awareness of climate change issues within sectors, undertaken by sector leaders, with the support of EPICCA such as through annual summits focussed on information networking;
- improved engagement with Aboriginal people. This needs to be considered as part of broader efforts across the State to involve Aboriginal people in adaptation planning;
- development of a vision for a vibrant and diverse regional economy that considers the impact of climate change on key sectors and plans for a "low carbon" future; and
- training the next generation of industry and community leaders who can participate in adaptation planning processes.

Action: Invest in maturing the enabling conditions for adaptation in the region and promote sectoral planning activities that take account of cross-sectoral interactions. Particular emphasis should be on further evolving the regional governance approach and training the next generation of industry and community leaders.

8.4 Periodic review

This document has recorded the facilitated deliberations of regional leaders on the Eyre Peninsula at a point in time, but such deliberations are always incomplete and future conditions will continue to unfold. As a consequence, a final action is to re-consider this plan periodically, such as every 2-3 years, in a spirit of adaptive management. Not only will such reviews be able to take account of how conditions are changing, but participants will also be able to build on this work. Future reviews should look closely at where profound transformative change may in fact be needed in complex issues such as coastal development and others mentioned here.

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Attachment A – Integrated Vulnerability Assessment results

This Plan has been informed by the results of an Integrated Vulnerability Assessment (IVA) prepared for the Eyre Peninsula Integrated Climate Change Agreement Committee. The IVA followed the method described in the Local Government Association of South Australia's *Guidelines for Developing a Climate Change Adaptation Plan and Integrated Climate Change Vulnerability Assessment*.

Table A.1. Summary results for an Integrated Vulnerability Assessment prepared for the Eyre Peninsula. Results relate to primary indicators.

Indicator	Vulnerability description
Economic capital	
Ports and jetties	High
Telecommunications	High
Sheep and wool production	High
Fisheries	High
Broadacre crops	High
Electricity supply	High
Rail	High
Buildings	High
Tourism	High
Roads	High
Water infrastructure	Medium
Construction and engineering	Medium
Mining	Medium
Retail trade	Medium

Indicator	Vulnerability description
Business and personal services	Low
Social capital	
Education	High
Emergency management	High
Buildings	High
Health	High
Land assets	High
Community planning and development	High
Existing social capital	High
Social Inclusion	High
Environmental capital	
Groundwater	Very high
Regional native flora	High
Regional native fauna	High
Surface water	High
Water dependant ecosystems	High
Landscape fragmentation	High
Regional native vegetation communities	High

Attachment B – Interview and workshop participants

Name	Organisation
Mark Anderson	Greening Australia
Graeme Baldock	Private farmer; Councillor, District Council of Kimba
Heather Baldock	Private farmer; Eyre Peninsula Natural Resources Management Board (Chair)
Simon Clarke	Spencer Gulf and West Coast Prawn Fishermen's Association
James Crocker	SA Water
Steve Dangerfield	SA Water
David Davenport	Rural Solutions SA
Geoff Dodd	Port Lincoln Council
David Elliss	Australian Southern Bluefin Tuna Industry Association
Angela Faulkner	RDA Whyalla and Eyre Peninsula (Deputy Chair); Eyre Peninsula NRM Board member
Brad Flaherty	BNJ Consulting
Brian Foster	Private farmer; EPICCA (Chair)
James Guy	Department of Environment, Water and Natural Resources
Rohan Hamden	Department of Environment, Water and Natural Resources
Iggy Honan	Natural Resources Eyre Peninsula, Department of Environment, Water and Natural Resources
Eddie Hughes	Councillor, Whyalla City Council
Tony Irvine	CEO, EP Local Government Association

Name	Organisation
Greg Kerr	Natural Resources Eyre Peninsula, Department of Environment, Water and Natural Resources
Annie Lane	Natural Resources Eyre Peninsula, Department of Environment, Water and Natural Resources
Julie Low	District Council of the Lower Eyre Peninsula (Mayor)
Stephen Mayfield	SARDI
Stuart Modra	Private farmer; Lower Eyre Agricultural Development Association Committee member
Jonathon Newbury	School of Population Health, University of Adelaide
Jeff Pearson	Private farmer
Phil Pisanu	Department of Environment, Water and Natural Resources
Andrew Polkinghorne	Private farmer; Member of the Implementation Committee, Australian Grain Growers Co-op
Evelyn Poole	Natural Resources Eyre Peninsula, Department of Environment, Water and Natural Resources
Christian Pyke	AgriFoods
Sean Reardon	Flinders Ports
Stacey Richardson	Goyder Institute
Scott Siviour	Private farmer
Bryan Smith	Private farmer; Eyre Peninsula NRM Board member
Murray Townsend	Coastal Protection Branch
Peter Treloar	Member for Flinders
Paul Watson	South Australian Sardine Industry Association

Name	Organisation
Damian Windsor	Tumby Bay Council
Cecilia Woolford	EPICCA
Jonas Woolford	South Australian Abalone Industry Association